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Cotton in Uzbekistan: Water and Welfare

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Cotton has been a major crop in Uzbekistan at least from the time of the Russian empire. However, its rise to become the dominant product of Uzbek agriculture and a major factor in global cotton production occurred during the Soviet period. This rise was made possible by two main factors, the expansion of the volume of land under irrigation and Soviet central planning. Irrigation allowed increased crop production. Central planning both mandated that the crop be cotton and that it be traded within the Soviet structure in exchange for water, energy, and food as part of an integrated national system.

Since the disintegration of the Soviet Union and independence of Uzbekistan in 1991, the politics of Uzbek cotton have simultaneously seen both inertia and change. On one hand, the government has continued to maintain significant aspects of the former central planning system, for example mandating that local farmers must plant cotton, and centralized control of output and input prices at well below market rates. On the other hand, it has allowed a shift towards increased farmer control of many aspects of both land and water management. At the same time, the government and farmers have had to face the breakdown of the Soviet state. This has meant that trade can no longer rely on central direction and internal co-operation but rather must be based on market mechanisms or negotiated agreements between sovereign states.

Concurrent with the recent political and economic shifts, environmental problems, often directly related to the rise of cotton production, have increasingly impinged on Uzbek agriculture in general and cotton production in particular. The most notable of these problems is the now famous shrinking of the Aral Sea. However, less well publicized salinization and waterlogging of farm lands, both related to irrigation operations, may in many ways be of even greater significance, at least in terms of agriculture.

The net impact of these and other factors has been a significant decline in Uzbek cotton production in the post-Soviet era. The specific goal of this paper is to provide an examination of each of these factors in the evolution of the Uzbek cotton economy and on the broader economic and physical environment of the region. The broader goal of the paper is to highlight the complex interactions between agricultural policy and resource use systems, particularly water, in Central Asia and beyond.

Background

Uzbekistan is the most populous country in Central Asia and has the largest agricultural sector. Within Uzbekistan, agriculture is the largest sector of the economy, accounting for more than 30 per cent of GDP, 40 per cent of employment and 60 per cent of foreign exchange earnings.[1] Of Uzbekistan's 45 million ha, about 60 per cent is used for agricultural purposes and of that 4.3 million ha or 12 per cent percent is irrigated.[2] While the area of irrigated land appears relatively small within the context of overall land utilization, irrigation in fact accounts for almost 80 per cent of all water use in the country.[3] Irrigated lands account for the vast majority of all cotton, as well as wheat, production.

Cotton was, until recently, the dominant crop in the Uzbek agricultural economy. The territory of modern Uzbekistan was already considered an important cotton growing region even in Russian imperial times. This role was substantially enhanced during the Soviet period, especially after 1950, when it was decided that Uzbekistan would form the centre of the nation's cotton production. Starting in the 1950s, seed cotton production grew from 300,000 tons to a peak of three million tons by the mid-1980s.[4] This increase was made possible by two factors. First, irrigation was expanded. Second, Soviet planners mandated that these newly irrigated and other lands be used to grow cotton on the large scale state and co-operative farms that dominated the agricultural economy. Cotton production was supported with supplies of critical inputs including tractors, combines, gins and, perhaps most notably, water. This water, primarily from the Amu Darya and Syr Darya, the two main tributaries of the Aral Sea, largely emanated from neighbouring republics.

Importantly, cotton production in the Uzbek republic took place as part of a centrally co-ordinated and planned national system. The irrigation water needed to support cotton production was supplied through the construction of facilities to first store waters of the Amu Darya, Syr Darya and their tributaries and then released at suitable times in the cropping year, particularly the summer. The storage facilities were primary built in upstream soviet republics and could alternatively have been used by them to produce power for heating in the winter months. In compensation for water releases favouring cotton, Uzbekistan, Russia and other republics provided alternative fuel to their upstream neighbours. Similarly, Uzbekistan's cotton was sent out of the Republic in a centrally co-ordinated exchange for food stuffs and other products.

Uzbekistan and the other Soviet republics of Central Asia gained independence with the collapse of the Soviet Union in 1991. This massive change and the events preceding it had wide ranging implications for the politics and economy of Uzbekistan as well as for the region as a whole. For Uzbek cotton production in particular, the net result was a decline in both production and exports of some 50 per cent (see Figure 1) due both to a reduction in cultivated land and declining yields.[5]

Why Has Uzbek Cotton Production Declined?

