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# Water in Turkmenistan

**by**

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## Abstract

Turkmenistan, like all Central Asian countries, is critically dependent on water because of its arid desert climate. The Amudarya, flowing from the Pamir and Tien-Shan Mountains to the tragically dying Aral Sea, is the main source of water for all agricultural and non-agricultural uses in Turkmenistan. Given the constancy of water resources and the rapidly growing population in the country, the annual water availability per capita decreased by 50% during the last 35 years, dropping to 4,000 cu.m in 2004. Water has thus become the principal strategic resource that determines the region's economic development options.

Water allocation from Amudarya is governed by regional agreements between all Central Asian states. Turkmenistan's share is 22 cu.km per year, or 36% of the river's total runoff. Agriculture is the main water user in Turkmenistan, consuming 95% of the available resources. The emphasis on the expansion of cotton production in the Soviet era and the strategy of food self-sufficiency aggressively implemented since 1992 have led to accelerated growth of irrigated areas, which increased by nearly 4 times in the last 40 years, reaching 2.3 million hectares. Almost half this area – 1 million hectares – has been added during the 15 years since independence.

Irrigation is expanded without proper engineering attention to efficient conveyance of water, using mostly unlined canals and ditches with loss rates exceeding 30%. Effective water use per hectare of irrigated land has steadily declined, and it is now one-half of its level in 1970. Inadequate water availability is one of the reasons for low crop yields in Turkmenistan. The expansion of the collector-drainage network lags far behind the expansion of irrigation: between 2000-2004 the collector-drainage network grew by 7%, while the irrigated area increased by 26%. This has led to accelerated rise of the groundwater table, deterioration of soil quality, and increased salinity. More that 1.6 million hectares, or 73% of irrigated land in Turkmenistan, is salinated.

Increased use of concrete or plastic lined ditches, adoption of new efficient technologies – sprinkling, drip-irrigation, subsoil irrigation, and careful attention to water consumption for crop irrigation will significantly reduce water losses and seepage into the ground, and alleviate the problems associated with rising groundwater table. Adoption of water-saving technologies is costly, but it is essential for improved efficiency of water use. This technological approach will make it possible to increase the irrigated area in Turkmenistan to 4-5 million hectares while actually raising crop yields. It will thus help the country's agriculture achieve its economic potential.

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Turkmenistan is a huge Central Asian country of 491,200 km$^2$, nearly 50 million hectares – the fourth largest by area in the former Soviet Union (FSU) after Russia, Kazakhstan, and Ukraine. However, about 80% of the land area is without surface runoff and it is covered by one of the largest sand deserts in the world—the Karakum Desert. The habitable area is strictly limited, and this huge country has a small (albeit rapidly growing) population of about 6 million people, which puts it in one group with the FSU midgets – Armenia, Georgia, Azerbaijan, the Baltic states. More than half the population (53%) lives in rural areas, compared to one-third in FSU, but only 5% of the country's agricultural land (2 million hectares) is cultivable, compared to 40% in FSU. The remaining 96% of agricultural land in Turkmenistan is desert pastures – 39 million hectares fit only for flocks of karakul sheep and camels, not for human beings. Thus, despite the huge expanses and the small number of people, the effective population density in Turkmenistan is very high: there is less than 0.6 hectares of arable land per rural resident compared to 2.1 hectares in FSU. Land and water are the two scarcest and most precious resources in this country.

**Table 1. Selected Characteristics of Turkmenistan and Some FSU Countries***

| | Country area, thousand km$^2$ | Ag land in use, million ha | Population, million | Population density, per km$^2$ | Population growth rate 1990-2004, % per annum |
|---|---|---|---|---|---|
| Turkmenistan | 491 | 40.5 | 6.5 | 13.2 | 4.0 |
| Uzbekistan | 449 | 17.8 | 26.0 | 57.9 | 1.7 |
| Kyrgyzstan | 200 | 4.5 | 5.1 | 25.5 | 1.0 |
| Tajikistan | 143 | 4.1 | 6.8 | 47.6 | 1.7 |
| Kazakhstan | 2,725 | 78.0 | 15.1 | 5.5 | −0.6 |
| Russia | 17,075 | 192.6 | 143.5 | 8.4 | −0.2 |
| Ukraine | 604 | 37.3 | 47.1 | 78.0 | −0.7 |

| | Arable land, % of ag land | Irrigated, % of arable[a] | Rural population, % | Share of agriculture in labor, % | Arable land per rural resident, ha | Share of agriculture in GDP, % |
|---|---|---|---|---|---|---|
| Turkmenistan | 5 | 106 | 53 | 48[b] | 0.6 | 20[d] |
| Uzbekistan | 23 | 100 | 64 | 34[c] | 0.3 | 28[d] |
| Kyrgyzstan | 29 | 79 | 65 | 52 | 0.4 | 33 |
| Tajikistan | 21 | 81 | 74 | 68 | 0.2 | 24 |
| Kazakhstan | 28 | 7 | 43 | 33 | 3.4 | 8 |
| Russia | 61 | 5 | 27 | 11 | 3.0 | 5 |
| Ukraine | 83 | 8 | 33 | 25 | 2.0 | 11 |

Source: All countries except Turkmenistan and Uzbekistan from CIS Interstate Statistical Committee, *Official Statistics of the CIS* (CD-ROM 2005-10); Turkmenistan from Turkmen National Institute of Statistics (private communication); Uzbekistan updates for population and land from www.statistics.uz and *Environmental Situation and Utilization of Natural Resources in Uzbekistan: Facts and Figures 2000-2004*, UNDP and UzStat (Tashkent, 2006).
*The data are for 2004, except where indicated otherwise: [a]1990; [b]1998; [c]2001; [d]1997.

