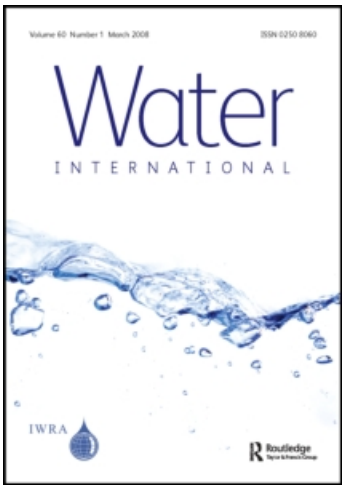


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# Adoption of integrated water resources management principles and its impacts: lessons from Ferghana Valley

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# Adoption of integrated water resources management principles and its impacts: lessons from Ferghana Valley

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The Ferghana Valley Project, initiated in 2001, has promoted institutional change in the post-Soviet irrigation sector in this part of Kyrgyzstan, Tajikistan and Uzbekistan. This paper presents the short-term (5-year) impacts of integrated water resources management project activities focused on water user participation in the South Ferghana Canal of Ferghana Province in Uzbekistan on irrigation water delivery and crop productivity. Irrigation performance assessment indicators indicate only slight improvements in water delivery and crop yields. Although water was important, larger changes in the agricultural sector of Uzbekistan dominated outcomes in this relatively short time span.

**Keywords:** integrated water resources management; South Ferghana Canal; water management; governance; water user participation; Ferghana Valley



## Introduction

Land reform in Uzbekistan, initiated before independence from the USSR at the end of the 1980s, gradually continued after independence (Abdullaev *et al.* 2007). The government first transformed Soviet state farms (*sovkhoz*es) into collective ones and then transformed all collective farms into semi-cooperative *shirkat* farms at the end of the 1990s. The reforms continued and the *shirkat* farms began to be transformed into the individual farming enterprises (Spoor 2004). The final stage of the land reforms in Uzbekistan commenced in 2003 by a presidential decree on the concept of the development of farming and continued during 2004–2006. In accordance with this decree, by 2006, all *shirkat*s would be transformed into individual farms through a process arbitrated by land reform commissions. At present there are three main types of agriculture production in Uzbekistan. Individual farmers primarily grow cotton and wheat for the state quota; individual commercial farmers produce rice, fruits and vegetables for trading; and family-household producers are growing a variety of crops for subsistence (Veldwisch 2008). The land reforms have resulted in a situation whereby along the main canal, instead of a few collective farms mainly growing cotton, there are now hundreds of individual farmers cultivating a variety of crops.

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The on-farm water management system which was part of the collective farming was also abolished along with the collective farm de-collectivization process. The state water management organizations (WMOs) formerly delivering water to the collective farm gates are now forced to deal with a multitude of individual farmers, growing different crops, and applying different agronomic and water management practices. The formerly prevailing system of water management, designed for a collective farming set-up, became redundant. Therefore, the need for a new organizational arrangement to manage water at the on-farm level and to distribute irrigation water between new individual farmers became an obvious necessity. However, the entire system of irrigation water management, designed to deal with monocropping – the cotton-growing collective farms – has also faced increasing problems with water distribution along the main canals, particularly when water scarcity leads to frequent clashes between water users.

Nonetheless, the Uzbek government has engaged in efforts designed to match water management techniques with changes in the agricultural sector. In 1996, the Uzbek government decided to merge the then separate ministries of agriculture and water management. This was an element of the nation-building exercises by the government, with the primary goal of placing water management into the service of the agricultural sector (Yalcin and Mollinga 2007). This decision corresponds closely with the overall agriculture policy of Uzbekistan, which utilizes a Soviet-type quota mechanism for cotton and wheat production (Kandiyoti 2003).

At the end of the 1990s, water user associations were created by a decree of the Cabinet of Ministries of Uzbekistan to fill the irrigation water management vacuum at the farm level. Although the Uzbek government used the term water user associations (WUAs), they did not necessarily constitute organizations of water user, but they were rather the continuation of the state's water management organizations. The acceleration of agricultural reforms (de-collectivization) led to the creation of hundreds of WUAs in place of the former collective farms (Wegerich 2000). WUAs have been given functions in the planning and distribution of water amongst different types of agricultural water users.