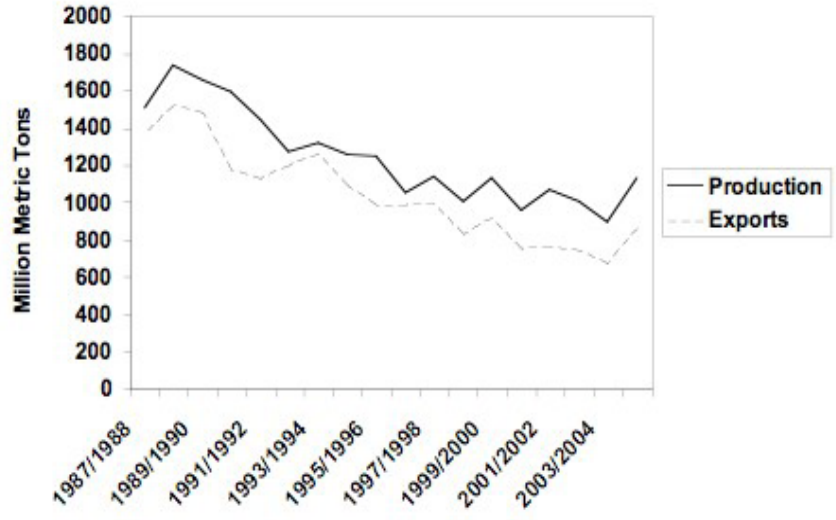
The reasons for the drop in Uzbek cotton production and exports are complex, and sometimes offsetting, but can be divided into two broad but interrelated categories. The first is political and includes direct cotton policy as well as other policies indirectly affecting the sector. The second is environmental and includes both the "natural" environment as well as the ability of farmers to adapt to that environment. Both categories are interrelated.

Policy Factors in the Decline of Uzbek Cotton

Immediate Response to the Soviet Collapse

As in most other former Soviet republics, the collapse of the Soviet Union brought massive disruption to the economy and hardship to the people of Uzbekistan. In rural areas, the centralized command system broke down and millions lost their livelihoods as the social infrastructure, previously supported by collective farms collapsed. The first serious post-Soviet policy change in the agricultural sector occurred in response to this crisis and took the form of the expansion of individual family plots. The objective of the policy was to ease social tension by ensuring that the population would be able to produce basic foodstuffs. Starting in 1986, over 1.5 million families were given the opportunity to extend their personal plots and some 0.5 million additional families acquired plots for the first time.

Figure 1. **Uzbek Cotton: Production and Exports**



Source:

In 1991 additional plots were allotted to families living in rural areas to provide fodder for cattle. During this short period of time, over 0.5 million hectares of irrigated land, more than 10 per cent of the total irrigated area, was allocated for small scale production, mainly vegetable growing. These plots had previously been used primarily to produce cotton and were in fact in some of Uzbekistan's most productive cotton lands with relatively unpolluted soil and low salinity.[6]

New Considerations for National Food Security

The second major change made to Uzbek agricultural policy after the end of the Soviet Union was driven by a desire to reconsider national food security and achieve grain (wheat) independence. During the Soviet Period, around three to four million tons of wheat were imported into the Uzbek Soviet Socialist Republic, primarily from other Soviet States, in exchange for cotton and as part of a national, centrally controlled system. After the collapse of the Soviet Union, wheat imports had to be paid for not with cotton, the demand for which had fallen within the system due in large part to the ensuing economic disruption, but with cash. Paying for these imports was a major burden for the newly independent government. Furthermore, importing large amounts of grain now had implications for national food security. In response, the Uzbek government mandated a shift in production away from cotton and towards wheat. The result was an expansion of the winter wheat area from 620,000 ha in 1991 to 1.2 million ha in 2004. As much of the areas newly sown had been amongst the best quality cotton fields, the result was a reduction in the cotton area of 30–35 per cent for at least one season per year (see Figure 2). Wheat production did increase substantially, from one million tons in 1991 to 5.2 million tons in 2004, and Uzbekistan has now become a wheat supplier with exports of some 500,000 tons annually over the last three years.[7]

