# CHAPTER 5
# INSTRUMENTS FOR INTEGRATED WATER RESOURCES MANAGEMENT

## 5.1. IWRM Toolbox

**(V.A Dukhovny., V.I.Sokolov)**

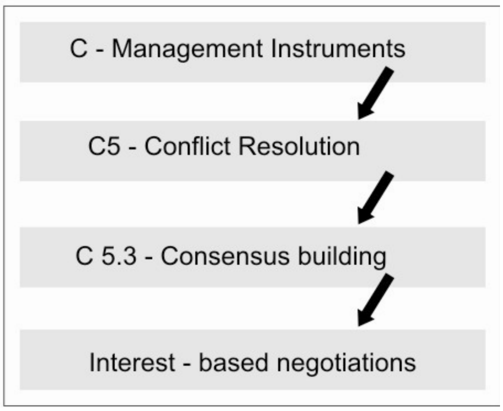
In 2002, the Global Water Partnership (GWP) has published the IWRM toolbox (in 2004, it was translated in Russian and this version can be found on the web at **www.gwpcacena.net**).

In addition, the interactive ToolBox (regularly updated) is to be found on the web at **www.gwptoolbox.org**.

Altogether about 50 different tools are represented in the ToolBox, and the areas covered are set out in Table 5.1.The characteristics of each tool described in the ToolBox allow the user to select a suitable mix and sequence of tools that would work in a given country, context and situation. The problems faced by water professionals are numerous and diverse, as are the political, social and economic conditions, so no blueprint for the application of IWRM can be given. Therefore, the ToolBox provides a range, which users can select and modify according to their needs. Some tools are preconditions for others; at the same time, other tools are complementary, e.g. demand management is strengthened by a simultaneous cost recovery policy. Integrated water resources management, by its nature, establishes and stresses the interrelations of actions, so the tools in the ToolBox are not designed to be used randomly or in isolation. Thus, for instance, water resources policies must take account of other sector policies, in particular land use.

Structurally, the ToolBox is organized in the hierarchical manner with each tool embedded in the wide perspective of IWRM. This structure is illustrated in a cascade below.

For example, a conflict over water resources may be the issue that a user wants to address. Entering Part C in the ToolBox under management instruments, the user will find a chapter on conflict resolution (C5) with a variety of tools. The user may choose to focus on consensus building (C5.3) as the primary goal and study the options listed under the consensus building tools. Going through this, the user may settle on interest-based negotiation as an appropriate approach. The tool is linked to complementary tools, and the user is directed to C 4.4 (communication with stakeholders), C 1 (demand and resource assessment) and A 3.5 (investment appraisal).




The tools are illustrated by real case experience. The cases give examples of how a tool has worked in a given combination and context. Cases are at varying levels of detail and include references to sources of further information.

As the ToolBox demonstrates there are numerous tools available to improve water governance; tools, which differ greatly from each other in their characteristics and the sequence of their use. It is, however, rare for one tool alone to be able to address the identified problems. Given that multiple problem causes are commonplace, it follows that several reforms, using several tools, may be necessary. In addition, for a tool to be effective and acceptable it may often be necessary to embark on several changes at the same time.

A chief shortcoming of the ToolBox is a set of uncoordinated tools without available instructions how to link, integrate and employ them for complete management integration. At the same time, the ToolBox puts insufficient attention to such management tools as water accounting, MIS, adjusting an irrigation schedule, interrelation of irrigation and drainage or surface and ground waters, methods of water use etc. Social mobilization as the powerful tool of initiating the involvement of numerous water users in water governance must play a special role among other tools.

The given chapter presents the most developed and tested methods and tools of introducing IWRM in Central Asian countries.

**Table 5.1**
**List of Tools in the IWRM ToolBox published by the GWP**

| | |
|---|---|
| **A** | **THE ENABLING ENVIRONMENT** |
| **A1** | **Policies - setting goals for water use, protection and conservation.** A group of tools in the ToolBox deal with water policies and their development. Policy development gives an opportunity for setting national objectives for managing water resources and water service delivery within a framework of overall development objectives. |
| **A2** | **Legislative framework - the rules to follow to achieve policies and goals.** The ToolBox includes tools for use in the development of water law. Water law covers the ownership of water, the permits to use (or pollute) it, the transferability of those permits, and customary entitlements and underpin regulatory norms for e.g. conservation, protection, and priorities. |
| **A3** | **Financial and incentive structures – allocating financial resources to meet water needs.** The financing needs of the water sector are huge, water projects tend to be indivisible and capital-intensive, and many countries have major backlogs in developing water infrastructure. The ToolBox has a group of financing and incentive tools. |
| **B** | **INSTITUTIONAL ROLES** |
| **B1** | **Creating an organizational framework – forms and functions.** Starting from the concept of reform of institutions for better water governance, the ToolBox can help the practitioner create the needed organizations and institutions – from trans-boundary organizations and agreements, basin organizations, regulatory bodies, to local authorities, civil society organizations and partnerships. |
| **B2** | **Institutional capacity building – developing human resources.** The ToolBox includes tools for upgrading the skills and understanding of public decision-makers, water managers and professionals, for regulatory bodies and capacity building for empowerment of civil society groups. |
| **C** | **MANAGEMENT INSTRUMENTS** |
| **C1** | **Water resources assessment – understanding resources and needs.** A set of tools are assembled to assist water resources assessment. Assessment starts with the collection of hydrological, physiographic, demographic, and socio-economic data, and setting up systems of routine data assembly and reporting. |
| **C2** | **Plans for IWRM – combining development options, resources use and human interaction**. Tools are available for river and lake basin planning entailing the comprehensive assembly and modeling of data from all relevant domains. The planning should recognize the need for parallel action plans for development of the management structures. |
| **C3** | **Demand management - using water more efficiently.** Demand management involves a set of tools for balancing supply and demand focusing on the better use of existing water withdrawals or reducing excessive use rather than developing new supplies. |
| **C4** | **Social change instruments – encouraging a water-oriented civil society.** Information is a powerful tool for changing behavior in the water world, through school curricula, university water courses and professional and mid-career training. Transparency and product-labeling are other key |

aspects.