Turkmenistan is an agrarian country, as is evident from its high share of rural population, high share of agricultural labor in total labor force, and high share of agriculture in GDP (**Table 1**). Yet by these characteristics Turkmenistan is generally comparable to its Central Asian neighbors: it can be characterized as highly agrarian only in comparison with Russia and Ukraine (as well as the FSU average). Turkmenistan's share of arable land in total agricultural land is very small compared with the other Central Asian countries, but all its arable land is irrigated (so is the arable land in Uzbekistan – another desert country in Central Asia). Turkmenistan's population is the smallest but fastest growing in Central Asia. With population growth accelerating from the long-term rate of 3% to 4% annually since 1990, Turkmenistan overtook Kyrgyzstan in 2000 and will very soon catch up with Tajikistan.

Agriculture in Turkmenistan is totally dependent on irrigation. Even sheep grazing in the desert need watered pastures to survive. Cotton, Turkmenistan's traditional cash crop, is known to be very thirsty, while wheat, which has been gaining rapidly in importance since the early 1990s, also relies on irrigation despite some relief from winter rainfall.

Turkmenistan's water problem is essentially caused by a combination of three factors: the country's rapidly growing population necessitates commensurate agricultural growth to produce enough food and fiber; agricultural production can only increase if the irrigated area is increased; and to complete the vicious circle, the growing irrigation demands place an increasing strain on Turkmenistan's intrinsically limited water resources.

The main source of water for Turkmenistan is the Amudarya River, which rises in the snow-covered mountains of Tajikistan, enters the country at the southeast corner along the Afghan–Uzbek border, and flows along the entire length of the northeastern border with Uzbekistan on its way to the rapidly dying Aral Sea. Most of the Amudarya water is withdrawn by Turkmenistan and Uzbekistan along this section of their common border. Amudarya is an international water resource and its use is controlled by multilateral agreements, which allocate to Turkmenistan 22 billion cubic meters, or 36% of Amudarya flow per year (**Table 2**).[2]

**Table 2. Internationally agreed allocation of water from Amudarya to Central Asian countries**

| | Maximum water intake, million cu.m | Percent of total flow |
|---|---|---|
| Kyrgyzstan | 400 | 0.6 |
| Tajikistan | 9,500 | 15.4 |
| Turkmenistan | 22,000 | 35.8 |
| Uzbekistan | 29,600 | 48.2 |
| Total Amudarya flow | 61,500 | 100.0 |

Source: National Plan of the President for Conservation of the Environment, Ashgabat (2002), p. 22.

Water intake from Amudarya is supplemented with surface runoff from three other rivers – Murgan, Tedjen, and Atrek, as well as minor quantities from small rivers and springs. Groundwater plays a marginal role in Turkmenistan's water resources. The total groundwater reserves reach 3.4 cu.km, of which only 1.3 cu.km is usable (actual groundwater use today is at a level of 0.4-0.5 cu.km). The structure of the typically available water resources is shown in **Figure 1**, where Amudarya figures prominently as the dominant source, accounting for 84% of total water in Turkmenistan.

[2] The 1992 Five-Country Agreement, as supplemented by an agreement between Uzbekistan and Turkmenistan signed in January 1996. In a meeting in Bukhara in November 2004, the presidents of Uzbekistan and Turkmenistan reiterated the importance of observing mutual understanding in all questions of water allocation from Amudarya.