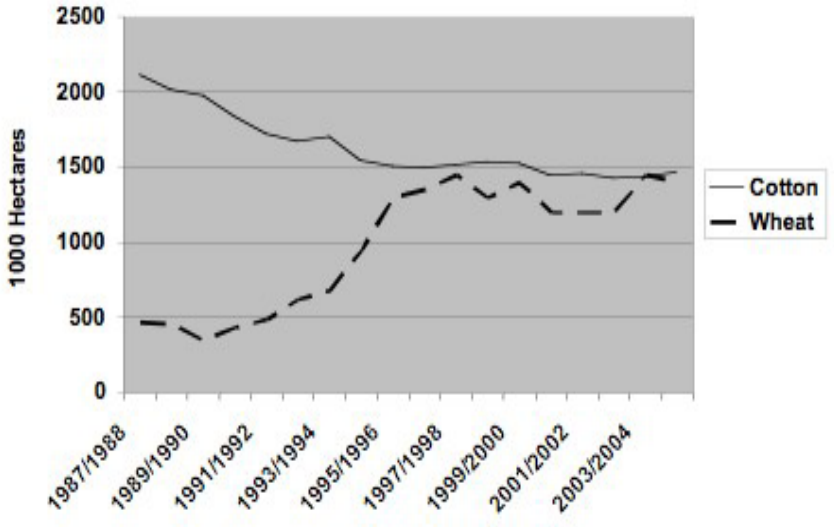
The Production Quota System

During the Soviet period, central planners could influence the cropped area and production through their control of state farms as well as farm inputs. After independence, the new government still sought to maintain control of at least certain aspects of farm output, for example in influencing the shift to wheat production just described. Control in the post-Soviet era has involved quotas on output and area, a state purchase system and price, quantity of production, controls on farm inputs. In 1991, 100 percent of all agricultural products were required to be sold to the state, except crops grown in the backyard plots of families. After 1995, state quotas were removed for all agricultural products, except cotton and wheat.[8] In the wheat production system quotas are somehow more flexible, allowing farmers either to sell 50 per cent of the quota in the open market or keep it for their own consumption.

For cotton, the most malign part of the quota system is not the amount of the production to be sold to the state (100 per cent), but the quota on the area which must be sown with cotton. Even if farmers fulfil their cotton production quota, they can still be penalized if the area they planted with cotton is less than the requirement. In effect, this gives farmers little incentive to increase land productivity (yields) so long as their overall output is sufficient to meet the production quota. There is a general belief that this system is a significant factor in the overall stagnation in cotton yields, especially when compared to wheat (see Figure 3). This belief is at least partially supported by evidence from 1992 to 1995 when cotton production was partially liberalized and only 50 per cent fell under the quota system. While not dramatic, yields did reverse their slow decline, rising from 0.76 t/ha in 1992 to 0.83 t/ha in 1995. This period also saw a partial liberalization of input markets which have otherwise largely been monopolized by the state.

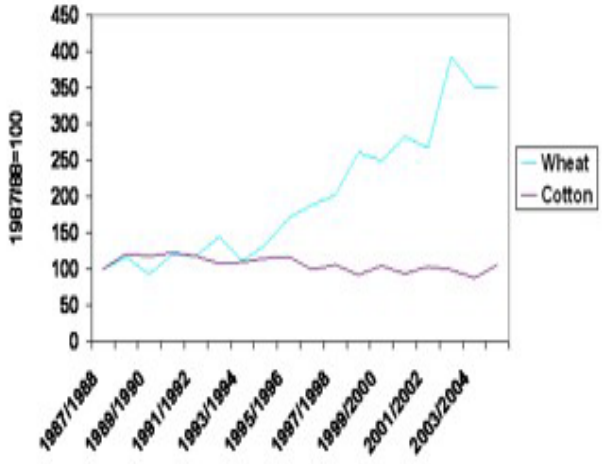
Also impacting output, the forced procurement by the state takes place at relatively steady state set prices. The difference between the international, export and internal (procurement price from farmers) prices can be substantial, for example, in 1995 the internal procurement price for cotton was some US$900 per ton, with state exchange rate (state exchange rates were 250 per cent lower then

Figure 2. **Cropped Area: Cotton and Wheat**



Source:

Figure 3. **Yield of Wheat and Cotton in Uzbekistan**



Source: FAS

black market rates) or almost 50 per cent lower than the external price (see Figure 4). Internal and external prices became almost equal as world prices declined until 2001, but the gap has now again risen to the levels of the mid-1990s.

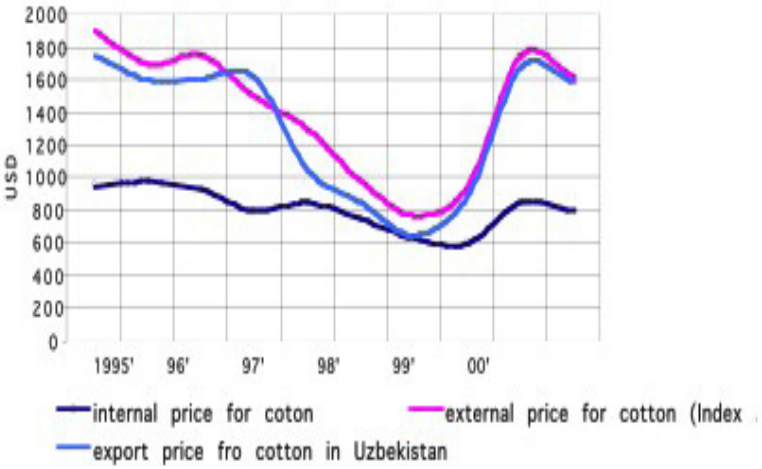
Somewhat offsetting the effective tax on cotton output has been the subsidization of inputs. Most farm inputs are in fact controlled by state monopoly at a net subsidy. A major part of the subsidy comes in the form of bank credits which are supplied at negative real interest rates. To gain access to these funds, farmers must produce cotton and wheat under the quota system.

