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Agricultural Water Use and Trade in Uzbekistan: Situation and Potential Impacts of Market Liberalization

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ABSTRACT *The focus in Uzbekistan on cotton and its irrigation led to large increases in water use with significant downstream impacts, particularly on the Aral Sea. While agriculture is still heavily influenced by the state, Uzbekistan has become more integrated in the global economy since its independence. The major goal of this paper is to examine the interrelationship between agricultural policies and water use during the last 15 years and how moves towards freer markets, such as those which might occur under the World Trade Organization, may impact Uzbekistan's water resources in the future. The results show that partial or full market liberalization may result in an increase in water use. However, the greater message is that non-water policies can have a major impact on water outcomes and therefore should be considered in any discussions of water sector reform.*

Introduction

Agriculture is the backbone of Uzbekistan's economy, contributing almost one-third to the annual GDP. More importantly, agriculture provides the livelihood for most of the 60% of the population who live in rural areas (Djalalov, 2001). Agriculture is also a great consumer of the natural resources, and it accounts for 92% of Uzbekistan's 56 billion cubic metres (BCM) total water use (Dukhovniy *et al.*, 2002), equivalent to 60% of all water use in Central Asia. Since the collapse of the Soviet Union, 80% of Uzbekistan's water supplies have come from neighbouring countries, primarily via the Rivers Amu Darya and Syr Darya (Mirzaev, 1996). Thus, agriculture and agricultural policy in Uzbekistan now have significant international dimensions.

Cotton was the dominant crop within Uzbekistan's agricultural sector during the Soviet period. Although grown for hundreds of years in the region, the more recent expansion of cotton was made possible by two main factors: the extension of the irrigated area and Soviet central planning. Irrigation allowed increased crop production, and central planning imposed cotton as the major crop. In exchange for cotton production, central planning

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provided Uzbekistan with water, energy and food from elsewhere in the integrated national system. The growth of irrigated agriculture, in particular for cotton, has been associated with a range of water related environmental problems, most famously the shrinking of the Aral Sea, but also including less publicized salinity and water-logging of irrigated lands throughout the Sea's two river basins.

Since the disintegration of the Soviet Union and independence of Uzbekistan in 1991, the policies of Uzbek agriculture have simultaneously been subject to both inertia and change. On the one hand, the government has maintained significant aspects of the central planning system. The state still controls the area and quantity of cotton produced, as well as the purchase prices. On the other hand, it has allowed a shift towards increased farmer control of many aspects of production, in particular, those related to land and water management. At the same time, it has been forced to develop new trading relationships with other former Soviet states and the rest of the world, which has led to the mandated expansion of the wheat area to meet local food needs.

The first goal of this paper is to examine the policies that, over the last 15 years, have determined the nature of Uzbekistan's current agricultural economy and hence been a driver of its water use and management. From that understanding, the second goal is to highlight the possible impact of Uzbekistan's moves towards increased integration with the international agricultural trading system, such as membership in WTO, on future water use. An analysis of a range of possible scenarios is done using the WATERSIM model to highlight the connections between non-water policies, such as trade, on global water use.

Recent Agricultural Policies of Uzbekistan

After the collapse of the Soviet Union, the newly emerging states began to change their agricultural policies. In Uzbekistan, changes included: (1) re-distribution of land to families, in order to prevent social unrest; (2) increasing wheat production for food security; (3) implementing a quota system for cotton and wheat; (4) changes in agricultural subsidies; and, (5) disintegration of large collective farms. The following sections of this paper describe in detail these developments in Uzbek agriculture and some of their impacts on water resource use.

Land Re-distribution to Family Plots in Order to Prevent Social Unrest

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 livelihood as the social infrastructure, previously supported by collective farms, collapsed. The first series of post-Soviet policy changes in the agricultural sector occurred in response to this crisis in the form of the expansion of individual family plots. The objective of the policy was to ease social tension, already in evidence before the end of the Soviet Union, 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. In 1991, additional plots were allocated 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 the total irrigated area, was allocated for small-scale production, and mainly used for growing vegetables. These plots previously produced cotton and were, in fact, some of Uzbekistan's most productive cotton lands, with soils of high organic matter and low salinity. The increase of both size and area of the family owned plots had a two-fold impact on water resources: an increase in irrigation water consumption and competition for water between family plots and farmlands (personal communication with Dr Tahir Madjidov 2004).[1] The competition for water between the family plots and farmlands is one of the challenging water problems of irrigated agriculture in Uzbekistan and elsewhere in Central Asia (Abdullaev *et al.*, 2006).

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 the desire to reconsider national food security and achieve grain (wheat) independence. During the Soviet period, approximately 3–4 million tons of wheat was imported into the Uzbek Soviet Socialist Republic annually, primarily from other Soviet States, in exchange for cotton. After the collapse of the Soviet Union, the demand for cotton from traditional barter-based exchange markets (Russia and other FSU states), while still high, declined in favour of cash-based markets elsewhere. Similarly, wheat could no longer be bartered for cotton, but rather had to be paid for in cash. Paying for these imports was a major challenge for the newly independent Uzbekistan and had implications for national food security. In response, the Uzbek government mandated a reduction of cotton production and an increase in that of wheat. Due to an overlap of the growing seasons for wheat and cotton, an increase in the wheat area meant a decrease in the cotton area. The result was an expansion of winter wheat area from 620 000 ha in 1991 to 750 000 ha in 1996 and a similar decline in cotton area (Figure 1). Wheat production increased substantially, from 1.0 million tons in 1991 to 5.2 million tons in 2004, and Uzbekistan has became a wheat exporter of some 500 000 tons annually over the last three years (FAOSTAT, 2005).