**C5 Conflict resolution – managing disputes, ensuring sharing of water.** Conflict management has a separate compartment in the ToolBox since conflict is endemic in the management of water in many countries and several resolution models are described.

**C6 Regulatory instruments – allocation and water use limits.** A set of tools on regulation is included covering water quality, service provision, land use and water resources protection. Regulations are key for implementing plans and policies and can fruitfully be combined with economic instruments.

**C7 Economic instruments – using value and prices for efficiency and equity.** The ToolBox holds a set of economic tools involving the use of prices and other market-based measures to provide incentives to consumers and to all water users to use water carefully, efficiently and avoid pollution.

**C8 Information management and exchange – improving knowledge for better water management.** Data sharing methods and technologies increase stakeholder access to information stored in public domain data banks and efficiently. complement more traditional methods of public information.

## 5.2 Monitoring Water Sources and Water Use

**(R.R. Masumov)**

Monitoring water sources and water use is one of ways to improve water management efficiency. The efficiency of water resources use depends on well-handled impacts of specific IWRM instruments on behavior of water users [3] including the following tools:

- ***Building water knowledge*** (workshops, training seminars);
- ***Technological tools*** (water measurement devices);

The given section presents technological tools. Establishing the appropriate water measurement system on all water sources and arrangement of all available information in a common database are of top-priority value under water governance. At that, it is necessary to note that if this activity was earlier organized at top levels of water management hierarchy rather well, may be, without sufficient control, then at the level of water users (present WUAs) the status of the stream-gauging network, water measurement and accounting system including processing and analyzing data is quite low. The IWRM-Fergana Project may be presented as the good example of improving water use efficiency through employing monitoring tools.

Monitoring activity was initiated in 2002 by the field checkup of waterworks on pilot main canals resulting in the drawing up of the list of hydrometric equipment requiring replacement or partial modernization. Replacement of gauging rods (water-depth rods) was implemented at all gauging stations and posts on pilot canals. Modern flow-meters were procured to personnel of all hydro-operational sites under the Canal Administrations (CA). In addition, the IWRM-Fergana Project has held training seminars for CA staff and prepared the manual on water measurement and accounting for the specialists servicing the pilot main canals. On-the-job training in calibration of the gauging stations with using new propeller-type current meters (ISB-01) and a tube-type current meter (GTR-type) that are given in Figure 5.1 was held for the CA staff.

In the process of training, a great consideration was given to the accuracy of available information on flow rates. Participants of training seminars have selectively analyzed flow rate charts and tables for the balance and check gauging stations on the pilot irrigation canals. The analysis has shown that flow rate characteristics calculated for some head and balance gauging stations had impermissible inaccuracy (more than 5%) due to changes in the hydraulic regime at the gauging station resulting from side-slope erosion, sedimentation etc.


An action plan was developed to improve the situation related to an accuracy of flow rate measurements by means of elimination of above-mentioned causes. After rehabilitation of canal cross-sections in the vicinity of gauging stations, the Canal Administration has held on-the-job training for personnel covering the adjustment of a discharge rating curve at gauging stations and preparation of new equations and computational tables using the PC for calculating flow rates.

Putting the obligatory four-time measurements a day into practice of all the water-gauging divisions at all balance and check gauging stations on the pilot canals is another action for improving the accuracy of water accounting practice. All these measures have also allowed entering reliable data on flow rates into the database of the on-line information system that can be used for designing the canal waterworks automation.


**Figure 5.1 Instruments for Flow Rate Measurements**

More precise definition of flow rates of pumping units withdrawing water for irrigation is also critical for improving the accuracy of water accounting. Ultrasonic flowmeters installed on discharge pipelines of the pumping stations in the end of 1990s have failed now due to the lack of proper O&M by the special service of manufacturers. At present, pumping stations' discharges are estimated using the design parameters of pump units. Taking into account that service life of many pump units exceeds 20 years it is possible to assume that the estimate of discharges using the design parameters of pump units can be rather inaccurate. In 2007, this fact was proved by the special measurements of flow rates at the alignment downstream of one pumping station withdrawing water from the SFC. Comparison of flow rates that were measured and computed using the design parameters of pump units has shown the discrepancy in about 30%. Thus, equipping of the pump units with modern flowmeters and updating the discharge rating curves of pump units by means of the traditional flow rate measurements are a topical task that allows improving the accuracy of water accounting on the pilot irrigation canals.

During the growing season of 2002, the field surveys of waterworks on secondary and tertiary canals were implemented under *the Component "WUAs."* These surveys have revealed that all off-takes into private farms and dekhkan farms were not equipped with water-measurement means and regulators. Water accounting and analyzing of water allocation among primary and secondary water users are not conducted within WUAs' areas. As a result of these surveys the needs in equipping all off-takes into private farms and dekhkan farms with water-measurement means were specified. All types of standard water-metering facilities and ancillary hydrometric equipment that allow operating them without special calibration were recommended for equipping off-takes (Table 5.2).