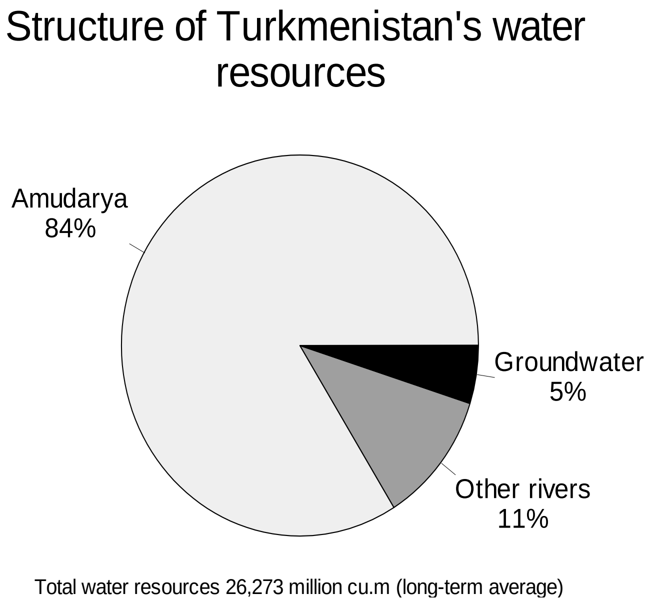


**Figure 1.**

## Irrigation

The critical importance of irrigation for agriculture in Turkmenistan, and especially for cotton growing, was realized soon after the annexation to the Russian Empire in 1884-85. Suggestions to divert the Amudarya water into east-west or north-south canals were formulated already in the early twentieth century. Massive investment in irrigation began during the first decade of the Soviet regime, and the irrigated area increased by 78,000 hectares, or 30%, between 1925-1928. As a result, the sown areas grew from 254,600 hectares in 1925 to 332,200 hectares in 1928.

Expansion of irrigation networks continued all through the 1930s and was resumed after World War II with the launch of the Karakum Canal project in 1954. The construction of the 840-km main section from Amudarya in the east to Gok-Tepe just west of Ashgabat was completed in 1967, but work continued all through the 1970s and well into the 1980s, extending the canal west toward the Caspian Sea. Today it is the longest canal in the world, stretching over 1,400 km of desert along the southern border with Afghanistan and Iran. The Karakum Canal increased the irrigated area around it from 141,500 hectares in 1954 to 530,000 hectares 30 years later. Since the 1970s irrigation from the canal has accounted for about 50% of total irrigated area in Turkmenistan (the other 50% receives water through a system of smaller provincial-level canals). In addition it allowed to water 5 million hectares of desert pasture. The Karakum Canal is known colloquially in Turkmenistan as the “river of life” because of its role in reclaiming desert for agriculture and providing livelihoods to hundreds of thousands of rural people. Yet benefits for some people have brought adversity to others: the diversion of water from Amudarya into the Karakum Canal and for other irrigation uses along the river’s course has contributed to the Aral Sea disaster, affecting adversely large parts of the population in Uzbekistan and Kazakhstan.

Irrigation covers practically the entire cultivable land in Turkmenistan. However, because of the huge expanses of desert pastures, a mere 5% of agricultural land is irrigated. Between 1965 and 1994 irrigated land grew at a fairly constant annual rate of about 4%. The total irrigated area more than tripled in 30 years, increasing from 0.5 million hectares in 1965 to 1.7 million hectares in 1994. Irrigated land continued to grow after 1994, but at a much reduced rate of about 0.5% annually. By 2004 the irrigated area had exceeded 2 million hectares. **Figure 2** (drawn on a logarithmic scale, so that slopes reflect growth rates) illustrates the dramatic slowdown of irrigation growth after 1994.

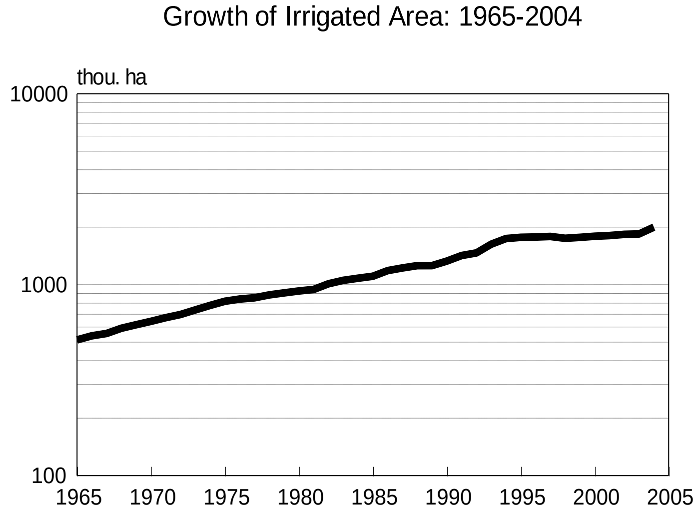


**Figure 2.**

Despite the relatively slow growth in the last decade, Turkmenistan added 99,000 hectares of irrigated land between 1994 and 2003, a cumulative increase of 6% in 10 years (**Table 3.5**). The latest data for 2004 show an abrupt jump in irrigated area from 1.8 million hectares to 2.2 million hectares – an increase of 23% in one year. We have to await further confirmation of this figure and additional data for later years before concluding that Turkmenistan has resumed a trajectory of rapid irrigation growth.

**Table 3. Irrigated land and rural population 1965-2003**

| Year | Total irrigated land, '000 ha | Population, '000 | Rural population, '000 | Irrigated land per rural person, ha/person |
|---|---|---|---|---|
| 1965 | 514 | 1917 | 993 | 0.52 |
| 1970 | 643 | 2222 | 1126 | 0.57 |
| 1975 | 819 | 2555 | 1326 | 0.62 |
| 1980 | 927 | 2896 | 1512 | 0.61 |
| 1985 | 1107 | 3270 | 1718 | 0.64 |
| 1990 | 1329 | 3714 | 2027 | 0.66 |
| 1995 | 1771 | 4587 | 2526 | 0.70 |
| 2000 | 1793 | 5369 | 2906 | 0.62 |
| 2001 | 1808 | 5640 | 3047 | 0.59 |
| 2002 | 1834 | 5937 | 3191 | 0.57 |
| 2003 | 1843 | 6299 | 3357 | 0.55 |

Source: Turkmen National Institute of Statistics.