Under the quota system, each head (*hakim* in Uzbek) of the administrative unit was made personally responsible for fulfilling state quota plans. Therefore, they utilized power and all available means to deliver on time all the inputs needed to grow cotton and wheat, including water. Often, due to inefficiencies in the irrigation system and water application methods, the amount of water withdrawals into the administrative units was much higher than their water shares ("limits in local"). As a result, the tail-located irrigated areas were receiving much less water than they were entitled to. In 2000–2001, the whole tail-end of the Amu Darya, Khorezm and Karakalpakstan regions received less than 40% of their water shares. Hundreds of thousands of hectares of irrigated land were left with no irrigation. As a response to growing problems with water distribution, in 2003 the Uzbek government transformed existing territorially based water management structures into hydrologic basin organizations. The main goal of this change was to reduce administrative interference by local *hakim*s in water management and divide the functions of different departments within one ministry (Yalcin and Mollinga 2007).

Although the Uzbek government has been engaged in efforts to overcome the negative impacts of de-collectivization on irrigation water management, the concepts it used were still based on centralized, state-controlled water management. Although the water management concepts were not in contradiction with the nature of the Uzbek state, the growing competition of private interests at the farm level could no longer be handled by purely administrative means.

Integrated water resources management (IWRM) in the Ferghana Valley (FV) project is funded by the Swiss Agency for Development and Cooperation (SDC) and implemented through the association of two partners, namely the Scientific-Information Center (SIC) of the Interstate Commission for Water Coordination in Central Asia (ICWC) and the Central Asian sub office of the International Water Management Institute. The project has been implemented in the Ferghana Valley and includes Kyrgyzstan, Tajikistan and Uzbekistan. It has been in operation since 2001 and currently it is in its fourth, consolidation, phase.

Within the frame of the IWRM in the Ferghana Valley project, two new ideas were tried in order to complement and upgrade the changes by the Uzbek government in irrigation water management. The first was the establishment of one management unit for one whole canal which before was divided by two provinces. The second change was the establishment of unions of water users (UWUs), which provided a higher platform for representation of water users than common WUAs at the former farm-level, secondary canals.

This paper is an attempt to assess directly the impacts of the above-mentioned project innovations on water delivery and productivity of agricultural crops. The analysis of the impacts of the innovations which the project brought to water delivery and crop yields in the South Ferghana Canal (SFC) command area was undertaken for two different periods: (1) before the project interventions (2000–2001) and (2) after the project activities (2002–2005).

Measuring the impact of institutional changes on the day-to-day water management practices such as water delivery and on agriculture performance such as crop yields is problematic and complicated. Water delivery which is based on operational rules is affected by many factors and many players. The change in operational rules brings with it low transaction costs and is therefore frequently effected by both water managers and water users (Ostrom 1992). By contrast, the institutional changes, in the form of the introduction of new organizational innovations such as the formation of UWUs, require change in constitutional rules (Ostrom 1992); such changes have high transaction costs and require much more time. However, the new organizational innovations, such as UWU at the main canal level, even though operational for several years, do not have the level of authority necessary to change the operational and constitutional rules of water management at the main canal level.



## *Methods and materials*

### *Project area: Ferghana Valley and South Ferghana Canal*

The Ferghana Valley is located in the south-east of the Central Asian region and the eastern part of the Aral Sea Basin. The valley is surrounded by mountains (the Alatau Range in the north, the Tian Shan Mountains in the east and the Alay Mountains in the south), with the exception of the narrow western opening through which the Syr Darya River drains into the lower basin of the Aral Sea. The larger central part of the valley falls within the Republic of Uzbekistan, while the northern and eastern fringes are located in the Kyrgyz Republic and a small area in the valley's west and southwest belongs to the Republic of Tajikistan.