**Table 5.2**
**Summary table of standard water-metering facilities and ancillary hydrometric equipment necessary for pilot WUAs (based on data of field surveys in 2002)**

| Water-metering facilities and ancillary hydrometric equipment | Pilot WUAs "Akbarabad" | Water-metering facilities and ancillary hydrometric equipment | | |
|---|---|---|---|---|
| | | | "Akbarabad" | |
| Weir | 7 | Weir | 7 | Weir |

| Water-metering facilities and ancillary hydrometric equipment | Pilot WUAs "Akbarabad" | Water-metering facilities and ancillary hydrometric equipment | | |
|---|---|---|---|---|
| | | | "Akbarabad" | |
| Flow-measuring flume | 35 | Flow-measuring flume | 35 | Flow-measuring flume |
| Fixed channel | 16 | Fixed channel | 16 | Fixed channel |
| SANIIRI orifice | - | SANIIRI orifice | - | SANIIRI orifice |
| Water-depth rod | 86 | Water-depth rod | 86 | Water-depth rod |
| Hydrometric bridge | 30 | Hydrometric bridge | 30 | Hydrometric bridge |

Necessary gauging equipment was manufactured by the special-purpose factory "Suvasbobuskunmash" in Tashkent (Uzbekistan) and delivered to the pilot WUAs in January 2003. Equipping of water users' off-takes with water-metering facilities was implemented in successive steps. First of all, the training seminars for WUAs' water users covering issues of construction and operation of water-metering facilities and their calibration (preparing the passport of water-metering structures) were held. Constructing the gauging stations and posts equipped with different types of water-measuring devices was being implemented under direct supervising of the specialist in hydraulic measurements, and this allowed providing a good quality of works (Fig. 5.3).

**a) WUA «Zarafshan»;**

Constructing the gauging posts equipped with SANIIRI flow-measuring flumes "WLS" was conducted by two methods. The first method is the on-site manufacture of flumes using collapsible portable formwork for pouring concrete; and the second one is delivery and assembling pre-cast flumes (Figure 5.4).

**b) WUA «Japalak»**

**Figure 5.3**
**Gauging posts equipped with Chipoletti weirs: where: 1 – Chipoletti weir; 2 – stiffening bar; 3 –gauging rod "RUG"**

a) On-site manufacturing flumes using collapsible portable formwork

b) Assembling pre-cast flumes

**Figure 5.4 Constructing gauging posts equipped with SANIIRI flow-measuring flumes "WLS"**

A high quality of the gauging posts enabled the pilot WUAs' personnel to certify the ready-built gauging posts in timely manner and without any comments from the National Standardizing Authority. Equipping all off-takes with water-metering facilities was confidence-building measure of water users to water management organizations regarding water allocation. A special form for submitting applications for irrigation water was developed and introduced in the pilot WUAs for more active involving of water users in the process of water management and allocation. As a result, each water user could submit his application for irrigation water beforehand. WUA's personnel was reviewing the applications of each water user and establishing priorities of water distribution for next ten-day period. Introducing such an order enabled the WUA's personnel to establish the rigid schedule of water distribution in accordance with the daily water use plans drawn up beforehand and to supply irrigation water to all water users taking into consideration their real demands in fairer manner. It is necessary particularly to note that, first of all, an end user receives irrigation water according to the established schedule of irrigation water distribution and delivery (Figure 5.5). The so-called "publicity board" recommended by the project personnel and demonstrated in each WUA plays an important role in disseminating information on a sequence and rate of water delivery to each water user on the daily base.

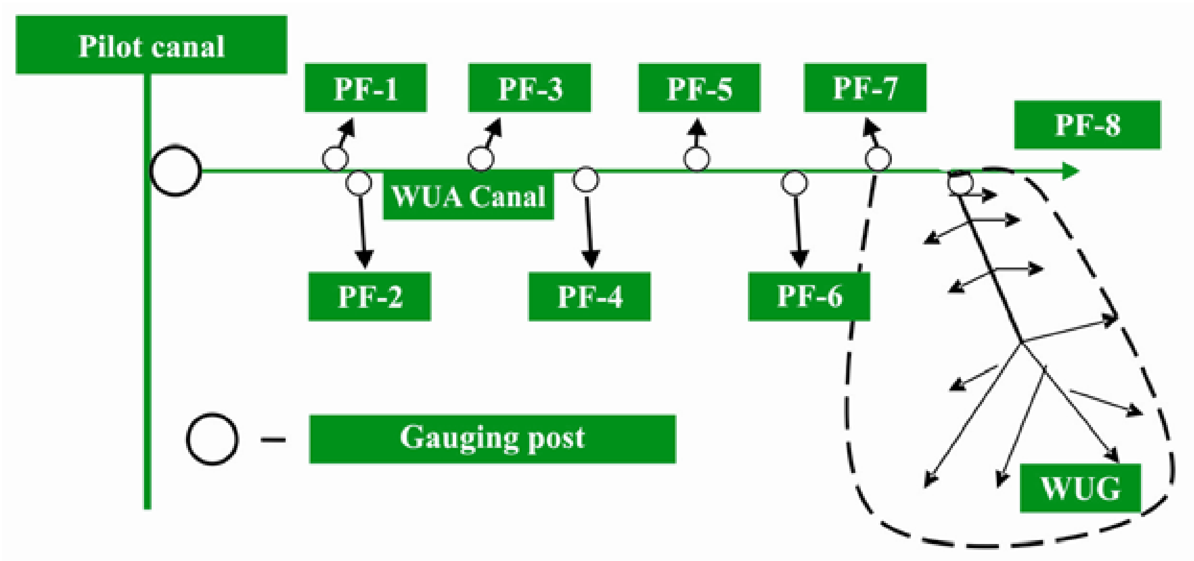



**Figure 5.5 A Linear Network of the Secondary Canal in the WUA**

In addition, the programs of training seminars included topics related to the water accounting in WUAs (daily three-time water measurements at the gauging posts with writing down into the register of an established format) along with on-the-job training of water users covering water measurements using water-metering devices and their maintenance. WUAs' personnel were completely procured with the methodological guidelines developed in the frame of the project (e.g. "Manual on Water Measurement and Accounting for WUAs' Specialists").

By the end of 2004, these measures allowed WUAs' personnel to solve their major task – equitable water distribution among WUAs' members resulting in lowering the level of social tension.

