Cotton in Uzbekistan: Water and Welfare

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Abstract

Uzbekistan has the largest agricultural sector of the 5 Central Asian countries of the former Soviet Union, and agriculture is the largest sector of the Uzbek economy, accounting for some 30% of GDP, 40% of employment and 60 % of foreign exchange earnings. Within Uzbek agriculture, cotton has been the key crop, and Uzbek cotton holds a major position in global cotton production and trade. The rise to dominance of cotton production in the area of modern Uzbekistan was a function both of irrigation development and the mandates of central planning during the Soviet period. Since the fall of the Soviet Union in 1991, the role of cotton in Uzbekistan has also declined sharply. The first goal of this paper is to provide a basic overview of the factors behind this decline. These include the immediate response to the Soviet Union's dissolution, new views on national food security, changing institutional arrangements for land and water management, and, interrelated, declining environmental conditions. The change in cotton output has implications not only for the Uzbek economy and global cotton trade, but also for water use and the environment in the now internationally shared and globally sensitive Aral Sea basin. Thus the second goal of the paper is to examine the linkages between cotton production and water use in Uzbekistan, and how water will affect cotton, and vice versa, in the future.

Key words: Uzbekistan, Central Asia, cotton, irrigation, water management, Aral Sea, land degradation

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2. Introduction

Cotton has been a major crop in Uzbekistan at least from the time of the Russian empire. However, its rise to true dominance of Uzbek agriculture and as a major factor in global cotton production occurred during the Soviet period. This rise was made possible by two main factors, the expansion of irrigated area and Soviet central planning. Irrigation allowed increased crop production. Central planning both mandated that the production be cotton and that it would 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 the area farmers must plant to cotton and controlling output and input prices at well below market levels. 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 dictate and internal cooperation 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 de-watering 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.

3. Background

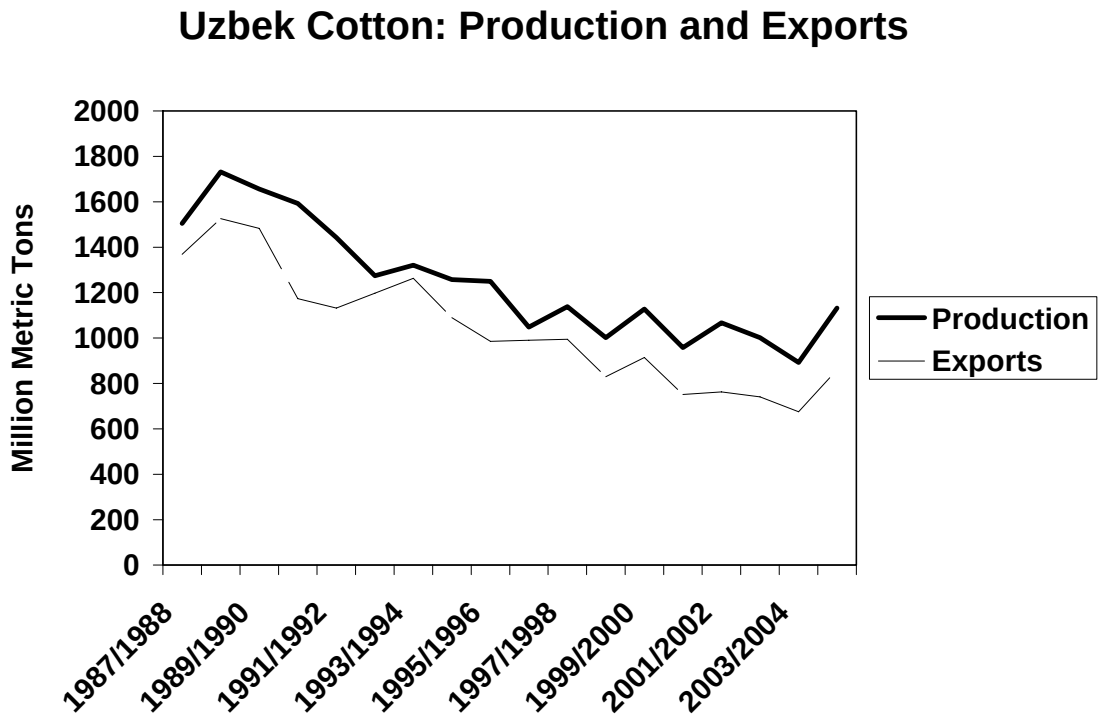
Uzbekistan is the most populous country in Central Asia and has the largest agricultural sector. Within Uzbekistan, agriculture is the largest sector of the economy, accounting for more than 30% of GDP, 40% of employment and 60% of foreign exchange earnings (ADB 2000). Of Uzbekistan's 45 million hectares, about 60% is used for agricultural purposes and of that 4.3 million ha or 12% percent is irrigated (FAO.2003). While the area of irrigated land appears relatively small within the context of overall land utilization, irrigation in fact accounts for almost 80% of all water use in the country (Freshwater 2004). 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 area 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 center of the nation's cotton production. Starting in the 1950s, seed cotton production grew from 300,000 MT tons to a peak of 3 million MT by the mid 1980's (Uzbekistan Review. 1990). 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 cooperative 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 neighboring republics.