The Ferghana Valley forms the upper to mid-reach of the Syr Darya River basin, which is formed from the confluence of the Naryn and Kara Darya rivers. The average temperature in the valley is 13.1°C, ranging from −8°C to 3°C in January and 17°C to 36°C in July. Annual precipitation ranges from 109 mm to 502 mm whereas evaporation ranges from 1133 mm to 1294 mm throughout the Ferghana Valley. The long-term (1970–2000) average annual precipitation for the SFC command area is 175 mm. During the study period (1999–2004), precipitation rates were mostly higher than the long-term average, with the highest value of 330 mm in 2003 and the lowest of 150 mm in 2000. The effective

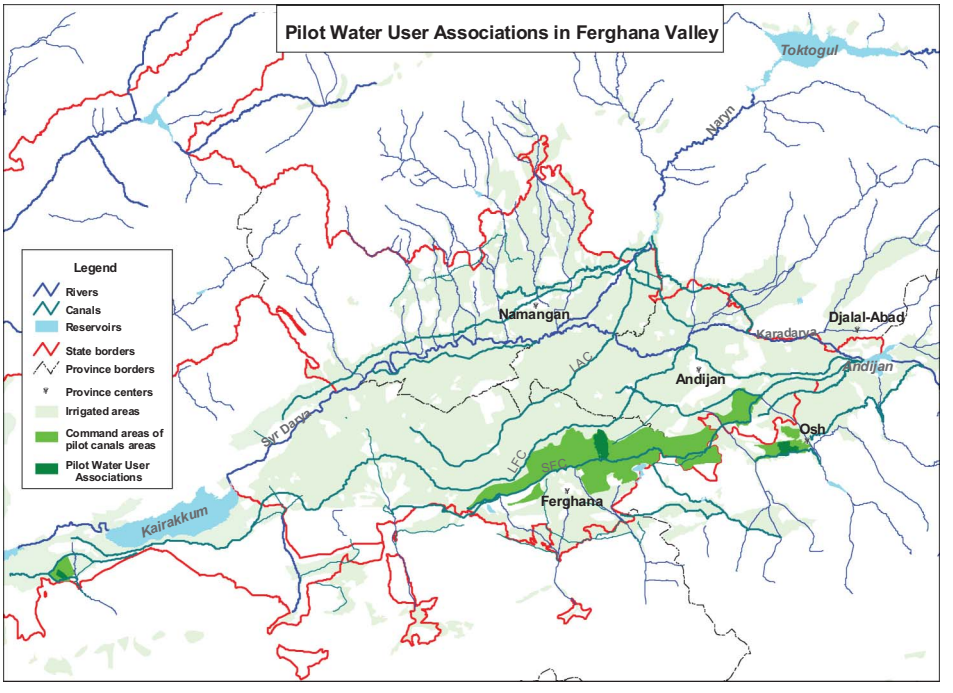


Figure 1. Map of the Ferghana Valley.

precipitation rates amount to only 15–20% of the totals, because they occur in winter, when only winter wheat is grown due to low temperature, and little is stored in the soil through to the start of the crop season. Therefore, the authors have ignored the role of precipitation in water supply for the study years.

The SFC is located in the southern part of the valley (Figure 1) and was built in 1936 and then reconstructed and extended in 1940. The SFC is 135 km long, with 60 km located in Andijan Province of Uzbekistan and 85 km in Ferghana Province. It is lined from head to tail and receives water from Andijan reservoir. The inflow to the canal is 100 $m^3/s$. The total irrigated area under the SFC command is 83,884 ha, of which 26,983 ha are located in Andijan Province, 53,155 ha are in Ferghana Province and 3746 ha of command are in Kyrgyzstan. The Karkidon Off-Channel Reservoir is used during the irrigation season as an additional source of water supply to the SFC.

The South Ferghana Main Canal is divided into nine hydrographic units (*gidouchastka*). The units are organized in the parts of the canal where major water distribution-intake points are located. In each unit, the head of unit, hydrotechnician, gatekeepers and mechanics (if there are pumps) are present. The decisions made by the canal management organization (CMO) on water distribution are implemented by the staff of the appropriate hydrounit. The decision and information exchange occur through the use of communication equipment (radio, cell and phone lines).