The paradox of the quota and procurement system is that, on the one hand, it forces cotton production through quotas while on the other it gives a disincentive to produce via its procurement pricing. An added irony of central Asian agricultural policy comes out when Uzbekistan is compared to neighbouring Tajikistan. In Uzbekistan farmers are forced to grow cotton through a quota system, because the overall policy environment discourages production. In Tajikistan farmers are given a limit on their cotton area, so that a sufficient amount of land is reserved for wheat.

Farm Restructuring

The final major policy factor impacting cotton in the post-Soviet period has been the restructuring of farms, which started in 1992 and accelerated after 1996. This change, and its place within the overall economic system, also has implications for the way Uzbek agriculture interacts with the environment as

Figure 4. **Internal and External Prices from Cotton in Uzbekistan (US$/ton)**



Source: Cotton Outlook 2000

will be explained later. During the Soviet period cotton was produced in large scale collective farms, typically of sizes of 2,000–3,000 ha. The farms managed all aspects of the production system including mechanization (e.g. tractors and combines) and irrigation. Because the farms were believed inefficient, their land was split after independence into smaller, though still collective, farm units known a "shirkats." However, no reform of the other systemic assets such as irrigation was undertaken. The result was that the land management units no longer matched the input units, and poor performance was ensured. Therefore co-operative farms remained low performing: cotton yields were lower then in the 1980s and the overall economic performance of such farms was weak.

At the beginning of the reforms, in 1992, individual farming systems were emerging at the same time as co-operative farms and were looked upon by the Uzbek government as experimental farming. The individual farms initially were allotted lands with low fertility and poor water supply.

Until the year 2000 the major focus of government policies was the improvement of incentive systems and the partial allocation of management decisions on production to family units within "*shirkat*" farms. These attempts led to a small increase in agricultural productivity; however, it was difficult to develop both truly co-operative management and stimulate individual initiatives. It was partially due to the fact that "*shirkat*" farms were created on the basis of old collective farms with a centralized top-down approach.

Beginning in 2003, the government of Uzbekistan began to transform the

shirkats into individual farms. According to the new policy, priority is given to the development of the individual farms as the major producer of agricultural commodities. According to the new concept, from 2004–2006 a total of 1,020 "*shirkat*" farms (55 per cent of their total number) will be transformed into individual farms. Individual farms in 2004 already occupied 47.7 per cent of irrigated lands, employed 765,300 workers and provided 20.4 per cent of the agricultural economy, including 51.5 per cent of cotton production and 46.2 per cent of grain production (see Table 1). The character of agricultural reforms in Uzbekistan for the past 10–12 years can be characterized as a slow transformation of the collective farming system into individual farming units. After 10 years of gradual decline in cotton yields, figures recovered back to 2.6 t/ha levels by 2004, indicating the positive response to the agricultural transition (see Figure 1).

Table 1. **Allocation of Cultivated Area and Agricultural GDP by Different Types of Agricultural Enterprises (in %)**

Types of farms	Share in agricultural area		Share in agricultural GDP	
	1995	2004	1995	2004
Collective Farms	15.0	0	12.0	0
Shirkats (co-operative)	75.0	72.6	48.1	14.6
Individual farms	3.8	16.7	2.6	10.5
Dehkan farms	6.2	10.6	33.3	74.9

Source: State Department for Statistics of Uzbekistan, 2004

Dehkan farms are legalized family plots, orchards from which most of Uzbekistan's population earns its income. The state encourages family plots to be registered as legal entities so that they can acquire credits or other financial supports (e.g. leasing). *Dehkan* farms can grow all types of crops, except cotton. All crops grown by *dehkan* farms are not bound by quotas allowing them to sell their products in the open market. The majority of products (fruits and vegetables) grown by *dehkan* farms are exported to Russia and Kazakhstan.

Other important aspects of farm reform include land rights and the tenancy system. Along with farm restructuring have come legal changes on land use and allocation. In July 1998 a new land code was introduced which strengthened land usage rights and gave greater security of tenure to individual farmers. At present individual farms have 49 years tenancy rights. However, according to the land regulations, land rights can be revoked for farmers who do not fulfil production agreements three years in a row. This uncertainty makes strategic investment in

land conservation as well as water management risky, thereby reducing resource productivity.

Environmental Factors in the Decline of Uzbek Cotton Production

The dramatic decline of the Aral Sea is one of the most globally known environmental disasters in the world. The decline was and is a direct consequence of agricultural, especially cotton, expansion in Central Asia in general and Uzbekistan in particular. However, while cotton may have adversely impacted the Aral Sea, the connection between the degradation of the Aral Sea and cotton production is less clear. What is more important is how the water of the Aral Sea's tributaries, as well as the land of the Aral Sea basin, have been and will be managed.

Water Availability and the Aral Sea

The plight of the Aral Sea is often highlighted as a case study in the impact of water scarcity. Thus it might seem reasonable to conclude that this increasing water scarcity has played a role in the decline of Uzbek cotton and will continue to do so in the future, in particular since the Aral Sea's two main tributaries flow through Uzbekistan and are the key suppliers of water to the countries irrigated cotton. However, this is not the case.