The shift towards wheat production appears to have had two impacts on water use in Uzbekistan, one related to the total quantity of irrigation water consumed and the other related to irrigation management. In terms of water use, cotton receives 10 000–12 000 cubic metres/ha, with virtually all water coming from irrigation. On the current

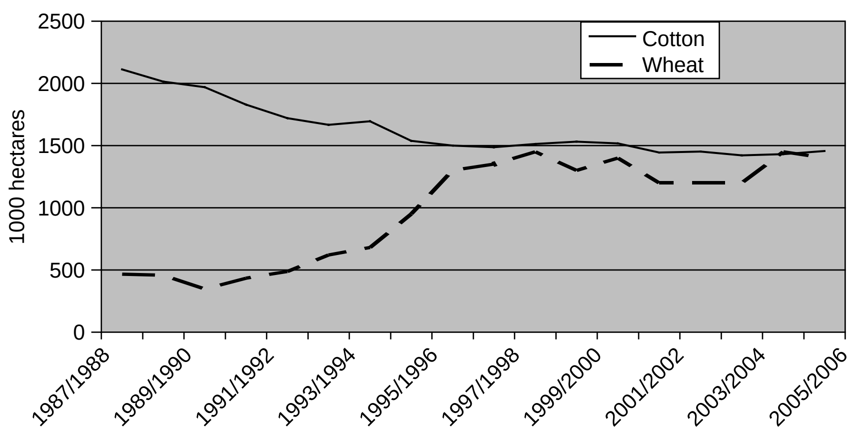

Figure 1. Cotton and wheat area 1987/88–2005/6, Uzbekistan

area of 1.5 million ha, this amounts to 15–18 BCM of water or 27–35% of agricultural water use. Winter wheat is irrigated four to six times during the growing season (October–June) and consumes approximately 8000–9000 m^3 of water per hectare. However, only about 60% of total water consumption is delivered through irrigation, with the rest supplied by rainfall (Atakulov, 2004). With a total area now similar to that of cotton, winter wheat consumes approximately 10 BCM of irrigation water, equal to the 20% of agricultural water use. Thus, the shift from cotton to wheat area has decreased overall irrigation water requirements.

In terms of irrigation management, the large increase in the area under winter wheat has had a negative impact on the state of the irrigation-drainage (I&D) network, and has resulted in higher irrigation water consumption rates than would otherwise have been the case. Earlier, under cotton monoculture, during the non-vegetation period of October–March, there were no crops in the field, and the I&D network was cleaned and prepared for the next season during the fallow fall–winter months. At present winter wheat is grown from the fall (October) to the next vegetation season (June). While the evapotranspiration of wheat during this period is low, it still requires five to six irrigations. Therefore, the I&D network is operating almost 12 months a year, leaving little time for cleaning or minor repairs.

The Production Quota System

During the Soviet period, central planners could influence the cropped area and production by controlling state farms as well as inputs to those farms. After independence, the new government still tried to maintain control of some aspects of farm output, for example, influencing the shift away from cotton and towards wheat production described above. Initially, the Uzbek government had quotas for almost all agricultural products. According to Sirajiddinov & Kasimova (2001), the major objectives of the state quota policy at the beginning of 1990s were to supply essential agricultural products to protect people from food deficits, increase agricultural productivity, increase rural employment, increase agricultural exports and decrease imports.

The cotton and wheat quota. Since 1995, the quota system has been applied only to cotton and wheat (Khan, 1996). Cotton production is controlled through quotas on area and output as well as related controls on output and input prices and marketing. However, the most malignant aspect of the cotton quota system concerns the designation of *particular* areas to be sown with cotton, irrespective of their current appropriateness. As a result, even if farmers fulfil 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 as long as their overall output is sufficient to meet the production quota. The quota system for wheat production is somewhat more flexible than that for cotton. Farmers are allowed to sell 50% of their quota in the open market or to keep it for home consumption. The land to be sown with wheat is also strictly controlled and the same rules are applied as for cotton.

There is a general belief that the quota system is a major factor in the overall stagnation of cotton yields (Djalalov, 2001; Spoor, 2003), especially when compared to wheat (Figure 2). This belief is at least partially supported by evidence from 1992 to 1995, when cotton production was partly liberalized and only 50% fell under the quota system.

While not dramatic, yields did bounce back slightly, rising from 0.76 tons/ha[2] in 1992 to 0.83 tons/ha in 1995. This period also saw a partial liberalization of input markets, which were later re-monopolized by the state.