### *Assessment of the water delivery performance of the SFC*

Performance assessment in irrigation and drainage can be defined as the systematic observation, documentation and interpretation of activities related to irrigated agriculture with

the objective of continuous improvement (Bos *et al.* 2005). Small and Svendsen (1992) identified four different types of performance assessment: (1) operations, (2) accountability, (3) interventions and (4) sustainability. Irrigation performance indicators cover better-known aspects related to adequacy, equity and reliability of the water service (Wolters 1992, Murray-Rust and Snellen 1993, Bos *et al.* 1994). However, the evaluation of irrigation water use has undergone major changes in the last 20–25 years. It began as an assessment of classical irrigation efficiencies (Bos and Nugteren 1974) and developed to define performance indicators (Bos *et al.* 1994) and a framework of water-accounting at the regional scale. Bos *et al.* (1994, 2005), after thorough research, suggested a package of indicators which are related to the performance of (1) the water delivery system, (2) the environment and (3) the economics of irrigated agriculture.

The change in per hectare water delivery rates to the nine units of the SFC was used as a performance indicator to assess the impact of the project interventions. If one takes into account that the cropping structures along the nine units of the canal are quite similar due to the state quota, then, in theory, per hectare water delivery to the units should be roughly equal.



### *Crop yields in WUAs located along the South Ferghana Canal*

The major crops grown along the SFC are wheat, cotton, fruits, vegetables and fodder. There are a few hundred hectares of pasture land within the command area in the hills. All irrigated cultivation in the command area is dependent on irrigation water from the SFC. The availability of irrigation water is a major factor in ensuring stable crop yields. Therefore, the authors assumed that the changes in water management would have an impact on the provision (equity, timeliness) of water for irrigated crops, which is a determining factor for crop yields.

The state quota crop (cotton, wheat) yields in Uzbekistan are strictly recorded at the farm, district, province and national levels by the respective state statistics offices. However, due to the specifics of the state order quota, the data relating to the higher levels are "cooked up" in order to suit official plans. Therefore, farm-level data are far more reliable. For this study, the project team has collected data relating to wheat and cotton yields for the period of 2001–2005 from farming units of WUAs located along the SFC.

## Results and discussion

### *Project interventions – water management by hydrographic boundaries and water users' representation*

#### *Water management prior to project interventions*

Prior to the project intervention, the SFC was managed by the two separate WMOs of Andijan and Ferghana provinces of Uzbekistan. For water allocation, each of the WMOs developed separate water use plans for their portions of the same canal. The water plans were then submitted to the Andijan Water Reservoir Management, which is under the direct management of the Ministry of Agriculture and Water Management in Tashkent. Two water use plans of the SFC were reviewed by Andijan Water Reservoir Management in order to match the water availability in the reservoir with water demands. The reviewed water use plans were then sent back to the WMOs of the two provinces.

During the cropping season (April–September) and off-season (October–March), water releases are supposed to be based on water plans. However, in reality, due to

frequent disturbances caused by both technical problems (damage to reservoir gates or pumps) and external administrative influences, water was released in a more ad hoc manner. Often, local *hakim*s in charge of agricultural production requested their territorial WMOs to withdraw/supply more water to the irrigated lands under their control. Due to the administrative hierarchy, the WMOs were obliged to obey the local administration. This resulted in considerable deviations from the water use plans. In order to adjust the water allocation to the realities of the administrative system, the managers of both parts of the SFC developed an arranged demand process of water ordering and delivery. The primary water users submitted their water requirements every 3 days to the district offices of the WMOs, which then prepared consolidated requests and submitted them to the dispatch centres for each of the two provinces. The dispatch centres of both parts of the SFC would then send the requests for the water to the Andijan reservoir management.

The competing request for water from both sides of the SFC made effective water management virtually impossible. Although Andijan reservoir had the right to cut water demands according to water use plans and water availability, personal connections were used to release demanded water from both provinces. The frequent conflicts over the water distribution between two provinces resulted in mistrust between the two elements of the SFC. The water managers in Ferghana Province (lower reach) suspected that Andijan (upper reach) withdrew more water than planned or requested. In turn, the Andijan reach accused Ferghana of excessive water use due to the availability of water from internal Karkidon reservoir (personal communication, official of a water management organization 2001).