The expansion of irrigation, primarily for cotton production, was in fact the primary cause for the Aral Sea's decline. This decline did not come as a surprise to Soviet planners, contrary to popular belief in the West. While the overall impact of the Aral Sea's drying may not have been fully appreciated, the impact of increased irrigation from the Aral Sea's main tributaries, the Syr Darya and Amu Darya, on the sea's overall volume was expected.[9]

There is enough water in the Aral Sea's tributaries to keep the current irrigation systems functioning indefinitely. In fact, a major problem in the Syr Darya is that there is too much water in the upper part of the system, at least at certain times of the year because of the current timing of releases from upstream. This volume of water is too great to make it through the river channel in the area of Chardara water reservoir and so is instead backing into a large inland lake rather than entering the Aral Sea. In the Amu Darya basin, Turkmenistan is creating an artificial lake with 130 cubic km of volume, which must be filled with drainage water. However, the concern is that the existence of such a lake will not help water conservation in the region.

In fact, the major problems of water as related to cotton production in Uzbekistan are related to its poor management and the resulting impact on land resources as described in the next section.

However, while there is no evidence water scarcity has been a significant factor in cotton production to date. During the shortage of water (1985–86, 1999–2001) the production of the cotton failed in tail ends of the irrigation systems.

Contrary, in the wet years land conditions in the saline and waterlogged areas declined and cotton production decreased. Water shortages could be a problem in the future, though this is not likely because of a lack of absolute volume. Since the break-up of the Soviet Union, the waters of the Amu and Syr Darya have been internationalized. The system which had been set up to trade water for cotton and power disintegrated. Attempts have been made to re-formalize these agreements for the post-Soviet age through a series of agreements and treaties. However, there has been increasing dispute, and it is as yet unclear what the final outcome will be.

Salinity and Water Logging

Conditions for cotton production in Uzbekistan have deteriorated significantly, resulting in significant areas of irrigated land being affected by high levels of salinity and rising water tables and leading to crop yield losses exceeding 30 per cent. In Uzbekistan 63.5 per cent of the irrigated land is affected by salinization. Declining agronomic productivity associated with salinization and elevated water tables has contributed to the development of endemic poverty and reduced incomes in the rural communities of the region. The major reasons for land degradation, especially salinity, are outdated drainage systems, which were built during the 1970s and were not properly maintained in the last 10–15 years, over-irrigation and inappropriate agronomic practices.

The dominant approach adopted by irrigation farmers to mitigate salinity in the region is to apply excessive amounts of water to salt affected fields in order to leach salts below the effective root zone. It has been estimated that between 20 and 25 per cent of the annual available surface water in the region is used for leaching which could otherwise be delivered to the Aral Sea to lessen its degradation.[10] The application of excess surface waters to fields has resulted in the development of elevated water tables that effectively exacerbates the problem by encouraging further salinization. When soils become highly saline farmers tend to abandon affected fields resulting in large tracks of saline/waterlogged soils.

It is estimated that annually between two and three per cent of the irrigated area of the Hungry steppe (Mirzachul) – one of the largest irrigated regions of Uzbekistan – is taken out of crop production due to salinization. The rehabilitation of these salinized areas requires significant technical expertise and financial investment. A recent assessment of the costs associated with the rehabilitation of salinized soils in the Hungary Steppes was in excess of US$1.2 billion.[11] Whilst these costs include the development of significant irrigation and drainage infrastructure in the reclamation process, there are cost effective strategies that can potentially be used in the rehabilitation process that involve plant based production systems.

The use of plants in the remediation of saline soils is an emerging low cost

approach in the recovery of abandoned irrigated fields.[12] In this respect the creation of highly productive fodder systems through the establishment of palatable halophytes in saline areas has been shown to remediate saline soils as well as provide an income to resource poor farmers.

In a 2000-2004 study in the highly saline lands of the Syrdarya province of Uzbekistan the potential use of *Licorice naked* to reclaim abandoned saline areas was assessed over a four year period before the land was reverted back to a cotton / wheat crop rotation. After four years of Licorice growing cotton yields in the highly saline areas recovered from initial 0.87 t/ha to 2.42 t/ha and salt content of the soil in the *L. naked* treated plot declined during the study whilst those in the control increased. The study has clearly demonstrated the ameliorating affect of *L. naked* in bringing abandoned salt affected soils back into production to be a low cost method which can be adopted by resource poor farmers.[13]

Water Availability and Reliability

Institutional Deficits in Water Management

There were two institutional deficits, which caused the decline in cotton production: (i) inadequate water management institutions to the restructured agricultural system and (ii) outdated water allocation mechanisms, the absence of a water rights system and ineffective water distribution methods.

Agricultural restructuring in Uzbekistan, following the collapse of the former Soviet Union, has led to a multiple increase in the number of individual farm units along secondary and tertiary canals.