In general, it can be said that the quota system for cotton and wheat has a negative impact on water management and use. Water management organizations are forced to deliver water to the cotton and wheat growing farms first, and withhold supplies from potentially higher value agricultural and non-agricultural users. A second problem with the quota system with respect to water management is its impact on operational costs and their recovery. While irrigation water delivery at the system level is still free, newly-established Water Users Associations (WUAs) who distribute water at the farm level must charge for their services in order to generating operating funds. The fixed prices at which cotton and wheat are procured simply do not leave enough money with farmers to pay for WUA services and, as a result, many of WUAs are unable to pay for operations and maintenance and are in effect non-operational.

Rice and other crops. As already mentioned, production quotas no longer restrict rice. However, it is still worth examining here given the outcomes the quota, subsidy and its subsequent removal have had on the production. The production of rice, the major food crop after wheat, was steady until 1999, with crop yields increasing from 2.00 tons/ha in 1995 up to 2.56 tons/ha in 1999. The total production of rice reached a peak of 420 800 tons in 1999 before dropping to 67 800 tons in 2001, with an average yield of only 1.23 tons/ha. The reasons for falling rice production and low yields are two-fold. The first is a deficit of water, especially in 2001, and the second is the abolition of state order systems. The state removed all support, subsidies and credits from rice growing farms in 2003 and, in some water-short areas it even prohibited farmers from growing rice. However, after initial declines in yield and production, production moved back up to 1999 levels. This indicates that if farmers are given the right to grow crops of their choice, they can, at least in some circumstances, maintain yields and production outside the state system. However, rice production, especially in those areas where the government

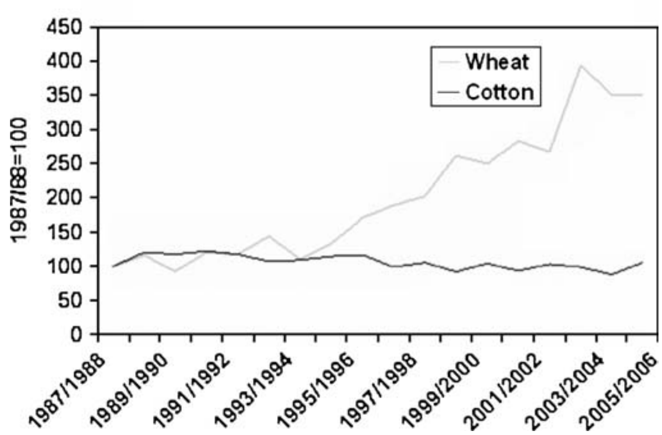

Figure 2. Cotton and wheat yield in Uzbekistan 1987/88–2005/06, Uzbekistan. *Source*: FAS.

proscribed production, is often accomplished by irrigating with low quality drainage waters, leading to reductions in land and water productivity.

Subsidies

During the Soviet period, Uzbek cotton was amongst the most highly subsidized crops. Inputs were provided to collective farms at large discounts, and credits were allocated to state-owned enterprises by the government banking systems at concessional interest rates (FAO, 1996). The state still controls, monopolizes and subsidizes input markets. Starting in 1993, the government established a range of state owned agencies for agricultural inputs, which provide inputs such as machinery and fertilizers. Credit subsidies, both through low rates and write-offs, especially for collectives, also exist. For example, the government forgave US$ 135 million in 2001 and postponed the repayment of another US$25 million (Akhmedov, 2002). In 2004, the Uzbek government provided approximately US$400 million in subsidies, equivalent to approximately 43% of the value of the cotton crop. It also provided subsidies to the agricultural sector of which $261 million or 65% went to irrigation service provision.[2]

Agricultural subsidies have been reduced over time (Figure 3), with predictable outcomes. For example, during the last 10 years, the rate of application of fertilizers per hectare for grain crops declined from 250 kg/ha (1990) to 180 kg/ha (2004), and many farm managers consider it unprofitable to apply the average recommended rates (FAO, 2003).

Farm Restructuring

During the Soviet period, cotton was produced on large-scale collective farms, typically from 2000–3000 ha in size. The large farms managed all aspects of the production system,

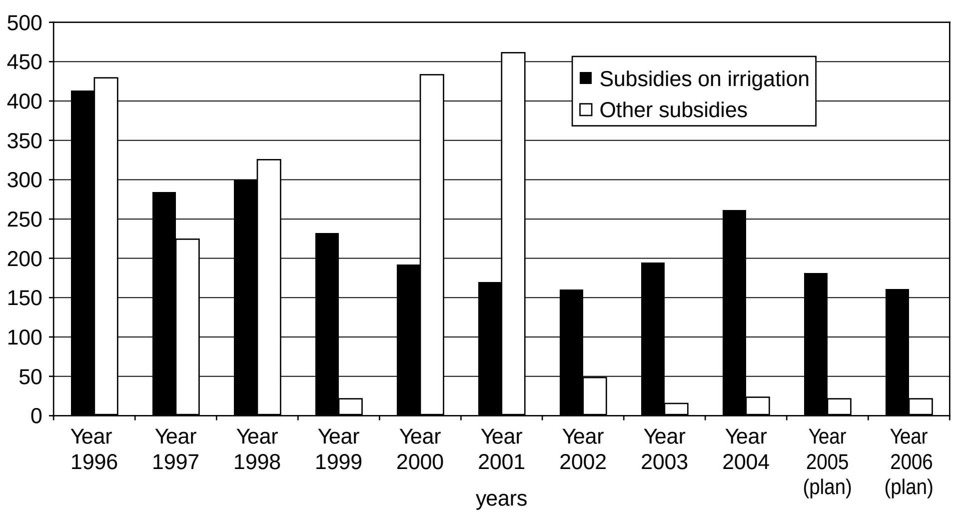

Figure 3. State agricultural subsidies 1996–2006, Uzbekistan (million US dollars). *Source:* Adapted from Djalalov (2001).