At present division of private and dekhkan farms is in progress within pilot WUAs in the project area. In 2007, according to survey data, the number of private and dekhkan farms in the WUA "Zarafshan" in Tajikistan and in the WUA "Akbarabad" in Uzbekistan has almost doubled in comparison with 2004, and their number in the WUA "Japalak" in Kyrgyzstan has increased up to five thousands. At the same time, in our opinion, the level of availability of water measurement facilities in WUAs has to be reasonable. The project consultants have therefore proposed grouping small farms (see Figure 5.5) into water user groups (WUGs) with delegating their powers to an elected leader who will be responsible for water distribution. In this case, the right of each water user to have water-metering device at his off-take cannot be excluded. Hypothetically, in the process of fund accumulation, raising awareness of the need to support accurate irrigation water supply, and economic strengthening of WUAs, each farmer or another water user will hold an interest in installing water-metering device at his off-take to avoid excess payment and to have grounds for defending his water demands against the WUA.

One cannot be restricted only by activity related to equipping the canal network, WUAs, farms and other water users with water-metering facilities. It is also necessary to provide the methodology and means for specifying numerous indicators (e.g. volumes and quality of return water permissible for reuse) that are important not only for water management organizations and land reclamation agencies but also for water users themselves for successful water use and management, as well as for evaluating the water use efficiency and impacts (see Chapter 3).

It is necessary to establish the system of monitoring and evaluating return water that can be used for irrigation. In dry 2006 and 2007, when available water resources were limited, many WUAs in the SFC command area were forced to use drainage water from inter-farm collector-drains and tubewell drainage (TWD) for irrigation. In particular, drainage water was used for irrigating 300 ha in the WUA "Akbarabad" located in the command area of canal RP-1, raising water availability by 25-30%, on average. At the same time, in some places temporary cofferdams were arranged in collector-drain channels for diverting drainage water by gravity resulting in backwater and raising groundwater table on adjacent areas and, finally, in deteriorating the water and salt balance on lands of upstream WUAs. Therefore, drainage water use must be organized under supervision of the PHAE that is responsible for monitoring drainage water disposal through inter-farm collector-drains.

Climatic conditions essentially affect amount and timing of water applied. For example, rainy and belated spring, relatively cool summer and warm and dry autumn were observed in 2007. Therefore, rapid information on changes in the water and salt balance within the area where drainage water was used for irrigation and daily and long-term forecasts of the Hydro-Meteorological Service were very important. All this information should be promptly transferred to the WUA Council to develop appropriate measures aimed at adjustment of water consumption, lowering groundwater table and preventing soil salinization in the command areas of inter-farm collector-drains.

## 5.3 Evaluating and Managing Water Demands

**(Sh.Sh. Mukhamedjanov, M.G. Khorst, N.N. Mirzaev, G. Stulina)**

The tools simple for understanding and use were developed in the frame of IWRM-Fergana Project for management of the irrigation and agricultural practice, namely the modeling software that can be easily applied by local specialists, taking into consideration available data, in order to draw up the irrigation schedule. Three versions of the modeling software "Daily Computing the Water Balance and Irrigation Schedule" were developed. The first one is based on daily measurements of evaporation in a field. The second one, that uses the formula suggested by S. Ryzhov, is based on daily measurements of the soil water content in a field; and finally third version is based on the model «CROPWAT» [32] with using climatic data (air temperature, rainfalls, relative air humidity, wind velocity). The first two models that are used by local consultants and specialists at the provincial and regional level were designed for timing irrigations and specifying their amounts. The model "CROPWAT" is designed for forecasting and adjusting timing and amount of water applied by the regional specialists. In the process of their developing, the models "Daily Computing the Water Balance and Irrigation Schedule" and «CROPWAT» were tested and calibrated by using field data on actual soil water content. Precondition for providing the required accuracy of calculations is the reliability of daily field measurements and data on soil parameters determined on each demonstration field in the course of special field surveys.

For assessing and analyzing the actual practice of water applications, we have calculated the optimal amounts and dates of irrigations based on data on soil characteristics on each demonstration field, rainfall, evaporation, watertable depth and initial soil water content, and then compared them with amounts that were calculated based on soil moisture deficit. Irrigation water demand depends on the field water balance, crop water requirements and soil water content. Computations of daily water balances for all demonstration fields under cotton were carried out. As a result of these computations, water requirements, amounts and dates of water applications and inter-irrigation periods were established.

Monitoring of actual irrigations over the whole growing season was implemented for comparative analyzing the adequacy of actual water application rates to the estimated ones. It was determined that at the initial phase of project implementation, actual basic indicators of irrigation considerably differed from the estimated ones. For example, unproductive water applications were observed in September and October in farms of Soghd Province (Figure 5.6). In accordance with computations, the water application rates ranging from 700 to 1200 $m^3$/ha would provide optimal soil moisture for crops up to the end of the growing season.