The WMO managements of both sides of the canal considered it their role to gain as much water as possible for their portion of the same canal. The water was delivered sometimes without any need for it, with water flowing into the natural drainage system without being used for irrigation. At the same time the tail areas of the canal were suffering from a lack of water for irrigation.

Before the Uzbek reforms commenced, the IWRM FV project proposed, in 2001, to merge the two separate WMOs along SFC and to introduce water user unions. The suggestion was made based on analysis of water management in SFC and water user surveys.



### *Water management in South Ferghana Canal after project intervention*

As stated earlier, the IWRM FV project has brought about two major changes in water management in the SFC: (1) introduction of the basin principle (hydrographic water management) by merging two separate WMOs into one; and (2) formation of a water user union (UWU) for the involvement of water users in the governance of water management at the canal level.

#### *Hydrographic water management*

The introduction of hydrographic water management went smoothly; the Ministry of Agriculture and Water Management of Uzbekistan, the major partner of IWRM FV project, issued a decree for a unified canal management unit (CMO) for SFC. The new unified organization – the CMO – took over the water management from the two former territorial units. All the capital equipment (tractors, cars, excavators etc.) and staff were transferred to the new CMO. The CMO management was now responsible for the entire canal, preparing one water use plan and having control over the water distribution along whole canal.

The office of CMO was located in the middle of the canal, with direct reporting to the central dispatch centre of main canals of the Ministry of Agriculture and Water Management of Uzbekistan. Now water releases to the irrigated areas along the canal were handled by one organization – the CMO. Although preparation and implementation of water use plans remained somehow similar to the previous practices, the distribution of water saw an improved coordination due to the single decision-making body for whole canal.

*Water user unions*

The second project intervention was more social in nature and almost revolutionary by the paternalistic standards of Central Asian water management as it involved the inclusion of water users into the water governance system at the main canal level. For this purpose, water user unions of the SFC were organized through nomination of water users' representatives from each of the nine sub-units of the canal. This was a new idea and therefore proved to be somewhat more challenging to implement. IWRM FV project staff, jointly with representatives of CMO and WUAs along the pilot canal, prepared the statute of a canal water council (CWC). The statute was approved by the respective water agencies of each country. The process of CWC formation was initiated by group meetings and discussions with both water professionals of the CMO and WUA members along the canal. The WUAs elected their representatives for the CWCs. The IWRM FV project provided training for the elected members of CWCs on water management and public participation in water sector. The process of formation of the CWC took almost 18 months. After the formation of the CWC, decadal joint meetings of the CMO and CWC became regular events. Members of the CWC began to present problems related to water provision for their respective locations to the CMO during regular meetings. Conversely, during the meetings CMO managers started to present water use plans and its implementation (water distribution) along the canal for CWC members. The mutual exchange of information between the CWC and CMO over water planning have made transparent both the process of water planning and its implementation.

*New innovations: linking water users and the canal water management*

The establishment of the UWUs is an important water management innovation introduced in the region by the IWRM Ferghana project (SDC 2005). UWU activity began with rapport-building between the project and two major stakeholders: the state water management organization (CMO) and water users along the canal. The rapport-building was conducted through regular meetings, at first separately with each stakeholder group and later in joint meetings. The second step involved social mobilization of water users.

A group of local people with appropriate technical and social backgrounds were selected and trained by the project staff to become social mobilizers. They visited WUAs, the remains of collective farms and private farmers to explain the idea of including water users in the governance of water at the main canal level. In contrast to creating a single management body for the canal, the nurturing of the principles of water user representation and participation in the canal governance required a longer period of time.

The initial stakeholder meetings in nine canal units resulted in the formation of the first UWUs at each hydrounit; this process took almost eight months. Roughly five to seven representatives of water users from command area of each hydrounit were nominated in the general meetings of the WUAs, Afterwards, the representatives gathered together in the office of the hydrounit and elected the union's chairman for the hydrounit.

In many cases, water users elected WUA and *shirkat* leaders to be their representatives in a UWU at the hydrounit level. It was a clear indication that water users preferred those who are better connected to effectively deal with and voice their problems at the higher hierarchical level of the system. In the next stage of the process, the hydrounit unions nominated their chairman as representatives to the UWU of SFC.