In the 1960s the soviet government started its "virgin land development" programme, which included the construction of the water reservoirs, a net of new irrigation systems and the development of millions of hectares of desert and virgin lands. In the old irrigation systems, such as the Fergana Valley, a few new main canals were constructed to improve water availability for irrigated agriculture. The performance indicator of irrigated agriculture was deemed to be the amount of cotton produced and the effective utilization of resources was never an issue. The water management infrastructure was taken care of by centralized, hierarchical organizations, branches of the Ministry of Agriculture and Water Management. The management of water was territorially organized and only in a few cases were inter-district (hydrographic) canal management organizations were created.[14] The sole goal of centralized, hierarchical and territorially based water management systems was timely delivery to meet the demands of cotton growing mega farms. However, due to its territorial character water management organizations were always failing to fulfil their main objective – equitable water distribution. Such ineffective water management led to the frequent conflicts over irrigation water. However, the soviet system had its tools and approaches in place, which included repressive measures for preventing conflicts over wa-

ter between territories, including then Soviet republics, nowadays independent Central Asian states.

After independence, almost all states of the region conserved water management systems as they were in soviet times. The only changes were of an economic character, putting part of the operation and maintenance (O&M) cost to the water users' shoulder, through creation of water users associations and charging for water delivery. The major change to the agricultural sector was the dismantling of large collective farms into small farms, through land distribution.[15] The formation of numerous smaller farm units, sharing formerly on-farm structures led to the further deterioration of fair and efficient water distribution.[16] The reaction of the Central Asian states, including Uzbekistan, was the launching of Water Users Associations (WUAs) to replace the former on-farm systems. However, the main irrigation systems in Uzbekistan were still managed territorially.

In 2003 Uzbekistan launched a major step in its water-sector reforms, introducing the basin water management principle.[17] On 21 July 2003, the Cabinet of Ministers of the Republic of Uzbekistan issued a decree (No. 320) with far-reaching consequences for the management of the water sector in the country. The purpose of the decree was to initiate a process for the transfer of the administrative-territorial system of water management to a basin system of water management. This is the first step in the reform of the redundant institutions of water management. This reform has already brought changes in water management, O&M funding, water distribution equity between major canals and water users representation in water management has improved.[18] However, there is one other major problem with existing water management system in Uzbekistan – the absence of the water rights system.

During the collective farming system water distribution was scheduled according to "agro-technical operations plans." Since the mid-1960s water distribution in Central Asia was demand-based. In the mid-1980s, the "restricted water demand principle" ("*limitirovannoye vodopol'zovazniye*" in Russian) was introduced, requiring proportionate adjustments to initially expressed water demands subject to lower water availability in the system. All these above-listed water distribution mechanisms lacked clear water-rights systems. The allocation of the water was based on administrative, short term decisions, making water distribution unreliable. It seems clear that changing bits and pieces of the old, outdated and rigid water allocation system is an impossible task. Water rights based on seasonal planning (crop based) cannot be efficient in a system where only a few people know what are the actual water requirements for each crop. On the other hand, it is almost unimaginable that all farmers can be educated on crop water requirements. The water rights must be simple, clear and user accepted, but not imposed by "water bosses." At present Uzbek water law does not recognize the clear definition of water rights. The solution to this situation is to introduce wa-

ter rights (proportional, area-based, etc.) for the water users groups (WUGs) or WUAs. Interviews with water users, managers and local authorities indicate that allocation of water in Uzbekistan is outdated, fitting only to the collective farming systems. Crop based planning is unimaginable, especially for multi-cropped, fragmented land use under individual farming systems. However, legal changes, through introduction of water rights alone will not bring improvements to the water management. Therefore, realization of the water rights system is the most important approach for improving water management. The core of this approach is the mobilization of water users (WUGs or WUAs) around this idea. This will be a panacea against the undefined, top-down water allocation, which exists in the irrigation water management system of Uzbekistan.

The water management framework for improving cotton production (and other agricultural crops) must be complete and universal for all hierarchical levels of water management (WUA, main canal, irrigation basins). This framework should include: (i) helping water users organize into self-identified groups (e.g. informal WUGs or formal WUAs, WUFs) by canal sections, formally or informally; (ii) wherever such groups are already established then the basic principles of individual or group water entitlements (rights) must be decided or adopted; (iii) water management organizations then should carry out water allocation and planning against such entitlements; and (iv) both WUAs and water management organizations should decide on the ways which water can be distributed among the WUGs; (v) these steps must then be complemented by a monitoring and evaluation function, to make sure the whole system works as required.

Outdated Technical Infrastructure

The irrigation and drainage (I&D) system of Uzbekistan is most complicated and interlinked. There are the following structures of irrigation infrastructure in Uzbekistan: (i) main canals, which are major artificial water arteries and deliver water to the irrigated areas; (ii) secondary or formerly inter-farm canals, which distribute water among co-operative farms and WUAs; (iii) tertiary and lower level canals, which deliver water to the faming (individual) units or sections of co-operative farms.