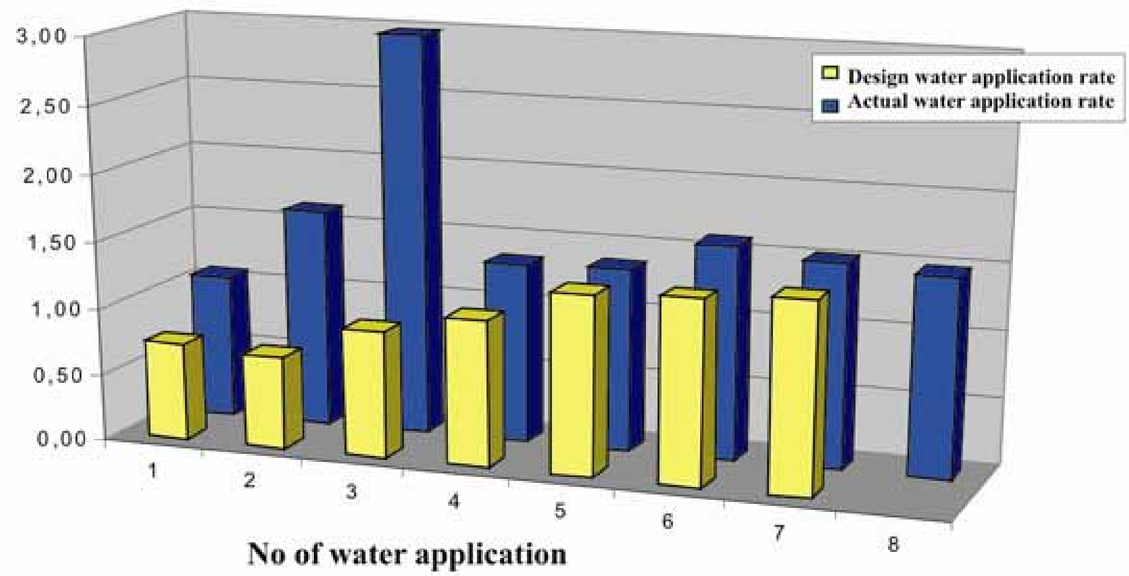



**Figure 5.6 Water Application Rates in the Farm "Bokhoriston" in 2002 (000' $m^3$/ha)**

Extra irrigations can only lead to slowdown of natural ripening of cotton and opening cotton bolls. Insufficient applications of water (both by amounts and timing) took place in farms "Sayed" and "Samatov" in July and August. In Fergana Province, actual irrigations close to the estimated irrigation schedule were observed in three farms with different soil and hydro-geological conditions. Actual irrigation norms exceed the estimated ones two times and even more in farm "Khojalol-Ona-Khodji" where thin topsoil is underlain by the pebble layer with considerable water permeability (Figure 5.7). In accordance with modeling computations more frequent water applications by smaller rates should be more efficient on these plots.

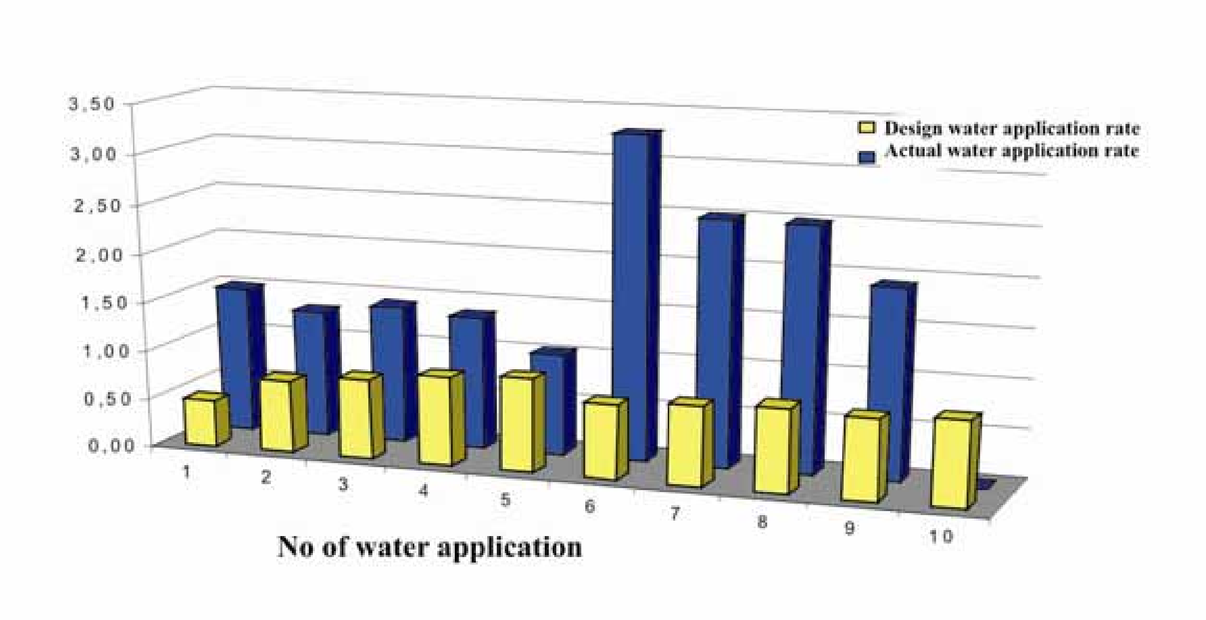



**Figure 5.7 Water Application Rates in the Farm "Khojalol-Ona-Khodji" in Fergana Province in 2002 (000' m$^3$/ha)**

There is some discrepancy in timing and amounts of actual water applications with estimated ones in the farm "Tolibjon" under implementing the same number of irrigations. It was determined that the first belated water application with a high rate disturbed the uniformity of following irrigations (both by amounts and timing). In accordance with computations of daily water balances, the optimal rates for water applications amounts to about 1100 m3/ha with an inter-irrigation period of 15 to 20 days.

In Osh Province, actual rates of water applications coincide with estimated values (only the first over-application of water was observed) but there is some discrepancy in timing. Analyzing soil water content prior to the first irrigation in the farm "Sandyk" has shown that there were not the need to apply high irrigation rates because abundant rainfalls were in May and actual soil moisture deficit on 3rd June amounted to only 505 m$^3$/ha while actual water application made up 1463 m$^3$/ha (Figure 5.8).