Importantly, cotton production in the Uzbek republic took place as part of a centrally coordinated 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 favoring cotton, Uzbekistan, Russia and other republics provided alternative fuels to the upstream counterparts. Similarly, Uzbekistan's cotton was sent out of the Republic in a centrally coordinated 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 at large. For Uzbek cotton production in particular, the net result was a decline in both production and exports of some 50% (see **Figure 1**) due both to a reduction in sown area and declining yields (Djalalov, 2001; **FAS**).

Figure 1



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3. 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 categories 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.

3.1 Policy factors in the decline of Uzbek cotton

3.1.1 Immediate response to 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 to the agricultural sector

occurred in response to this crisis and occurred in the form of 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 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. In 1991 additional plots were allotted to families living in rural areas to provide forage for cattle. During this short period of time, over 0.5 million hectares of irrigated lands, more than 10% of 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 soils with high organic matter and low salinity (personal communication with Dr.Tahir Madjidov[5]), 2004.

3.1.2 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 3-4 million tons of wheat was 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 Soviet Union, wheat import 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 food 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 winter wheat area from 620,000 ha in 1991 to 1,200 000 ha in 2004. As much of the areas newly sown had been amongst the best quality cotton fields, the result was a reduction in cotton area of 30-35% for at least one season per year (**figure 2**). Wheat production did increase substantially, from 1.0 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 3 years (FAO, 2005)

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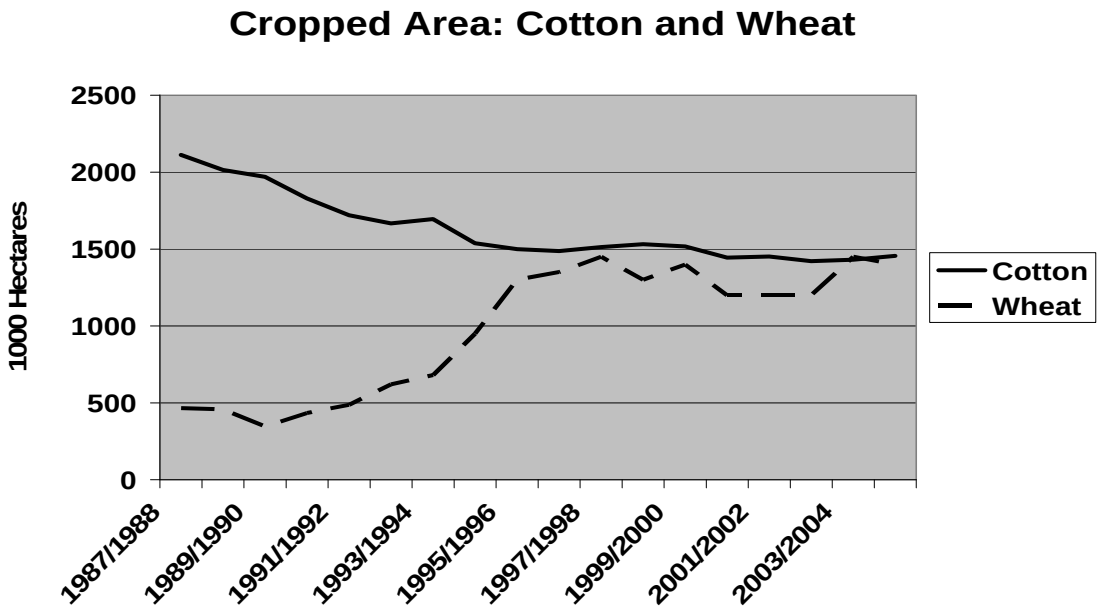
Figure 2