including agricultural machinery (e.g. tractors and combines) and irrigation. Because the farms were believed to be inefficient, their land was split into smaller, although still collective, farm units known as *shirkats* after independence. However, no restructuring of other system assets such as irrigation was undertaken. The result was that the land management units no longer matched the input units, resulting in poorer performance of, for example, and irrigation and drainage networks. The net result was low performance, resulting in cotton yields lower than during the 1980s. A second trend in farm management after independence was the emergence of individual farms, which began in 1992. Individual farms were initially considered as experimental by the government and allocated low fertility lands with poor water supply.

At the beginning of 2003, the government of Uzbekistan began to transform the collectives into individual farms. According to the new policy, priority was given to the development of the individual farms as the major producers of agricultural commodities. Between 2004 and 2006, 55% of the collective farms were to be transformed into individual farms. By 2004, individual farms already occupied 16.7% of agricultural lands area, hired 765 300 workers and provided 10.5% of the agricultural gross product, including 51.5% of cotton production and 46.2% of grain production. The final transformation related to farm structure was the rise of the so-called *dehkan* farms, legalized family plots from which most of the Uzbekistan's population earns income (Djalalov, 2001). The state now encourages family plots to be registered as legal entities so that they can acquire credit and benefit from other financial instruments (e.g. leasing). *Dehkan* farms are allowed to grow any crop except cotton and sell output in the open market. They cannot join the cotton and wheat quota system. Much of the production, primarily fruits and vegetables, grown on *dehkan* farms is exported to neighbouring Russia and Kazakhstan. However, what is most striking about *dehkan* farms is their large contribution to agricultural GDP, estimated at 25% in 2004, despite their relatively small area (Djalalov, 2001).

Changes in farm organization have a direct relationship with water management. Until the mid-1990s, secondary canals only needed to supply water to one large collective farm. The system of interaction between water management organizations (WMOs) and primary water users (collective farms) was based on seasonal water contracts. The contracts had the status of water rights for users and described the amount and timing of water delivery. The contracts also described the roles and responsibilities of WMOs in water supply and the obligations of primary water users in conservation and efficient water use and maintenance of irrigation infrastructure.

As the transformation to smaller farm units progressed, the number of water users and the number of requests for water services increased, while the quantity of water needed per request fell. WMOs were unable to sign water contracts with the large number of water users, discipline in water use declined and both WMOs and water users failed to follow the established rules, resulting in widespread disruption in water provision with direct impacts on farm productivity.

Other important aspects of farm reform include land rights and the tenancy system. Together with farm restructuring, legal changes in land use and allocation were introduced, which strengthened land use rights and gave greater security of tenure to individual farmers. At present, individual farmers have 49-year tenancy agreements. However, legally, the land rights can be cancelled if farmers do not fulfil production agreements three years in a row. This uncertainty makes strategic investment in land conservation as well as water management risky, reducing resource productivity.

Irrigation Water Management Reforms

After the disintegration of collective farms into numerous individual farming, units' workload of water management organizations (WMOs) has increased tremendously. Former on-farm water management level, previously handled by collective farms has been left unattended. However, financial and human resources of WMOs have not been increased since agricultural reforms. Therefore, WMOs could not sign water contracts with numerous water users at the former on-farm level, resulting in a loss of discipline and neglect of roles by both parties.

Ownership and funding of on-farm water infrastructure of collective farms was discontinued after de-collectivization of agricultural production, the funding of on-farm water infrastructure started to diminish and, as result, it has degraded dramatically.

Until 2003, the management of major irrigation canals and water reservoirs was solely under state control. All irrigation infrastructure at the main system level was managed territorially, through provincial and district level water management organizations. Each of the territorial units (district, province) had state production quotas for cotton and wheat. As water was such a crucial factor, each governor tried to appropriate more water for his or her district. The resulting territorial fragmentation of water resources management led to inequitable water distribution and head-tail water disputes.

On 21 July 2003, the Cabinet of Ministers of the Republic of Uzbekistan issued a decree (No. 320) to reform the water management system by transferring water management from an administrative-territorial system to a basin approach. The main goal of this reform was to consolidate water management through the establishment of Water Users Associations (WUAs) and Canal Management Organizations (CMOs), operating within single hydraulic units, in order to ensure equal access to water for different users and improve water use efficiency.

Trade Liberalization Scenarios and its Impact on Water

Membership of the WTO: Agricultural Water Use Impacts

The World Trade Organization (WTO) was established in 1995 to promote freer international trade by reducing tariffs and subsidies and providing a rule-based system, in which all members are treated equally. Uzbekistan had targeted membership of the World Trade Organization (WTO) even before it was officially founded, and has held observer status in WTO meetings since 1994. In 1998, Uzbekistan established an inter-ministerial committee on WTO issues under the supervision of the Prime Minister. Uzbekistan's interest in joining the WTO is probably a result of two forces. Accession may be viewed as valuable on its own for new rights, new and expanded market access and protection of trading interests within the multilateral legal system that WTO provides. At the same time, accession may be seen as a necessary competitive response to neighboring countries that are already WTO members (e.g. Kyrgyzstan) or believed to be close to membership (e.g. Kazakhstan).