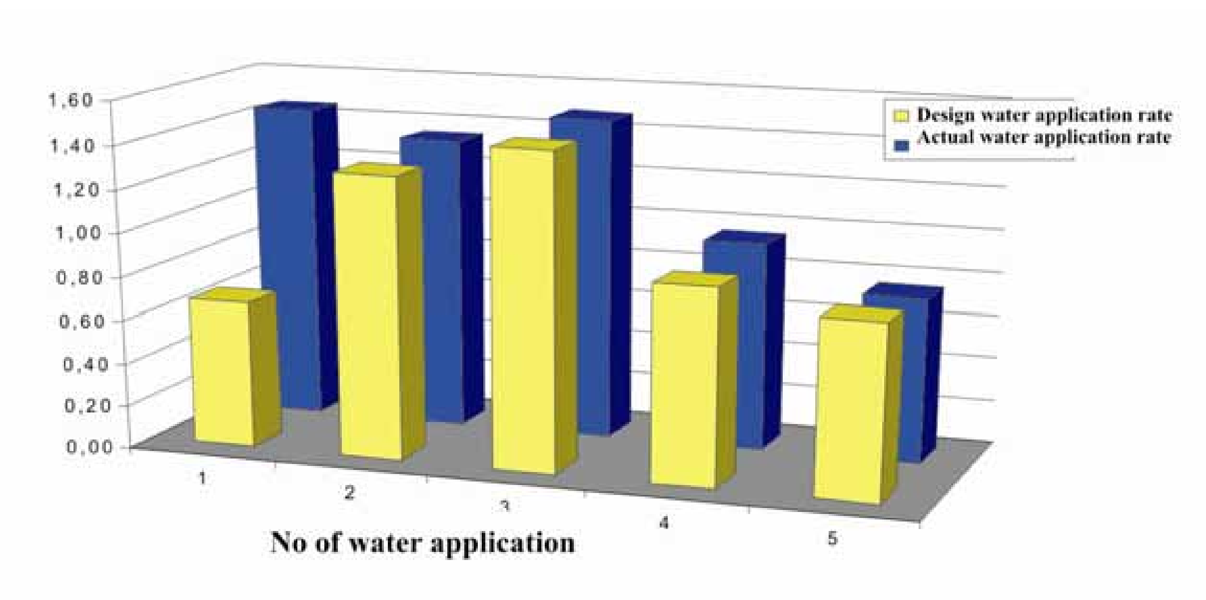



**Figure 5.8 Water Application Rates in the Farm "Sandyk" in 2002 (000' m$^3$/ha)**

**Water application management based on the project recommendations:**

In 2003, scheduling of irrigations basically depended on current weather conditions. This issue should be considered in detail because weather conditions in that year required considerable amendments in irrigation water use, date of sowing, and soil treatment. As subsequent months have shown, a fault in these matters was worth much. Only timely and correct measures implemented at the pilot sites have saved the 2003 yield.

Analyzing meteorological data in March and April enabled the regional project group to identify a more accurate sowing date for cotton that was shifted to later terms than usual. It was recommended to start the sowing season in the end of April or in the beginning of May. Most of farms under pressing of local authorities were forced to start the sowing season in the beginning of April. As a result most of private farms have re-sown cotton in May. Shifting sowing dates has predetermined adjusting the irrigation schedule. Frequent abundant rainfalls in May alternated with sunny days without precipitations did not allow determining real water demand using the simulation program for its computation. It was the situation when the soil-water content over the soil profile was sufficient but an upper soil layer started to dry up. In usual years, plants would grow normally without irrigation because in mid of May a depth of root system makes up more than 10 cm, and roots can extract required water from soils. In that year, a root system of cotton, which was behind the normal growth (a rootage depth was less than 10 cm), could not extract required water from soil horizons where the moisture content was quite sufficient. Computational models have not shown the necessity in irrigation; however, based on assessing an actual situation, the decision was made to start the first water application by small rates in farms which conducted the sowing in the first ten-day period of April. Farmers, who conducted the sowing in the end of April and in the beginning of May, have made watering only to stimulate young growth and then waited for next irrigation in June.

Planning next water applications on each demonstration site was carried out based on the formula suggested by S. Ryzhov and modeling the daily water balance. The regional group, parallel to local specialists, has set daily data on evaporation and a width of shading into the model "Daily Computing the Water Balance and Irrigation Schedule." Daily data were transferred from provinces to the regional office by e-mail. Analyzing the results of modeling for May has shown that there is not the need in irrigation under daily evaporation ranging from 2 to 8 mm/day (a cumulative soil moisture deficit amounted to 12 -24 mm).

The need in the first water application over demonstration sites has arisen since mid until the end of June. Setting a date of water application is carried out based on the results of modeling with some advance time (2-3 days); for this purpose, data on soil moisture deficit and evaporation for a past day are being analyzed. Input data for a past day are set into appropriate boxes of the computational model (a few days in advance in order to specify a date of water application ahead of time). A date of water application is checked and, if necessary, adjusted according to data on actual soil water content, which is measured by observers on demonstration field each two-three days. Pre-irrigation soil water content (a refill point) used for specifying a date of water application is accepted as 70% of field capacity (FC) for all fields on average. Following dates of irrigations were set in line with the same sequence analyzing modeling data on evaporation and soil water content.

**Evaluating water applications and changes in soil water content on demonstration fields:**

Assessment of soil water content was conducted using data of actual measurements in the field. Sampling to measure soil moisture was performed on demonstration field each five days in May and each three days in mid of the irrigation season. On some fields (the farm "Khojalol-Ona-Khodji"), where frequent water applications are needed, a soil water content was measured each two days. A nature of soil moisture distribution depends not only on climatic conditions but also soil properties and hydro-geological conditions in the farms and can vary even within one field.

In Soghd Province, the period of reducing soil water content from FC to the limit when the need in irrigation arises (an irrigation interval) lasts 25 to 30 days in May; in June and first half of July this period makes up 20 days; and in the second half of July and until the end of August the intensity of soil water consumption is increasing and reducing in soil water content up to "wilting point" occurs during 7-8 days (Figure 5.9).