While the expansion of irrigated area slowed down markedly after 1994, the rural population grew at a fairly constant average rate of 3% during the entire period 1965-2003 (slightly accelerating to 3.5% per annum during the last decade 1995-2003). The per capita endowment of irrigated land accordingly increased from 0.5 hectares to 0.7 hectares during the three decades of rapid growth of irrigation networks (1965-1995), and then dropped back to 0.5 ha per rural person by 2004, when irrigation growth had slowed down.

Overall, both the population and the total irrigated area roughly tripled between 1970 and 2003. The explains the constancy of irrigated land per capita at the two end points of the entire period, despite some variation during the intervening years.

## Water use

Turkmenistan's long-term average water intake includes 26 billion cu.m of surface runoff (most of its from Amudarya) plus 0.5 billion cu.m from underground sources. Water intake from Amudarya and other rivers nearly doubled since 1970, but at the same time the loss rate increased alarmingly from 20% of intake in the 1970s and the 1980s to more than 30% since 2000 (**Table 4**). Because of mounting losses in the system, effective water use in 2004 was only 90% higher than in 1970, although gross water intake more than doubled during the period. This is an indication of growing inefficiency in water management, which reflects inadequacy of water conveyance facilities and severe deterioration of physical infrastructure. The distribution of water to various uses (including system losses) is shown in **Figure 3**.

**Table 4. Water intake and water use 1970-2004**

| | Water intake, mln $m^3$ | Water use by all users, mln $m^3$ | Agricultural users, % | Water use per ha irrigated land, thou. $m^3$ | Losses, % of intake* |
|---|---|---|---|---|---|
| 1970 | 12,738 | 10,276 | 98.2 | 15.1 | 19.3 |
| 1975 | 18,497 | 15,717 | 92.0 | 16.9 | 21.8 |
| 1980 | 20,990 | 17,536 | 94.5 | 17.6 | 21.0 |
| 1985 | 24,380 | 21,316 | 89.8 | 17.0 | 12.6 |
| 1990 | 22,435 | 19,800 | 87.7 | 14.0 | 22.6 |
| 1995 | 27,608 | 20,695 | 91.3 | 10.9 | 25.0 |
| 2000 | 24,917 | 17,430 | 89.7 | 8.7 | 30.0 |
| 2001 | 24,223 | 15,834 | 89.2 | 7.7 | 34.6 |
| 2002 | 27,153 | 19,128 | 89.9 | 9.4 | 29.6 |
| 2003 | 26,673 | 19,638 | 89.6 | 9.5 | 26.4 |
| 2004 | 27,958 | 19,251 | 88.8 | 7.6 | 31.1 |

*Calculated as the percentage difference between water use and water intake.

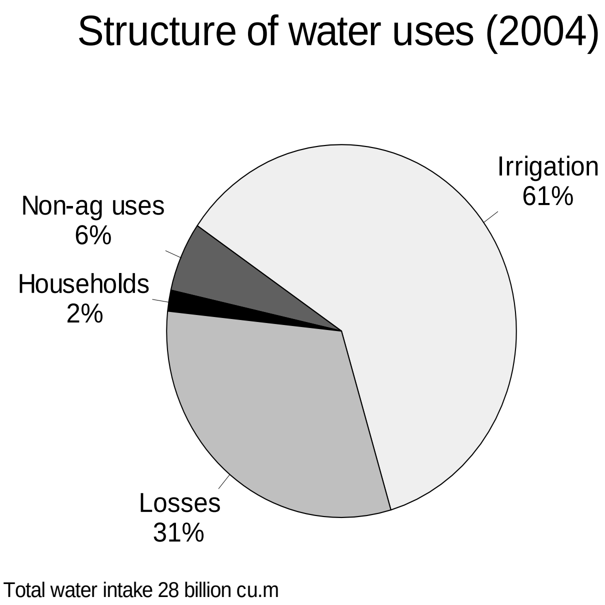


**Figure 3.**

Agriculture accounts for 90% of effective water use**.** Water reaches the end user through a complex system of primary canals, which draw water from the rivers, secondary canals, which distribute water to large farming units across the country, and tertiary canals, which distribute water to farmers within the large units. In the end, the fields are furrow-irrigated with water from tertiary canals delivered through fairly primitive ditches. The entire system is open-air and the canals are generally unlined. Evaporation and filtration are the main sources of conveyance losses in the system.

Water is exclusively owned by the state, which is entrusted with ensuring delivery and maintaining water quality. There are no volume charges for water ("water is free" according to the Water Code), and farmers are only required to pay 3% of their gross product to state-controlled irrigation agencies as a contribution to general maintenance and technical upkeep of water delivery systems. The government absorbs the cost of water as part of its policy of controlling both input and product prices in the general framework of state orders. This procedure is not particularly conducive to curtailing wasteful use of water.