Treating foreign goods and services equally to domestic ones will create difficulties for Uzbek enterprises, as they may not have the skills and resources to measure up to increasing competition in the domestic market. This is also true for the agricultural sector and is a major area of concern. At this point it is not clear if and when Uzbekistan will join WTO. It is even less clear what commitments on agricultural reform it will have to make unilaterally or will make in response to the as yet unfinished Doha round of the WTO. Thus, it is premature to discuss water-related consequences of specific policy outcomes. Instead, the paper here addresses the possible water impacts of a range of reforms that Uzbekistan might take under a free, or freer, trade and internal market regime.

Potential Impacts of Market and Trade Liberalization on Water Use

The forces behind the impacts of trade liberalization on water can be divided into four general areas: price liberalization, subsidy reduction, farm restructuring and secondary impacts on farm and water management. Table 1 gives an overview of expected impacts, and explanations are given in the subsequent sections. Summarizing all effects, it is likely that trade and related market reform will increase both water productivity as well as overall water demand, depending on the exact nature of the changes implemented.

Price and quota liberalization. Any trade liberalization scenario would probably include reform in internal pricing and the procurement arrangements for cotton and wheat. At present, purchase prices for both commodities are well below world market prices and would rise, perhaps double, with liberalization. One outcome of rising prices would be an expansion in the cropped area, and possibly the irrigated area if water is made available and additional investments in infrastructure are made. The second possible impact, also assuming a relaxation of the quota system, would be a shift in the relative area sown from wheat to cotton and also shifts between cotton, wheat and possibly horticulture. However, the support infrastructure (storage, processing and transport) for alternative crops has not yet been developed, so drastic shifts from cotton or wheat to other crops would not be

Table 1. Hypothesized impacts of trade and market liberalization on water demand and productivity[a], Uzbekistan

Measure	Water demand	Water productivity
1. Liberalization of output prices		
Overall area expansion	0	0
Shift from wheat to cotton	+	+
Yield increase	+	+
2. Input subsidy reduction	−	−[a]
3. Farm restructuring		
Land reform only	−	−
Land and water reform	+	+
4. Secondary impacts		
Increased yields	+	+
Water control	+/−	+

Notes: [a] water productivity in the physical sense decreases, but economic productivity increases.
0 = no change; − = decrease; + = increase; +/− = unclear

expected, at least in the short term. At present it appears that the gap between internal and world market prices is greater for cotton (100%) than for wheat (80%), suggesting a shift from wheat back to the cotton area. This shift back to cotton may be even more pronounced than the price ratios lead us to believe. Physical conditions give Uzbekistan a comparative advantage in cotton production, one of the reasons for Soviet planners to centre cotton production in the region. Further, as evidence shows, imports of wheat into Uzbekistan can be competitive, even at current prices. Uzbek cotton is also clearly competitive in world markets under current international marketing practices, although those practices can hardly be considered as reflecting real market conditions. All factors—current price ratios between cotton and wheat, physical conditions and current trade patterns—point to an increase in cotton area after price and quota liberalization.

In terms of water, the question then is whether a shift from wheat to cotton will cause a change in water consumption. Cotton is more water intensive than wheat per unit area. More importantly, all cotton water requirements are met by irrigation, while only 60% of wheat water requirements come from the irrigation supply. Thus, any shift back towards cotton will probably result in an increase in irrigation water demand.

An increase in crop prices and, therefore, farmer returns should give a direct incentive for farmers to apply additional inputs to increase yields. The yield effect will be further boosted if the land quota system is relaxed, allowing farmers to grow crops on the most suitable plots. Yield growth is typically associated with increases in water productivity and thus might facilitate an expansion in production without a proportionate increase in water use. However, increased yield, even if at higher water use efficiency, does imply higher levels of water use.

Reduction in input subsidies. Input subsidies have been declining in the post-Soviet period. Future reductions will probably continue downward pressure on yields and thus decreased water productivity, evapotranspiration and overall water use. However, in a liberalization scenario, it is likely that both output and input price reforms would occur simultaneously. Given the current, relatively low, level of subsidies and relatively large gap between procurement and international prices, the effect on overall water use would probably be close to that of output price reform alone.

Farm restructuring. In Uzbekistan, farm restructuring is seen as part of overall market reform and may thus also be considered within trade liberalization. While substantial restructuring has already occurred, there is still room (and plans) for further reform. The key question related to farm restructuring and water use is whether land reform is promoted in conjunction with or apart from water management reforms. It is known from experience at present that water management structures and institutions designed for collective management do not function well on individual farms. The result of attempting land reform without water reform has been a reduction in service delivery and deterioration of systems, and thus reductions in yield, water productivity and overall water use (although not necessarily diversions). With successful water management reform, giving farmers higher returns and the ability to pay for services, yields, water productivity and overall water use and withdrawals will probably increase.