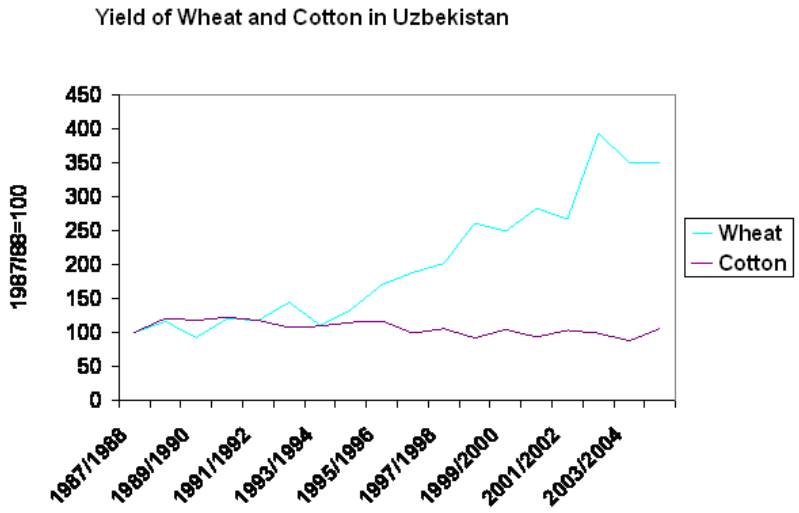
3.1.3 The production quota system

During the Soviet period, central planners could influence 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 (Khan, 1996). In the wheat production system quotas somehow more flexible, allowing farmers to sell 50% of the quota in the open market or keep it with them/

For cotton, the most malign part of the quota system is not amount of the production to be sold to the state (100%), but the quota on the area which must be sown with cotton. Even if farmers fulfill their cotton production quota, they can still be

penalized if the area they planted to 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 (**Figure 3**). This belief is at least partially supported by evidence from 1992 to 1995 when cotton production was partially liberalized and only 50% 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.

Figure 3 (Source: FAS)



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 $900 per ton, with state exchange rate (state exchange rates were 250% lower then black market rates) or almost 50% lower than the external price (**Figure 4**). Internal and external prices became almost equal as world prices declined until 2001, but the gap has now again risen to levels of the mid-1990s.