Turkmenistan irrigates 2 million hectares of land for agriculture, up from 0.6 million hectares in 1970 (see **Table 3**). The growth of irrigated area far outstripped the growth of gross water intake, and certainly the growth of water reaching the users net of system losses. While the irrigated agricultural area more than trebled between 1970 and 2004, water available to agricultural users increased only by 70% (the calculations are based on the water use numbers in **Table 4**). Water use for agricultural needs per hectare of irrigated land accordingly dropped by one half from 15,000 cu.m to 7,500 cu.m between 1970 and 2004 (see **Table 4**).

### Collector-drainage network

Under conditions of continuous massive irrigation as in Turkmenistan, considerable importance is attached to collectors and other drainage facilities intended for the removal of excess water from the soil. Without proper drainage, soil may become waterlogged due to rising water table and its salinity may increase to levels detrimental to crop growing. Expansion of irrigated areas naturally requires expansion of the collector-drainage network.

Unfortunately, the growth of drainage networks in Turkmenistan has not caught up with irrigation growth (**Table 5**). The area under irrigation increased by 26% just between 2000 and 2004, while the collector-drainage network added only 7% of canals to its total span in this period. The network density correspondingly decreased by 15%, dropping from 19 meters per hectare to 16 meters per hectare. These densities should be compared to the norm of 45 meters per hectare recommended by soil-melioration engineers. Network "sufficiency" today is less than 40% of this norm.

**Table 5. Inadequacy of the collector-drainage network**

| | 2000 | 2004 | Change 2004/2000 |
|---|---|---|---|
| Irrigated area, '000 ha | 1794 | 2260 | +26% |
| Network length, km | 34,444 | 36,981 | +7% |
| "Sufficiency"* | 43% | 37% | |

*Percent of the engineering norm (45 m/ha).

The inadequacy of the collector-drainage network is reflected in severe deterioration of soil quality. In 14% of irrigated land the water table has risen above the critical level, and 1,650 hectares, or fully 73% of irrigated land, are salinized (Table 6).

**Table 6. Deterioration of soil quality in irrigated areas (2004)**

| | Hectares | Percent of irrigated area |
|---|---|---|
| Water table above critical level | 315 | 14% |
| Unsatisfactory drainage | 539 | 24% |
| Salinized soil | 1,650 | 73% |
| Of which: | | |
| High salinity | 225 | 10% |
| Medium salinity | 976 | 43% |

**Box 1. Turkmen Lake, or *The Lake of the Golden Age***

The Turkmen Lake is a radically novel approach to disposal of drainage water from irrigation. Following a decision adopted in August 2000 by the President of Turkmenistan, the country is constructing a huge artificial lake in the middle of the Karakum Desert, on the site of a natural dry lake in the Karashor Lowlands. The lake is on the border between Akhal and Dashoguz velayats, some 350 km north of the capital Ashgabat. The lake will be filled with drainage water through two new collectors, the Great Turkmen Collector from the south and the Dashoguz Collector from the north, with combined length of over 1,000 km. Starting in 2009, the collectors will divert to the lake annually up to 10 cubic kilometers of saline drainage water , which is currently discharged into Amudarya. The lake's capacity will be 150 cu.km, with a surface area of 3,500 sq.km and depth of 130 m.

It is argued by local water experts that the lake will reclaim 450,000 ha of waterlogged land, dramatically reduce the salinization of Amudarya, and provide a huge reservoir of water that will be recycled for irrigation after partial desalination treatment. The exact nature of desalination is not clear at this stage, but Turkmen scientists are apparently working on bio-plateau techniques and harnessing of solar energy for desalination. If successful, these techniques will produce huge amounts of new water for irrigation and make it possible to double the irrigated area from its current 2 million hectares to 4-5 hectares. Cotton and wheat production will increase at least by 30%, and the brackish lake will create new opportunities for the development of fisheries. There is a general optimistic vision of a "huge oasis" that will arise in the desert around the lake and along the new waterways.

Western experts working on the Aral Sea tragedy are less optimistic. They claim that the lake water will simply disappear through evaporation under the fierce desert sun, leaving salt sediments that will poison the entire area. The use of recycled lake water will only increase salinization of agricultural soils, as experience of other countries with the use of brackish water for irrigation has proved. These experts fear that, by virtue of its sheer size, the lake may be a source of considerable environmental damage to the entire region.

As always, the truth is probably somewhere in between the enthusiasts and the pessimists. The learned debates will continue, but the lake is rapidly moving toward its scheduled completion. The new collectors will start filling the lake in 2009, if not earlier.

## Adjustment of crop mix

The water problem in Turkmenistan is not new. It has been known for years. World experience suggests changing the crop mix, i.e., shifting to commodities that consume less water, as one of the standard responses to water scarcity. Cotton is a particularly "thirsty crop", and it requires intensive irrigation all through the summer months, when rainfall does not provide an alternative. It is well known, for example, that Israel, having achieved one of the highest yields of raw cotton in the world, was forced to abandon its cotton sector due to water shortages. We are witnessing de facto a similar response in Turkmenistan, and although it is probably not driven by considerations of water economy, the end result is a definite saving in water consumption without reduction of gross output.