Indirect effects. Water reforms are more likely to succeed if they are combined with other reforms that give farmers greater ability to pay for services. Similarly, reforms which increase the profitability of farming and reward farmers for efficiency are likely to lead to additional investments in both land and water management. In turn, these will lead to higher yields through better management practices, higher levels of input use and thus higher levels of water use (ET) and increased water productivity. However, it is also possible that improved management can reduce overall water use, even in the face of higher crop output, by improving the way water is applied and recycled, or through better plant varieties.

Scenarios and Assumptions

The future of Uzbekistan's internal and external agricultural policy is uncertain. What is clear, however, is that further transformation is probable as the country continues to evolve to meet the challenges of a post-Soviet era. To explore the impacts of this transformation on water resources, the paper formulated three scenarios for the period 2005–20 of possible directions that Uzbekistan's agricultural and trade future may take: (1) status quo; (2) regulated/controlled trade and market liberalization; and (3) full market-driven liberalization.

Status quo scenario: no WTO membership, no reforms. The first scenario, which can be considered as a baseline, assumes no further changes in agricultural policies or the agricultural production system. In particular, this scenario assumes no membership in WTO, no liberalization of trade regimes and no change in the cotton and wheat quota systems or internal markets. Because of low profitability in farming, irrigation systems will continue to degrade over time, decreasing water use efficiency and irrigated yields. Both irrigated wheat and cotton yields will decline as result. In the status quo scenario the area under wheat will increase at the expense of cotton. This increase is driven by a policy to supply current levels of food per capita and stock-feed needs while minimizing additional use of international markets. Without improvements in yield, this increased output will need to occur through an expansion in wheat area.

Releasing of cotton quotas: controlled market—no further trade liberalization. Under the second scenario, the government continues its gradual reforms of the quota system but does not join the WTO or otherwise liberalize trade. The government also continues internal reforms, including strengthening the legal system, reducing monopolies in the agricultural sector through privatization of cotton gins, machinery hire and input supplies. Under this market liberalization, it is expected that Uzbek agriculture will move back towards its state in 1990, at least in terms of cotton dominated cropping patterns. The primary reason is that relative and absolute returns to cotton production will be much higher than at present, since it will be farmers, rather than exporters, who would reap the majority of the benefits. This will lead to additional investment in water infrastructure and management, since such funds will be available and their investment profitable. On the one hand, better water management may make application more efficient and will sometimes 'save' water. On the other hand, it makes water use more profitable and therefore increases demand. However, for this to happen, farm and system level water management would also need to be adapted to be consistent with evolving farm size. Furthermore, such a scenario would also require the development of reliable wheat import markets, although not necessarily as envisioned under free trade regimes but rather, perhaps, again on Soviet-style lines.

Indeed, the Uzbek and Russian governments are already discussing rehabilitation of cotton exchange between the two states. Other possible options for grain imports are the former Soviet republics of Kazakhstan and Ukraine.

WTO accession and liberalization. Under the third scenario, Uzbekistan liberalizes its trade policy in line with the WTO or similar regimes, freeing agricultural trade and its internal agricultural system. This implies removing cotton and wheat quotas. Under this most market-driven scenario, with all cropping restrictions lifted by the state and farmers enjoying freedom to grow whatever they want, the cotton area will further increase at the expense of irrigated wheat. Driven by increased profitability of both wheat and cotton, there will be a substantial improvement of yields, efficiency and water productivity.

Scenario quantification and analysis. The scenarios are analysed using WATERSIM, a quantitative model that consists of two fully integrated modules: a food production and demand module based on a partial equilibrium framework, and a water supply and demand module based on a water balance and water accounting framework (Fraiture, 2006). Assumptions on basic variables, such as population, income growth, resulting food demand and water availability and non-agricultural water uses, were taken from baseline projections created for the Comprehensive Assessment for Water Management in Agriculture (Fraiture *et al.*, 2007). Growth rates in baseline assumptions that remain constant for all scenarios are given in Table 2.

Key drivers for change are population growth and income. Relative to population, income grows rapidly, resulting in shifts in diets and therefore water demand. Wheat consumption grows more rapidly than the population as a result of an income induced diet shift towards wheat and meat, using wheat grain supplemental feeds. Cotton demand increases at about the rate of population growth.

These changes are set against a more static water resources environment. Utilizable resources are estimated from the long-term average surface runoff and renewable

Table 2. Baseline assumptions for all trade and market liberalization scenarios, Uzbekistan

	2005	2020	Annual growth
Socio-economic			
Population (million)	28	35	1.5%
Per capita GDP (US$/cap/yr)	840*	2805	4.0%
Wheat demand (million tons)	4.3	6.9	3.2%
Cotton demand (million tons)	0.4	0.5	1.6%
Available resources (BCM/yr)			
Utilizable surface water resources	51.5	51.5	0.0%
Utilizable groundwater resources	7.8	7.8	0.0%
Utilizable return flows	10.9	10.9	0.0%
Total water available	70.2	70.2	0.0%
Water use (BCM/yr)			
Urban and rural water supply	4.1	4.2	0.2%
Industrial diversions	1.5	1.9	1.6%
Environmental allowance to Bigger Aral	6.1	6.1	0.0%