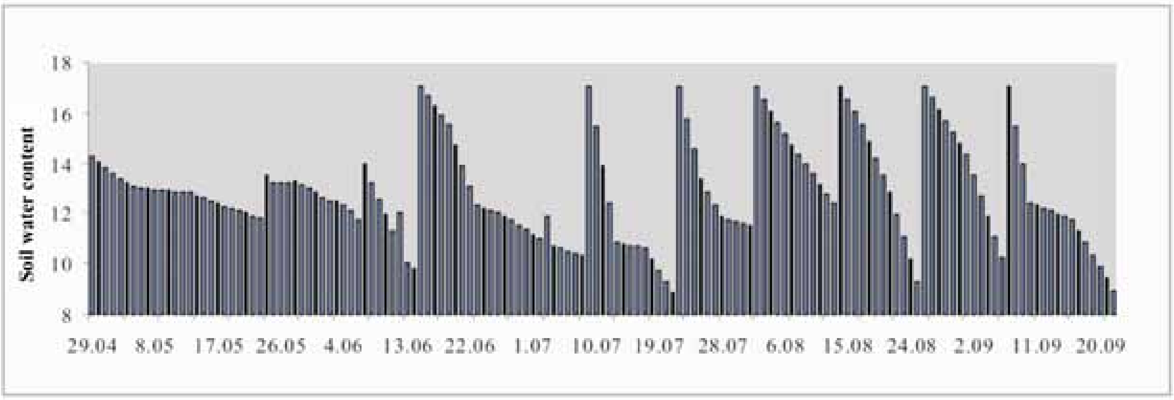



**Figure 5.9 Changes in the soil water content during irrigation intervals[24]**
**(Soghd Province, the Farm «Bokhoriston»)**

If in Soghd Province (Tajikistan) soil and hydro-geological conditions are similar in farms then in Fergana Province (Uzbekistan) these conditions considerably differ over farms and even over fields within one farm. Changes in soil water content also occur according to different patterns in different farms. In the farm "Khojalol-Ona-Khodji", after rainfalls in May and until 10th June, the period of reducing soil water content up to the limit when the need in irrigation arises lasted 20 days, then since July and until the end of the growing season, the period of consumption of water stored in soil amounted to 7 to 8 days (Figure 5.10). Absolutely other situation was observed in the farm "Turdialy" where, due to shallow groundwater table, perceptible reducing the soil water content was not observed during the whole growing season. Changes in soil moisture content on the demonstration field depend on fluctuations of watertable; and any correlation between decrease in soil water content and increase in air temperature was not revealed. Only after irrigation, reducing soil moisture close to field capacity was observed.

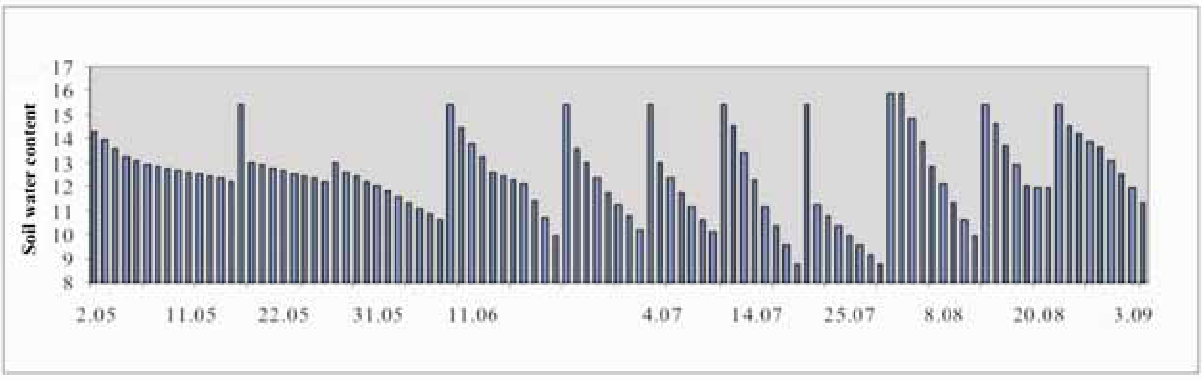



**Figure 5.10 Changes in the soil water content during irrigation intervals**
**in the farm "Khojalkhonona Khoji"**

In Kyrgyzstan, on the demonstration field under winter wheat, irrigation was needed only in May and June. At that, rainfalls in that period have conditioned the dynamics of soil water content, which is quite sufficient for proper crop growth. Decrease in soil water content started in the mid of June; and only one water application with a small rate was needed in June in the farm "Toloykon" (Figure 5.11).

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[24] The *irrigation interval* is the time between subsequent irrigations.