During the Soviet era, Turkmenistan was characterized as a cotton monoculture, holding the second place in cotton production among the six cotton republics of the former USSR. Cotton accounted for more than 50% of the sown area all through the 1980s. Another 30% was under feed crops (mainly grasses), which played a very important role in crop rotation keeping the soil healthy for cotton. Grain (mainly wheat) was grown on a mere 15% of the cropped area. This cropping pattern remained largely static during the last centrally planned decade of the 1980s . The situation began to change rapidly after 1990, when the government decided to emphasize wheat production, ostensibly in the interest of food self-sufficiency. The area under wheat was increased from 15% in 1990 to 50% in 1998 and the early 2000s (**Figure 4**). The increase in wheat areas came at the expense of some reduction in cotton cropping (which dropped from 50% in 1990 to 40% around 2000), but mainly due to a sharp contraction of areas cropped to grasses (which dropped dramatically from 27% in 1990 to a mere 3% around 2000). After 2002 national statistics register a sharp unexplained increase in areas under grasses and other feed crops, which this time came at the expense of cotton-cropped areas: grain areas remained unchanged at around 50% of sown land.

Structure of sown area 1980-2005

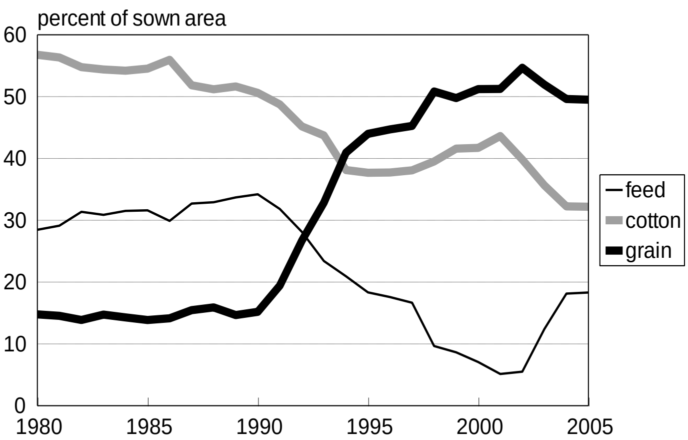


**Figure 4.**

Although grain overtook cotton by cropped area back in 1994, Turkmenistan did not go from "cotton monoculture" to "grain monoculture". Crop production today is diversified between two main crops – grain is the new leader with 55% of cropped area and cotton trails second with 40%. This change in product mix was primarily achieved by sharp reduction of grasses in Turkmenistan's cropping pattern, but it was also supported in part by the steady expansion of irrigated area over time. Due to the expansion of irrigation, the actual area under cotton declined only temporarily in 1990-1997: today it is at around 650,000 hectares, close to the cotton area in 1990 (620,000 hectares) and substantially larger than in 1980 (500,000 hectares). The declining share of cotton in cropped area is not the result of a physical decrease in cotton cropping: it is a reflection of the much faster growth of areas cropped to grain, which increased from 130,000 hectares in 1980 to 190,000 hectares in 1990 and then skyrocketed to nearly 1 million hectares in 2002-2005 – a five-fold increase in 15 years (**Table 7**).

Wheat uses 40% less water per hectare than cotton. According to 2004 data, wheat consumed 3,940 cu.m of water per hectare, compared with 7,040 cu.m per hectare for cotton. The shift from cotton monoculture to diversified wheat–cotton agriculture may have contributed to the stabilization of water use (and water intake) during the last decade despite the continued increase of irrigated areas (see **Table 4** for water data; **Table 3** for irrigated land). The national program that produced such a dramatic change in Turkmenistan's crop mix in less than 10 years may have inadvertently served as an important water-saving measure (in relative units, if not in absolute amounts). Overall, the change of the crop mix with its unintended beneficial impact on water economy did not adversely affect agricultural production: gross agricultural output (in constant prices) increased by nearly 50% between 1998 and 2002 (the latest year for which data are available), after recovering from the steep transition-induced decline that had begun in 1990-91. The value effect of the shift to lower-priced wheat apparently was more than offset by the steep increase in quantities.

**Table 7. Sown areas 1980-2002 (thousand hectares)**

| Year | Cotton | Grain | Potatoes, vegetables, melons | Feed crops (incl. grasses) | Total cropped |
|---|---|---|---|---|---|
| 1980 | 508 | 132 | 40 | 213 | 896 |
| 1985 | 560 | 143 | 48 | 272 | 1,028 |
| 1990 | 623 | 187 | 81 | 338 | 1,231 |
| 1995 | 563 | 657 | 47 | 220 | 1,494 |
| 1996 | 530 | 628 | 44 | 194 | 1,405 |
| 1997 | 482 | 573 | 35 | 168 | 1,266 |
| 1998 | 548 | 705 | 32 | 94 | 1,387 |
| 1999 | 621 | 743 | 30 | 79 | 1,493 |
| 2000 | 619 | 760 | 25 | 63 | 1,484 |
| 2001 | 779 | 915 | 25 | 48 | 1,786 |
| 2002 | 701 | 962 | 25 | 57 | 1,759 |
| 2003 | 627 | 914 | 23 | 179 | 1,759 |
| 2004 | 618 | 950 | 49 | 306 | 1,915 |
| 2005 | 645 | 991 | 43 | 321 | 2,002 |

Source: Turkmen National Institute of Statistics.