Note: *for the base year 2000.

groundwater resources, plus the re-usable return flows. Total return flow amounts to 23 BCM, of which 47% goes back to the rivers and canals and as such can be potentially reused for irrigation, 27% is evaporated from depressions, and 26% flows to the downstream countries. Thus total utilizable water resources amount to 70.2 BCM per year. For all scenarios, it is assumed that anticipated improvements in drinking water supply will occur, resulting in no change in use from the base year (4.1 BCM), despite growing demand, a savings of around 1 BCM of water.[3]

Withdrawals for economic uses in 2005 amounted to 56.0 BCM, of which more than 90% was for irrigation. Total groundwater diversions in the base year amounted to 5 BCM or 9% of the total water withdrawal, of which 49% was diverted for urban and rural water supply, 34% for irrigation and 17% for industry. In addition, 6.1 BCM of water can be considered as environmental flow—an average amount annually allowed to the Uzbek portion of the Aral Sea (Bigger Aral) since the early 1990s. The water availability and use figures indicate that the major part of Uzbek's water resources are already allocated, while food demand is increasing due to a richer and larger population, creating major challenges for water resources management.

Assumptions directly related to, and consistent with, the reform scenarios discussed earlier are given in Table 3. In the status quo scenario, irrigated yields decline slightly because of reduced profitability in agriculture. To keep up with wheat demand, the irrigated wheat area has to increase by 88%, while the cotton area declines by 40%. In the most market driven scenario, irrigated cotton and wheat yields grow annually by 2.7% and 1.5% respectively, which is consistent with the most optimistic yield scenario in the Comprehensive Assessment (Fraiture *et al.*, 2007). Overall irrigation efficiency in the base year is estimated at an average level of 40%. This figure accounts for both the field and system level efficiency (Antonov, 2000). Under market liberalization scenarios, efficiency will improve because of increased profitability of investments in irrigation.

Trade and water implications of the scenarios. Results of the scenario analysis are given in Table 4. In the base year, 38% cotton and 35% wheat are sown on the total irrigated area. In the status quo scenario, these ratios change to 39% and 21% respectively by the

Table 3. Assumptions on changes in key variables by scenario, Uzbekistan

	Baseline	Status quo	Controlled market	Full liberalization
	2005	2020	2020	2020
Crop production				
Irrigated wheat yield (thousand/ha)	4.40	4.35	4.90	5.55
Irrigated wheat area (million ha)	1.30	1.60	0.70	0.25
Rainfed wheat yield (thousand/ha)	1.50	1.45	2.65	1.90
Rainfed wheat area (million ha)	0.14	0.14	0.14	0.14
Irrigated cotton yield* (thousand/ha)	0.85	0.80	1.05	1.15
Irrigated cotton area (million ha)	1.41	0.85	1.65	2.20
Water use				
Total irrigated area (million ha)	3.7	4.1	3.9	4.1
Efficiency	40%	35%	45%	50%

Note: *cotton lint.

Table 4. Results of trade and market liberalization scenarios on crop production and water use to 2020, Uzbekistan

	Baseline	Status quo	Controlled market	Full liberalization
	2005	2020	2020	2020
Crop production				
Wheat production (million tons)	5.93	7.16	3.80	1.65
% Wheat prod from irrigated areas	96%	97%	90%	84%
Wheat trade (million tons)	1.63	0.26	− 3.10	− 5.25
Cotton production (million tons)	1.19	0.68	1.73	2.47
Cotton trade (million tons)	0.81	0.20	1.25	1.99
Water use				
Irrigated area (million ha)	3.7	4.1	3.9	4.1
Irrigated area with wheat	35%	39%	18%	6%
Irrigated area with cotton	38%	21%	42%	52%
Efficiency	40%	35%	45%	50%
Surface water use (BCM)	45.0	52.2	47.3	49.6
Groundwater use (BCM)	5.0	7.8	5.5	6.0
Agricultural water withdrawals (BCM)	50.4	60.0	52.8	55.6
Degree of water development[a]	80%	94%	84%	88%

Notes: Negative value denotes imports.
[a] Degree of development is defined as withdrawals over utilizable water resources (taking into account return flows). This includes the 6.1 BCM allocation to the Aral Sea for environmental purposes.

year 2020. Cotton exports drop while wheat production keeps up with increased demand. The irrigated area slightly increases from 3.7 million ha in 2005 to 4.1 million ha in 2020. Combined with deterioration in efficiency due to the mismatch of organizational units between collective water management and private farms, this results in 60 BCM of agricultural water use, an increase of 19% compared to the base year. An increase in groundwater use by 2.8 BCM partially offsets the surface water deficit. But this scenario will lead to serious water stress and water allocations to the Aral Sea may suffer and deltas of the Amu and Syr Darya may be affected.

At the other extreme, under the market liberalization scenario, cotton exports more than double by 2020 compared to the base year, to a total of 2 million tons of lint cotton. This is more than is required to make the textile industries of both Uzbekistan (0.5 million tons of lint) and Russia (almost 1 million tons of lint) operate at full capacity. At present, Russian mills work at less than half their capacity. Wheat imports will climb to 5.2 million tons, 75% of domestic demand. Increased demand for irrigation water as a result of water intensive cotton production is, to a certain extent, offset by improvements in water productivity, but an increase of 10% is still noteworthy, aggravating already existing problems related to water scarcity. Under the partial reform scenario, Uzbekistan's irrigation water withdrawals in 2020 are expected to increase by only 5% compared to the base year to 52.8 BCM.