The main canals ("*magistralniy*" in Russian) in Uzbekistan are mostly lined or very well equipped against seepage losses (tampered). Most of the main canals start from water reservoirs or from dams in the river. Every major water distribution point of a major canal is equipped with water regulation gates (manual or electrical). The volumes of water released from these points are measured regularly. If canals receive water through pumps then the reliability of the water supply fully depends on the availability of electricity. Communication between main canal reaches ("*gidrouchastka*" in Russian) is made by radio transmitter. However, the communication systems between canal reaches are outdated and

inefficient. Therefore the canal masters (heads of "*gidrouchastka*") in every reach have relative independence to make water distribution decisions. Therefore fluctuations due to simultaneous changes made in the different reaches of the main canal result in unreliable and unequal water distribution. Most of the main canals of Uzbekistan were built or reconstructed in the mid-1970s. Therefore most of the canal infrastructure (gates, bridges, and pumps) is outdated and requires upgrading. Lining materials (concrete) are ageing and need to be replaced. The same situation is present in the large and intensive drainage network, which is the only means of production for the saline areas. According to World Bank assessments, around US$2 billion are needed for the rehabilitation of I&D in Uzbekistan.[19] Outdated I&D infrastructure has a serious impact on cotton production. According to Umarov[20] and Khorst[21] the maximum cotton yields are achieved in the irrigated areas with properly maintained irrigation and drainage infrastructures. The lowest cotton production was monitored in the Syr Darya provinces (<2.0 t/ha), where I&D infrastructure mostly deteriorated.[22]

Institutional deficits, such as inadequate water management arrangements to the restructured agricultural system, outdated water allocation mechanisms due to the absence of water rights system lead to ineffective water distribution for cotton production. Together with outdated I&D infrastructure they are one of the major causes of cotton production decline in Uzbekistan. The importance of water as a cause of cotton production decline is equivalent to policy (agricultural) causes, discussed in the first section.

Discussion and Conclusion

Since independence in 1991, cotton production in Uzbekistan has declined by approximately one third. This decline is primarily a result of a reduction in the area devoted to cotton and, secondarily, of a minor decrease in yields. The decline in cotton cultivation and the current area planted to cotton are first and foremost results of explicit government policy. After independence, the government allowed some cotton areas to be transferred to the private cultivation of non-cotton crops and encouraged a shift to wheat production to cope with economic and political disruption and to meet new desires for national food security. The lesser cotton area which resulted has then been maintained by a coercive quota system for both planting and procurement. Should the quota system be removed with no other change in policy, it is fairly clear that cotton cultivation would decline further. However, it must also be remembered that output and input prices as well as credit are now controlled by the government. At current world price levels, a general freeing of the cotton sector would raise the prices farmers receive for their crops but would also raise the costs of production inputs. Predicting the net effect on both cotton output and farmer well-being, at least in the short term, is less than straightforward.

The minor decline in cotton yields is partially related to the decline in the volume of land used for cultivation. For example, farmers have been able to transfer some of the most productive cotton lands to the production of other crops including wheat and vegetables. However, other factors have also been at work. Environmental problems have certainly contributed to difficulty in maintaining, or increasing, cotton productivity. The shift from large collective farms towards family organization has resulted in a vacuum of responsibility and organization for the operation and maintenance of some irrigation and drainage systems. The impact, exacerbating problems emerging by the end of the Soviet period, has been land degradation primarily in the form of water logging and salinity.

However, the true driving force in cotton productivity improvement, or lack thereof, becomes evident when comparisons are made with Uzbekistan's other major crop, wheat. Typically grown in the same irrigated fields as cotton, wheat yields have more than tripled since independence. The comparison between cotton and wheat is perhaps especially surprising given the increasing levels of salinization and cotton's relative salt tolerance. This evidence strongly suggests that it is not the natural environment which has held down cotton productivity but rather it is the policy environment which is the culprit. In particular, the stagnation in yield appears to be largely a response to a government quota system for cotton which gives little, if any, incentive to increase productivity beyond the levels required to meet production quotas.

Global concern for the environment of Central Asia, including Uzbekistan, is focused not on land but rather water resources, in particular the environmental and human disaster taking place in the Aral Sea. There is no doubt that this disaster was precipitated by the development of irrigation, primarily to produce cotton. However, using the Aral Sea crisis as an example of the problems of growing water scarcity, both in Uzbekistan and globally, is incorrect as is the assumption that the dwindling water resources within the Sea are a sign that future Uzbek agricultural production is under threat. The decline in the Aral Sea is not due to a reduction in basin water supplies, but rather a decision to use those supplies for agriculture.