## Irrigation levels and crop yields

We have demonstrated the sharp decline in availability of irrigation water per hectare (**Table 4**) and the deterioration of soil quality due to inadequate drainage (**Tables 5 and 6**). Agronomists and irrigation engineers in Turkmenistan claim that cotton and wheat actually receive less than 65% of the optimal amount of water required for normal production: cotton receives about 7,000 cu.m per hectare compared with the agronomic norm of 11,000 cu.m, and wheat receives 4,000 cu.m compared with the agronomic norm of 6,400 cu.m.[3] Common wisdom suggests that these factors should have adversely affected crop yields per hectare. Yet it is very difficult to say if the reduction of irrigation volumes has depressed the yields of the main irrigated crop – cotton. **Figure 5** plots the quantity of water per irrigated hectare (smooth gray curve) and the cotton yield per hectare over time. The black triangles are the actually reported yields of raw cotton (in ton per hectare) and the two straight segments through the observations are a switching regression fitted to the cotton yields with 1995 as the switch point. Irrigation levels began their decline in 1985, while cotton yields remained constant for ten more years and then collapsed abruptly after 1995 (dropping on average by around 100 kg/ha each year over 10 years). Given this pattern of behavior, it is impossible to establish a statistical relationship between irrigation and cotton yields without additional information on weather, fertilizer consumption, pesticide application, etc.

The situation is made even more puzzling by the pattern of wheat yields. These fluctuate quite wildly, but analysis reveals a statistically significant upward trend (**Figure 6**). A simple

[3] Irrigation norms from *Polivnye rezhimy sel'skokhozyaistvennykh kul'tur po Turkmenskoi SSR*, MinAg of Turkmen SSR, Ashkhabat (1985).

regression model shows that wheat yields increased on average by 85 kg per hectare each year. In this way they rose over 35 years from 500 kg/ha in 1970 to 3,270 kg/ha in 2005 despite the reduction of watering levels. It may be argued that wheat is less dependent on irrigation than cotton, because it requires water in the winter, when the usual 150 mm of rainfall may add 1,500 cu.m of water per hectare. However, the whole question of the dependence of yields on irrigation (and other inputs) requires further detailed study, especially because of the conflicting behavior of wheat and cotton.