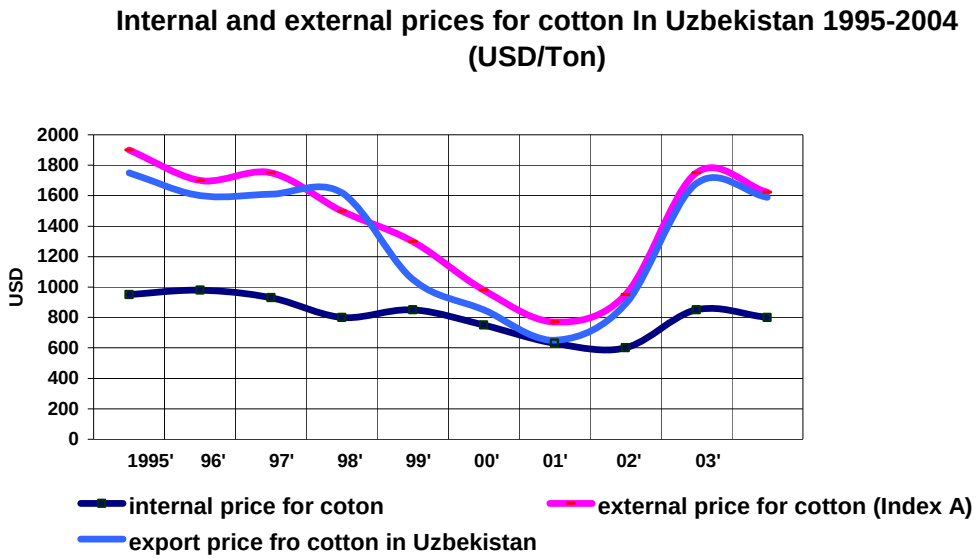


Figure 4. Source: Cotton Outlook 2000

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 credit which is 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 neighboring 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 they do not displace an inordinant amount of wheat area.

3.1.4 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 will be explained later. During the Soviet period cotton was produced in the large scale collective farms, typically of sizes of 2000-3000 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 system assets such as irrigation was undertaken. The result was

that the land management units no longer matched the input units, and poor performance ensured. Therefore cooperative farms remained low performing, cotton yields were lower then in 1980's, overall economic performance of such farms were negative.

At the beginning, in 1992 the individual farming systems were emerging the same time as cooperative farms and were looked by Uzbek government as experimental farming. The individual farms initially were allotted with low fertile lands, with poor water supply.

Until year 2000 the major focus of government policies were improving of incentive systems and partially allocating management decisions on production to the family units within "shirkat' farms. These attempts led to few increase of agricultural productivity, however it was difficult to develop truly corporative management forms and stimulate individual initiatives. It was partially due to the fact that "shirkat" farms were created on the basis of old collective farms with centralized top down approach.

Beginning in 2003, the government of Uzbekistan began to transform the shirkats into individual farms. According to the new policy, the priority is given to the development of the individual farms as the major producer of agricultural commodities. According to the new concept, within 2004-2006 in total 1,020 'shirkat' farms (55% of their total number) planned to be transformed into individual farms. The individual farms already in 2004 occupied 47,7 % of irrigated area, hired 765,300 workers and provided 20,4 % of the agriculture gross product, including 51,5 % of cotton production and 46,2 % of grain production (table 1). The trend of the agricultural reforms in Uzbekistan for past 10-12 years can be characterized as slow transformation of the collective farming system into individual farming units. After the 10 years of gradual decline of cotton yields it recovered back to 2.6 t/ha levels in 2004, indicating the positive response to the agricultural transition (figure 1).

Table1. 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 (cooperative)	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 Statistic of Uzbekistan, 2004

The dehkan farms are legalized family plots, orchards from which most of the Uzbekistan's population is earning its incomes. The state encouraging family plots to be registered as legal entities that they can acquire credits or other financial supports (e.g. leasing). The dehkan farms can grow all types of crops, except

cotton. All the crops grown by dehkan farms are not entitled for the quota, they can sell products in the open market. The largest portion of products, grown by dehkan farms are exported (fruits and vegetables) to the neighbouring Russia and Kazakhstan.

Other important aspects of farm reform are land rights and the tenancy system. Along with the farm restructuring have come legal changes on land use and allocation. In July 1998 a new land code was introduced which strengthened land use rights and give greater security of tenure to individual farmers. At present individual farms have 49 years tenancy rights. However, according to the land regulations, the land rights can be revoked for farmers who do not fulfill production agreements 3 years in a row. This uncertainty makes strategic investment in land conservation as well as water management risky, reducing resource productivity.

4. 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.

4.1 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 off take from the Aral Sea's main tributaries, the Syr Darya and Amu Darya, on the sea's overall volume were expected (Mirazev.1970)

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 artificial lake with 130 cubic km of volume, which must be filled with drainage water. However, the concern is existence of such 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 felt down. The water shortages could be a problem in the future though not likely because of a lack of absolute volume. Since the breakup 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.