A recent report by Chapagain et al.[23] indicates that each year Uzbekistan exports essentially the entire runoff of the Aral Sea basin in the form of the virtual water embedded in the cotton trade. Even if this is an overestimate, the implicit suggestion is that a reduction in cotton exports and the production behind them might free supplies for the Aral Sea. It is much more likely that any water "saved" from reduced cotton production will instead be used to produce other crops as has been the pattern to date. Soviet planners made the initial decision to trade the viability of the Aral Sea for agriculture. There is currently no reason to think that present and future governments will make a different decision.

If water scarcity is to be a factor in Uzbek cotton production, it is likely

to be because of tradeoffs between agriculture (in downstream Uzbekistan) and energy production (in upstream Kyrgyzstan and Tajikistan), not between agriculture and the environment, at least for the foreseeable future. How this will work out in practice will depend on the negotiating skills of the countries involved and their ability to work out solutions which maximize the benefits to all parties. The present regime is forcing some water to be put to entirely unproductive uses because of the timing of flows. Further water is being used unproductively, because of the state of current land and water management institutions which are as yet unable to fully ensure maintenance of irrigation and drainage systems. The question is not cotton per se. It is how to ensure that land and water resources are shared and used most productivity, and that the costs inflicted on the environment have a real payoff.

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Notes

1 Asian Development Bank, 2000.
2 Food and Agriculture Organization (FAO), *Fertilizer use by crop in Uzbekistan. The Land and Plant Nutrition Management Service*, Land and Water Development Division, 2003..
3 Freshwater, 2004
4 *Uzbekistan Review*, 1990
5 S. Djalalov, "Tendencies in Uzbekistan Farm Production," *Review of Centre for Effective Economical Policy*, Tashkent, 2001; FAS.
6 Personal communication with Dr.Tahir Madjidov, Chairman of NGO Suvchi, former staff of Ministry of Agriculture and Water Resources Management, 2004.
7 FAOSTAT data, 2005, http://faostat.fao.org/faostat
8 Khan, 1996.
9 Mirazev,1970.
10 WEMP, 2003.
11 World Bank, *Assessment of Irrigation and Drainage Infrastructure in Uzbekistan* (Russian), Report, 108 pp., 2003.
12 M. Qadir, R.H. Qureshi, and N. Ahmad, "Amelioration of calcareous saline-sodic soils through phytoremediation and chemical strategies," *Soil Use and Management*, No. 18, 2002, pp. 381–85; S. Muhammed, A. Ghafoor, T. Hussain, and A. Rauf, A., "Comparison of biological, physical and chemical methods of reclaiming salt-affected soils with brackish groundwater," in *Proceedings of the 2nd National Congress of Soil Science*, 20–22 December 1988, Soil Science Society of Pakistan, Faisalabad, Pakistan, 1990, pp. 35–42; M. Qadir, A. D. Noble, J. D. Oster, S. Schubert and A. Ghafoor, A., "Driving forces for sodium removal during phytoremediation of calcareous sodic soils," *Soil Use and Management*, No. 21, 2005, pp. 173–80; M. P. Jukova and A. N. Abaldov, Selection work with sorghum crops in the Stavrapol selection center (Sugar, wheat, sorghum)// Sorghum and corn. No. 5, 2004, pp. 14–17; E. I. Pankova, J. W. Kouzmina and S. Y. Treshkin, "The Influence of flooding area on soil-vegetation cover of the South Gobi oasis," *Water resources*, Moscow, Vol. 21, No. 3, 1994; E. I. Pankova, J. W. Kouzmina and S. Y. Treshkin, "The state of tugai vegetation in South Mongolian oasis and perspective their restoration," *Arid ecosystems*, Moscow, Vol. 2 No. 2–3, 1996; V. P. Tokhtarov, "Sorghum: predecessor,

fertilizing, soil treatment," *Sorghum and corn,* Vol. 5, code P1768, 2004, pp. 22–24.

13 H. Kushiev, A. Noble, I. Abdullaev and U. Toshbekov, "Remediation of abandoned saline soils using *Licorice naked*: A study from the Hungry Steppes of Central Asia," Submitted to *Agricultural Research*.

14 Irrigation of Uzbekistan, Volume-3, 1970

15 Abdullaev Iskandar, Mehmood Ul Hassan, Herath Manthrithilake and Murat Yakubov, "Making Water Distribution More Transparent: Application of the Time-Based Water Distribution Method to Tertiary Canals in Central Asia," IWMI. Draft of Research Report, 2005.

16 (Abdullaev, forthcoming).

17 Cabinet Ministries Resolution, 2003.

18 Abdullaev et.al. 2005; personal communication with Mr.Poziljon Rasulov, Deputy Head of Fergana Water Management Unit, Uzbekistan, 2004.

19 World Bank, 2003, op.cit.

20 Umarov, 2002.

21 Khorst, 2003.

22 MAWR Uzbekistan, 2004.

23 A. K. Chapagain, A.Y. Hoekstra, H.H.G. Savenije, R. Gautam. "The Water Footprint of Cotton Consumption," Value of Water Research Report Series No. 18. UNESCO-IHE, Delft, 2005.