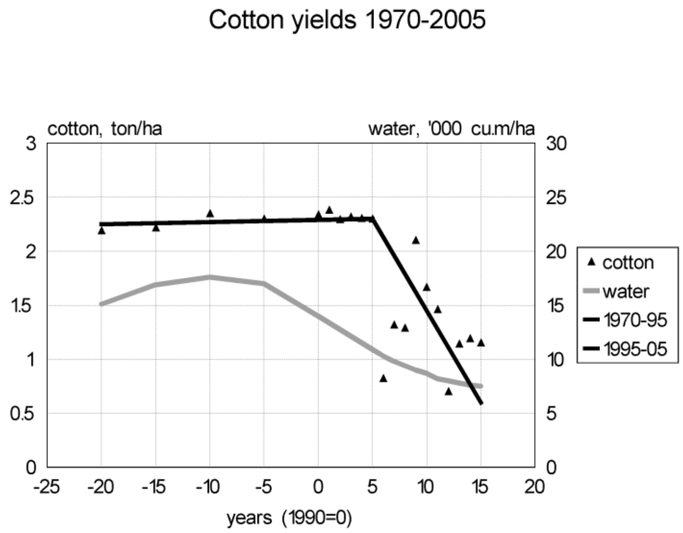


**Figure 5.**

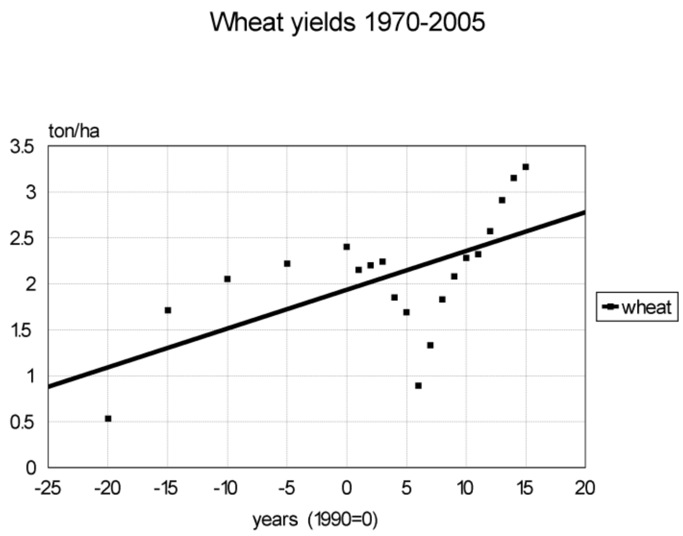


**Figure 6.**

Turkmenistan's cotton yields are not only decreasing over time, but they are also very low compared to other cotton-producing countries (**Table 8**). The yields of cotton lint achieved by Middle East countries, Egypt, and Mexico are around 3 times higher than the yields in Turkmenistan; the yields in the United States and Uzbekistan are double the Turkmen yields; and only South Asian countries (India, Afghanistan, Bangladesh, Pakistan) and Azerbaijan report yields equivalent to those of Turkmenistan. The situation is different with wheat yields, however: Turkmenistan's current yields approach 3 tons per hectare, which is close to U.S. yields and higher than the yields in Canada and the rest of CIS. Only the East European countries and the EU-15 (especially the United Kingdom) achieve yields that are substantially higher than 3 tons per hectare (**Table 8**).

**Table 8. Cotton and wheat yields: comparison of Turkmenistan with selected countries**

| Cotton producing countries | Cotton (lint yields on a relative scale) | Wheat producing countries | Wheat, ton/ha (2000-2005 averages) |
|---|---|---|---|
| Middle East | 3.2 | EU-15 | 5.81 |
| Mexico | 2.9 | Eastern Europe | 3.45 |
| Egypt | 2.6 | USA | 2.77 |
| USA | 2.1 | **Turkmenistan** | **2.75** |
| Uzbekistan | 2.0 | Developed Africa | 2.45 |
| Tajikistan | 1.4 | Canada | 2.28 |
| South Asia | 1.1 | CIS | 1.87 |
| Azerbaijan | 1.0 | Sub-Saharan Africa | 1.62 |
| **Turkmenistan** | **1.0** | | |

Source: Cotton lint yields from *Cotton: World Statistics*, Bulletin of the International Cotton Advisory Committee (September 2002); wheat yields from FAOSTAT.

## Conclusions

Turkmenistan is actively seeking ways to alleviate its water problem. Since nothing can be done about natural population increase and about the absolute limit on water intake from Amudarya, the focus of attention is on adoption of water-efficient irrigation technologies, such as drop irrigation, subsoil irrigation, sprinkling, and others. It is hoped that water-efficient irrigation technologies will reduce water consumption per hectare for a given level of yields and thus enable Turkmenistan to irrigate a much larger area with its limited water resources. According to some estimates, the irrigated area will double from 2 million hectares to 4-5 million hectares, increasing agricultural production by at least 30%. The adoption of water-efficient technologies will produce an additional benefit of slowing down soil salinization.

The options for drip irrigation in Turkmenistan are being explored in a number of ongoing pilot projects. Israeli drip-irrigation technology has been installed on an area of 600 hectares near Ashgabat. The cost of this particular project is US$2,250 per hectare. Since drip irrigation is expected to reduce water consumption per hectare by 30% to 50%, a careful economic and environmental-impact analysis is required to compare the outlay with the benefits of higher yields per unit of water and lower salinization. It should be borne in mind, however, that drip irrigation is not a panacea: while appropriate for cotton, which grows in orderly rows, it cannot be used on wheat fields, which have no row structure. Drip-irrigation hardware is highly sensitive to the quality of water: the silted water from unlined open-air canals and ditches will quickly clog the drip-irrigation lines, and even frequent maintenance and replacement of filters – in itself an expensive proposition – will not entirely solve this difficulty.

In its attempts to break through the water-quantity barrier Turkmenistan is thinking of irrigation with brackish or partially saline water. World experience clearly shows that this is an environmentally bad solution, as under conditions of massive irrigation even low-salinity water gradually deposits a huge mass of salt in the soil, leading to dramatic reduction of yields. Turkmenistan should explore more closely the options for deep desalination of its drainage water, taking advantage of the abundance of solar energy in the desert.

Without abandoning its experiments with novel technological solutions, Turkmenistan should perhaps pay more attention to conventional water-conservation methods. These include reduction of losses by lining the canals with seepage-blocking materials and using pipes instead of furrow irrigation. They also include better control of salinization and waterlogging by proper maintenance and construction of adequate collector-drainage networks. The efficiency of water use at the farm level can be increased dramatically by the simple expedient of installing water meters and holding farmers accountable for excessive withdrawal of water from the system. Finally, Turkmenistan should review its policy of non-payment for water and seriously consider the option of introducing water charges at the farm level. This is known to be an important psychological instrument for minimizing wasteful use of resources.

All these measures – whether high-tech or conventional – need money for implementation. Turkmenistan should seriously consider the options for increasing the budgetary allocations to water system maintenance and upgrading from its large cotton exports and natural gas revenues. The pattern of GDP growth in recent years shows that Turkmenistan can afford larger investments in its water system, and thus do justice to the popular saying that "a drop of water is a grain of gold."

**Note on data sources**

All the data in this article are based on official sources from the Turkmen National Institute of Statistics. Other sources of data are explicitly listed where appropriate.

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