The first meeting of the UWU of SFC consisted of nine people who selected the chairwoman and secretary. Although the UWU was formed relatively quickly, it took a further two years before it was registered with the Ministry of Justice of Uzbekistan.

According to its by-laws, a UWU (later renamed the Canal Water Council, or CWC) is an advisory, non-governmental organization of water users along the SFC. It has no power of approval or disapproval, and therefore its role and influence over water management issues is still limited. However, the presence of water users' representatives at every meeting of the CMO was itself a revolutionary step for the highly centralized water administration of Uzbekistan.

The members of the UWU underwent a series of training on water planning, water infrastructure, maintenance and operation as well as budgeting. The manager of the CMO began to present water use and implementation plans during the joint meetings of CMO and the union. The union members, representing their respective areas, are concerned with water delivery to their irrigated lands.

The cost of the union activities, such as regular meetings, travel costs of the council chairman, and salary of the secretary, are covered by the CMO budget. However, in order to provide for more independence, the General Assembly of the union announced the introduction of a fee to be collected from all primary water users (WUAs and *shirkat*s). A major problem facing the union is the difficulty of representing numerous water users along such a large canal, consisting of roughly 26 WUAs. If the number increases due to continuing land reforms, the union may just become another centralized and hierarchical body and may be ineffective in representing water users' needs.

In the future, as the representative of the users and stakeholders along the canal, the UWU could play a much more distinct role in IWRM, such as water allocation, drainage management, water quality, etc. Ultimately, the mandate of the UWU will very much depend on how all water-related activities in the command area are financed. It could range from a pure consultative role to one where the CWC would have full control of the management of all the assets under its jurisdiction (SDC 2005).



### *Impact of project interventions on annual water distribution along the canal*

A temporal analysis of per hectare water delivery was carried out for nine hydrounits of SFC. The period for the analysis was 2000–2006, whilst the years 2000–2001 represent a pre-intervention period. The changes on SFC water management occurred after 2003. The per hectare water delivery for the two periods are presented in Figures 2a and 2b.

Per hectare water delivery rates for the pre-intervention period (2000–2001) fluctuated between less than 400 mm/season at the head end of the SFC, and up to 2400 mm/season at the tail end of the canal. The cropping patterns along the SFC were similar, where 30–32% of irrigated land was under cotton cultivation and 35–40% under wheat. Therefore, one would expect more or less the same water delivery rates for all districts irrigated from the SFC. The highest water deliveries of more than 2000 mm were recorded both in 2000 and 2001 for the two most tail-located districts of the Ferghana Province. The lowest water delivery of 400–500 mm was registered for the head-located districts of Andijan Province (Figure 2a). The per hectare water delivery rates at the middle of the SFC appear to be more uniform, i.e. around 1000 mm for the pre-intervention period.

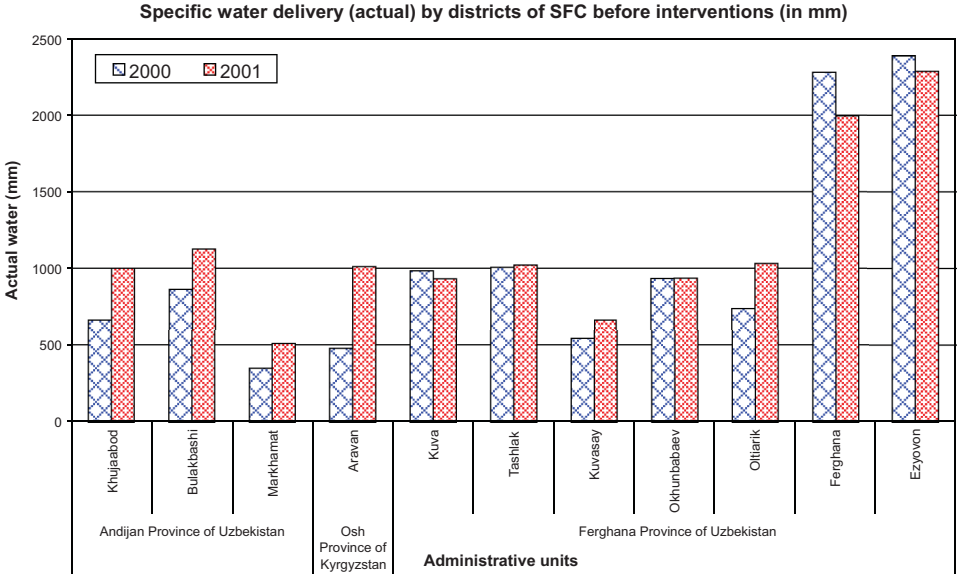


Figure 2a. Temporal variations of average per hectare water delivery before IWRM FV project interventions.