Interestingly, all three scenarios point to larger irrigation withdrawals, although the underlying reasons are different. A continuation of current policies will lead to a further deterioration of irrigation infrastructure, lower efficiencies and yields, thus requiring more water to keep up with growing food demand. Under the policy reform scenarios, farmers will favour cotton over wheat, leading to higher water demand as cotton uses relatively more water. On the other hand, full and partial reforms lead to incentives for farmers to improve yields and water productivity, and investments in irrigation infrastructure and efficiency. On balance, both reform scenarios are beneficial in terms of water and agricultural output.

Discussion

Since independence in 1991, cotton production in Uzbekistan has declined by approximately one-third. The major reason for the decline was a change in government policy. After independence, the government allowed the transfer of some cotton areas to private cultivation of non-cotton crops, and encouraged a shift to wheat production in order to cope with economic and political disruption and to meet new targets for national food security. The result was a smaller cotton area maintained by a coercive quota system both for planting and procurement. Environmental problems have also contributed to the difficulty in increasing, or even maintaining, cotton productivity. Land degradation, primarily in the form of water logging and salinity, has continued to impact yield. In addition, the shift from large collective farms towards rather family-based farm organization has resulted in a vacuum of responsibility in management for the operation and maintenance of irrigation and drainage systems.

However, another driving force behind cotton yields is evident when a comparison is made with another major crop in Uzbekistan—wheat. Typically grown alongside cotton, wheat yields have more than tripled since independence. The different productivity trends of the two crops are even more surprising given the increasing levels of salinization and cotton's relative salt tolerance. This evidence strongly suggests that it is not the natural environment that has kept cotton productivity down, but rather the policy environment. In particular, the stagnation in cotton yield appears to be largely a response to government's quota system for the cotton area, which gives little, if any, incentive to increase productivity beyond the levels required to meet production quotas.

The paper analysed the consequences of possible policy reform on the Uzbek cotton and wheat economies and how changes might translate into water demand. In particular, three scenarios were generated using the WATERSIM model for the period 2005–20. The first scenario assumes a continuation of the status quo—no changes in agricultural policies or the agriculture production system. This scenario results in a decline in cotton output, and an increase in wheat and an overall increase of irrigation demand of around 18% over the base period. The second scenario assumed a relaxation of the cotton quota and some other internal reforms, but without trade liberalization. These changes increase the profitability of cotton for farmers and cause a shift towards cotton at the expense of wheat, resulting in an increase in irrigation water withdrawals by only 3% compared to the base year. Under the third scenario, internal market liberalization is coupled with full trade liberalization. Cotton becomes even more profitable with total area growing by 88%, again at the expense of wheat and Uzbek agriculture moves back towards the domination of cotton monoculture. The result is an increase in water withdrawals by 8%, assuming improvements in water productivity and water use efficiency.

Conclusions

The results show that water demand in Uzbekistan is going to increase because of growth in population and income. However, the rate of growth will depend on the overall policy environment, with growth rates lower under partial and full liberalization than below the status quo. However, the important finding is not so much the exact projections but rather that non-water policies could have such major impacts on overall water use. This lesson is important for water managers and policy makers who wish to understand how best to change outcomes in water management. At the same time, it highlights the need for those involved in trade policy to consider the water related impacts of their decisions.

While impacts of policy change on the Aral Sea were not a major focus of this paper, the results do provide insights into possible outcomes. In a recent report, Chapagain *et al.* (2005) indicate 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, a result shown to be unlikely if liberalization occurs. Even if policy changes to reduce cotton exports, 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 reverse that decision. If water scarcity is to be a factor for the Uzbek cotton production, it is most likely to occur due to the trade-offs that exist in the region between downstream agriculture (Uzbekistan and Kazakhstan) and upstream energy production (Kyrgyzstan and Tajikistan), than between agriculture and environment, at least in the foreseeable future.

Looking outside of the region, it is likely that Uzbek cotton production leads, perhaps counter-intuitively, to global increases in water efficiency. This is because Uzbekistan’s cotton production uses less water per unit of output than most alternative producers do. Thus, from an international policy perspective, where there are concerns about the ability of existing water resources to feed growing populations and their growing incomes, there is also a trade-off between overall water savings and the destruction of the Aral Sea. How these trade-offs will be balanced in the real world will depend on the political skills of those involved. Having clear information on the nature of water trade-offs and the policies—water, agricultural, trade and others—which influence them, can at least give policy makers a better understanding of the options available.

Notes

1. Chairman of NGO Suvchi, former staff of Ministry of Agriculture and Water Resources Management.
2. Estimates of subsidies for 2004 are executed by World Bank consultant Anna Krole-Ris.
3. Per capita consumption is now a high 800 litres per day. More than 50% of all the water diverted for domestic use is lost due to leaking pipes and excessive use due to lack of incentives for savings. An easily achievable reduction in use by 500 litres per day would allow overall urban consumption to remain constant, despite a growing population.

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