4.1 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 leading to crop yield losses exceeding 30%. In Uzbekistan 63.5% of the irrigated land is affected by salinization. Declining agronomic productivity associated with salinization and elevated water tables have contributed to the development of endemic poverty in rural agrarian based communities in the region and reduced incomes. The major reasons of the land degradation, especially salinity is outdated drainage system, which was built during 1970's and were not properly maintained in the last 10-15 years, the irrigation with excessive water supply rates 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 – 25% of the annual available surface water in the region is used for leaching which could otherwise be delivered to the Aral Sea as increased environmental flow (WEMP, 2003). The application of excess surface waters to fields has resulted in the development of elevated water tables that effectively exacerbates the problem through the mobilization of further salt. 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 2-3% 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 USD $ 1.2 billion (World Bank, 2003). Whilst these costs include the development of significant irrigation and drainage infrastructure in the reclamation

process, there are potential cost effective strategies that can be used in the rehabilitation process that involves plant based production systems.

The use of plants in the remediation of saline soils is an emerging low cost approach in the reclamation of abandoned irrigated fields. Qadir *et al*. 2002; Muhammed *et al*., 1990; Qadir et al., 2005; Jukova *et al*., 2004, Pankova *et al*., 1994, Pankova *et al*., 1996, Tokhtarov, 2004). 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 2000-2004, in the highly saline lands of Syrdarya province of Uzbekistan study the potential use of *Licorice naked* to reclaim abandoned saline areas was assessed over a four year period before being reverted back to a cotton / wheat crop rotation. After 4 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 over the study whilst those in the control increased. The study has clearly demonstrated the ameliorating affect of *L. naked* in bring abandoned salt affected soils back into production that is low cost which can be adopted by resource poor farmers (Noble et. al. forthcoming).

4.2 Water availability and reliability

4.2.2. Institutional unconformities of Water Management

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

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

In the 1960's soviet government started its "virgin land development" program, which included also construction of the water reservoirs, net of new irrigation systems and development of millions of hectares desert and virgin lands. In the old irrigation systems, such as Fergana Valley the few new main canals were constructed for improving water availability of irrigated agriculture. The performance indicator of the irrigated agriculture was the amount of cotton produced and resources utilization effectiveness was never an issue. The water management infrastructure was taken care by centralized, hierarchical organizations, branches of ministry of amelioration and water management. The management of water was territorially and only in few cases inter-district (hydrographic) canal management organizations were created (Irrigation of Uzbekistan, Volume-3, 1970). The sole goal of centralized, hierarchical and territorially based water management system was timely delivery of demands of

cotton growing mega farms. However, due to its territorial character water management organizations were always failing to fulfill their main objective- equitable water distribution. Such ineffective water management led to the frequent conflicts over the irrigation water. However, the soviet system had its tools and approaches in place, including repressive measures for preventing conflicts over water between territories, including then soviet republics, nowadays independent Central Asian states.

After independence, almost all states of the region conserved water management systems as it was in the soviet times. Only changes were economical character, putting part of the O&M cost to the water users' shoulder, through creation of water users associations and charging for water delivery. The major change started taking place in the agricultural sector was dismantling of the large collective farms into small farms, through land distribution (Ul Hassan and et. Al.2005). Formation of the numerous smaller farm units, sharing formerly on-farm structure led to the deterioration of the water distribution discipline and equity further (Abdullaev, forthcoming). The reaction of the Central Asian states, including of Uzbekistan was launching of WUAs creation in the former on-farm system. However, the main irrigation systems in Uzbekistan were still managed territorially.

In 2003 Uzbekistan launched major effort on its water sector reforms, introducing basin water management principle (Cabinet Ministries Resolution, 2003). On July 21, 2003, the Cabinet of Ministers of the Republic of Uzbekistan issued a decree (#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 on reforming of the redundant institutions of water management. This reform already brought changes on water management, O&M funding, water distribution equity along major canals and water users representation in water management improved (Abdullaev et.al.2005 and personal communication with Mr.Poziljon Rasulov[6].2004). However, there is one other major problem with existing water management system in Uzbekistan- absence of the water rights system.