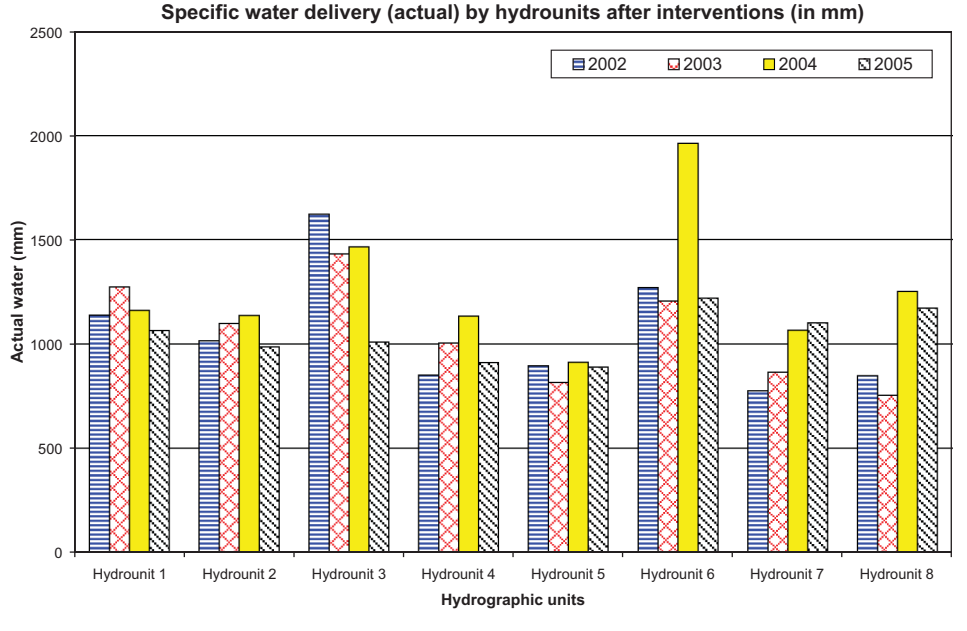


Figure 2b. Temporal variations of average per hectare water delivery after IWRM FV project interventions.

During the pre-intervention period, the water delivery rates were biased against the head-located districts of the Andijan Province; however, personal communication with water professionals from Ferghana revealed that perhaps the opposite was true (personal communications 2002). There could be two reasons for this situation. One is that the data

collected from the water management departments were not accurate, or that Ferghana water managers were talking about the water which comes directly from the SFC, ignoring the fact that they also use irrigation water from the internal reservoir which feeds Ferghana portion of the canal.

The water distribution rates have changed considerably after the IWRM FV project interventions. The incidence of extremely low and high water delivery rates is markedly reduced. Only one case of 1900 mm was recorded in 2004, for the Hydrounit 6 at the middle of SFC. The Hydrounits 3 at the head and 6 at the middle of the canal had, for the entire period of intervention, water delivery higher than 1000 mm (Figure 2b). The initial water delivery of the two tail units was in 2002 slightly lower than that at the head and middle of the canal. However, by the end of the study period, i.e. 2005, the water delivery for the tail-end units became >1000 mm, which was higher than that at the head and middle of the SFC. During the intervention period water delivery became more even, and extreme cases of <500 and >2000 mm water deliveries were rarely recorded. This can be attributed to the fact that a UWU had been created and had started to participate at the meetings of CMO on water distribution. The information on water delivery to the different parts of the canals has become more transparent and available to the representatives of the water users from the different parts of the canal.