During the collective farming system the 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 the initially expressed water demands subject to lower water availability in the system. All these above listed water distribution mechanisms lacked with 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 old, outdated and rigid water allocation system is impossible task. The water rights, based on seasonal planning (crop based) can not be efficient in the system where only few people are know what are the actual

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crop water requirements. In 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 did not recognize the clear definition of water rights. The solution from this situation is to introduce water rights (proportional, area based, etc.) for the water users groups (WUGs) or WUAs. The interviews of water users, managers and local authorities indicates that allocation of water in Uzbekistan is outdated, fitting only to the collective farming systems. The crop based planning 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, actualization of the water rights system is 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 panacea against the undefined, top-down water allocation, which exist in 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/ provided; (iii) the 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 how water can be distributed among the WUGs; (v) these all steps must be then complemented by the monitoring and evaluation function to make sure the whole system works as required.

4.2.3 Outdated technical infrastructure

The irrigation and drainage (I&D) system of Uzbekistan is most complicated and interlinked. There are following structure of irrigation infrastructure in Uzbekistan: (1) main canals, which are major artificial water arteries, delivering water to the irrigated areas; (2) secondary or formerly interfarm canals, which are distributing water among cooperative farms and WUAs; (3) tertiary and lower level canals, which are delivering water to the faming (individual) units or section of cooperative farms.

The main canals ("*magistralniy*" in Russian) in Uzbekistan are mostly are lined or very well equipped against seepage losses (tampered). The most of the main canals are starting from water reservoirs or from dam in the river. Every major water distribution point of the major canal is equipped with water regulation gates (manual or electrical). The volumes of the water released from these points are measured regularly. If canals receiving water through pumps then reliability of the water supply fully depends on availability of the electricity. The communications between main canal reaches ("*gidrouchastka*" in Russian) are excised through radio transmitter.

The communication systems between canal reaches are outdated and inefficient. Therefore the canal masters (head of "*gidrouchastka*") in every reach have relative independency to make water distribution decisions. Therefore fluctuations due to simultaneous changes made in the different reaches of the main canal resulting unreliable and unequal water distribution from main canals in Uzbekistan. Most of the main canals of Uzbekistan were built or reconstructed in mid 1970's. Therefore most of the canal infrastructure (gates, bridges, and pumps) are outdated and requires upgrading. The lining materials (concrete) are ageing and needs to be replaced. The same situation is large and intensive drainage network, which is only means of production for the saline areas. According to the World Bank assessments, around 2 billion dollar needed for rehabilitation of I&D of Uzbekistan (WB, 2003). Outdated I&D infrastructure has serious impact on cotton production. According to Umarov (2002), Khorst (2003) the maximum cotton yields are achieved in the irrigated areas with properly maintained irrigation and drainage infrastructure. The lowest cotton production was monitored in the Syr Darya provinces (<2.0 t/ha), where I&D infrastructure mostly deteriorated (MAWR Uzbekistan, 2004).

The institutional unconformities, such as inadequate water management institutions to the restructured agricultural system, outdated water allocation mechanisms due to the absence of water rights system resulting ineffective water distribution for cotton production. The institutional unconformities of water management and outdated I&D infrastructure are major causes of the cotton production decline in Uzbekistan. The weight of water causes in cotton production decline is the same as policy (agricultural) ones, discussed in section 1.

5. 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 area, and the current area planted to cotton, are first and foremost results of explicit government policy. After independence, the government allowed some cotton area to be transferred to 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 lower 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 area 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 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 wellbeing, at least in the short term, is less than straightforward.

The minor decline in cotton yields is partially related to the decline in area. For example, farmers have been able to transfer some of the most productive cotton

lands to productions 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 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 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 area 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. (2005) indicates that each year Uzbekistan exports essentially the entire runoff of the Aral Sea basin in the form of the virtual water embedded in cotton trade. Even if an overestimate, the implicit suggestion is that reductions 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 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 less productively than possible, 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 used and that the costs inflicted on the environment have a real payoff.

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