*Crop yields in WUAs located along the South Ferghana Canal*

Two crops, cotton and wheat, which are under state quota, prevail in SFC command area. The highest wheat yields are registered at 7.3 t/ha for the head of the SFC and the lowest of 4.8 t/ha at the tail of the canal before the project interventions. The cotton yields ranged from 2.8–2.9 t/ha up to 3.8–3.9 t/ha. The wheat yields were in decline towards the tail end of the canal but the cotton yield had more even rates (See Table 1).

The dynamics of the cotton yields for the period of interventions are illustrated in the decline witnessed in 2002 and then an increase. At the start of the project intervention, the cotton yields of the upper canal area were higher than those at the tail. This can be explained by the fact that the tail end of the SFC received excessive water deliveries during the pre-intervention period which may have negatively affected soil quality (salinity,

Table 1. Yields of main crops (cotton and wheat) by administrative units prior interventions (2000–2001).

| Administrative units/provinces | Administrative districts | Yield (t/ha) | |
|---|---|---|---|
| | | Cotton | Wheat |
| Andijan Province of Uzbekistan | Khujaabod | 3.32 | 6.53 |
| | Bulakbashi | 3.82 | 7.35 |
| | Markhamat | 3.64 | 5.84 |
| Osh Province of Kyrgyzstan | Aravan | – | – |
| Ferghana Province of Uzbekistan | Kuva | 3.28 | 5.94 |
| | Tashlak | 3.16 | 6.33 |
| | Kuvasay | 2.89 | 5.89 |
| | Okhunbabaev | 3.32 | 5.67 |
| | Oltiarik | 2.97 | 5.21 |
| | Fargona | 2.78 | 4.76 |
| | Ezyovon | 3.01 | 4.87 |
| Total and averages for SFC | | 3.219 | 5.839 |

Table 2. Dynamics of cotton and wheat yields (average) for intervention period (WUAs located along the canal).

| | Yield (ha) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Cotton | | | | Wheat | | | |
| Hydrounits | 2002 | 2003 | 2004 | 2005 | 2002 | 2003 | 2004 | 2005 |
| Hydrounit 1 | 38.3 | 29.6 | 31.9 | 29.8 | 76.8 | 75.7 | 60.9 | 65.2 |
| Hydrounit 2 | 34.2 | 31.3 | 32.6 | 32.7 | 84.5 | 85.9 | 60.8 | 63 |
| Hydrounit 3 | 33.1 | 26.8 | 32 | 30.7 | 67.3 | 75.1 | 52 | 55.4 |
| Hydrounit 4 | 35.3 | 25.9 | 30.9 | 20.2 | 81.2 | 80.4 | 58.6 | 61.1 |
| Hydrounit 5 | 33.5 | 29.5 | 30 | 30.4 | 85.7 | 83 | 59.6 | 61.5 |
| Hydrounit 6 | 31.4 | 18.7 | 22.7 | 30.6 | 48.2 | 59 | 60.4 | 58.2 |
| Hydrounit 7 | 22.7 | 12.6 | 19.3 | 26.1 | 46.6 | 50 | 51.2 | 53.6 |
| Hydrounit 8 | 24.7 | 21.9 | 24.2 | 31.1 | 44.9 | 44.4 | 50.7 | 38.4 |
| Averages | 31.65 | 24.54 | 27.95 | 28.95 | 66.90 | 69.19 | 56.78 | 57.05 |



waterlogging). By 2004–2005, the cotton yields of the tail end had come close to those at the head units.

The wheat yields had different trends during the intervention period. They increased in 2003, and then declined to 5.71 t/ha. The head of the canal had higher wheat yields than the tail end of the SFC (See Table 2).

### *Key finding*

Overall, average yields for both cotton and wheat for the intervention period declined slightly in comparison with those in the pre-intervention period. The decline of the crop yields can be attributed not just to water, although it is important. The agricultural sector of Uzbekistan was undergoing a process of change during the study period; the semi-cooperative farms (*shirkat*s in local language) were being de-collectivized into individual farms. Therefore the agricultural production system was placed under pressure due to ongoing changes. Although water is the most important component, other factors have had more aggregate impact on crop yields.

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