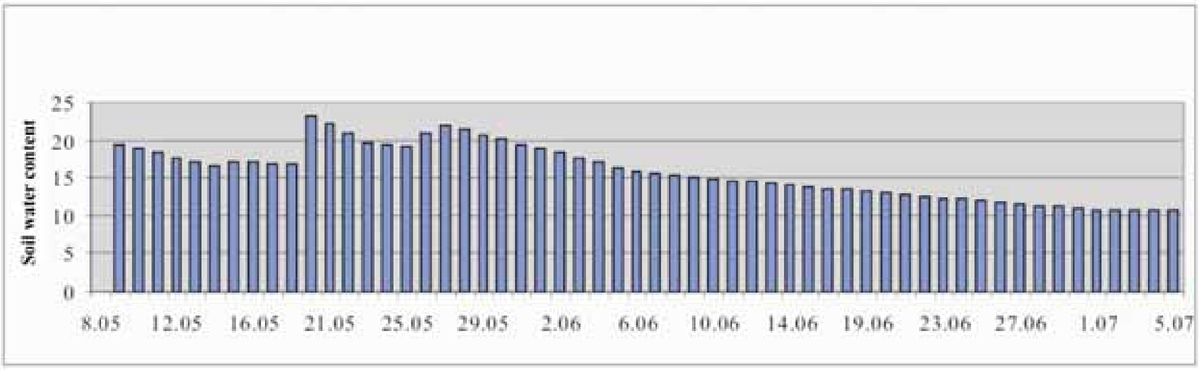



**Figure 5.11 Changes in the soil water content during irrigation intervals in the farm "Toloykon" in Kyrgyzstan**

**Assessment of evaporation on demonstration fields:** Evaluating the evaporation demand of the atmosphere was carried out by daily measurements using atmometers «Atmometers» (ET gage®) that were installed on each demonstration field. The evaporation from a field surface depends on air temperature changing over a year and a specific month. Evaporation values varied over the range of 5 to 12 mm/day during the growing season. The least evaporation values of 1 to 3 mm/day were observed in the first ten-day periods of May and June. Maximum evaporation values of 10 to 12 mm/day were being observed since the second half of June until 20th July. Although, it is necessary to note the non-typical reducing evaporation values in the end of June and in July, which sometimes were reaching 5-6 mm a day.

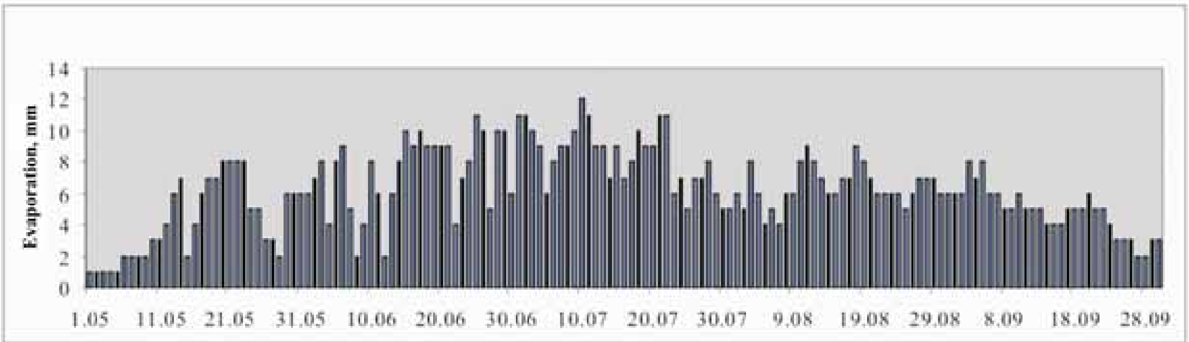



**Figure 5.12 Evaporation values measured on the demonstration site "Bokhoriston"**

Lower values of evaporation and precipitations have predetermined scheduling of irrigations (in May and at the beginning of June, irrigation was not required on all pilot fields). There is some distinction in evaporation values over the regions and some private farms. Maximum mean evaporation rates over the whole growing season were observed in Soghd Province in Tajikistan (7-8 mm/day), at the same time, in Fergana Province in Uzbekistan, mean evaporation rates were ranging from 6 to 7 mm/day, and in Osh Province in Kyrgyzstan from 4 mm/day in the upper zone (the farm "Toloykon") to 7 mm/day in the lower zone (the farm "Sandyk").

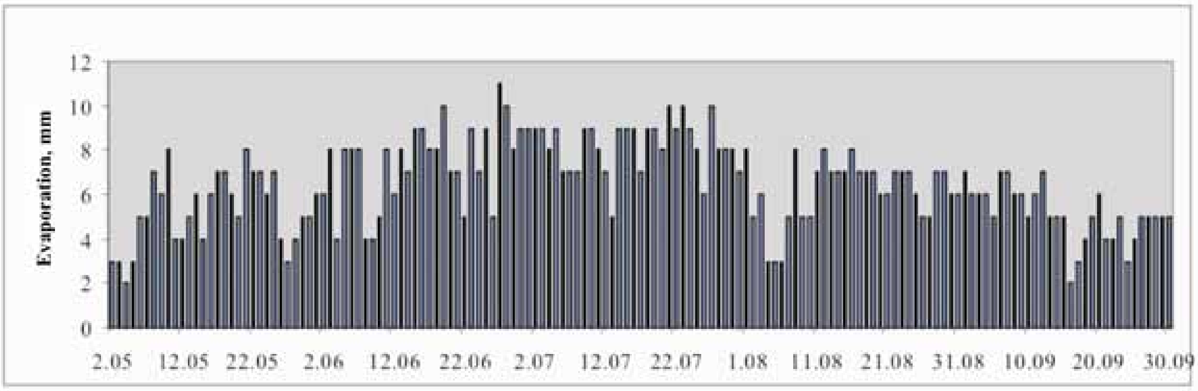



**Figure 5.13 Evaporation values measured on the demonstration site "Khojalkhonona Khoji"**

**Soil moisture content against evaporation on the demonstration fields:** A set of data on soil moisture conditions and evaporation over the growing season allowed us to find out the correlation between these parameters. Measurements of evaporation rates and soil water content in 2003 and 2004 enabled us to compare the soil moisture-evaporation relations for the years with different weather conditions. Both parameters are key factors affecting the irrigation schedule. Under field conditions there are not real possibilities for real-time measurements of soil moisture content but data on evaporation measured at the weather stations are always exist and, moreover, in many instances, satisfactory correlations between air temperatures and evaporation are available. Weather conditions in 2003 have predetermined lower values of daily evaporation and, as a result, more sustainable storage of water in soils. In 2004, weather conditions were more favorable for agriculture with the stable air temperature regime and less amount of rainfalls during the growing season. These conditions, in turn, resulted in higher daily evaporation rates and less sustainable storage of water in soils. The soil water content as a function of evaporation is illustrated in Figure 5.14 (the private farm "Sayed").

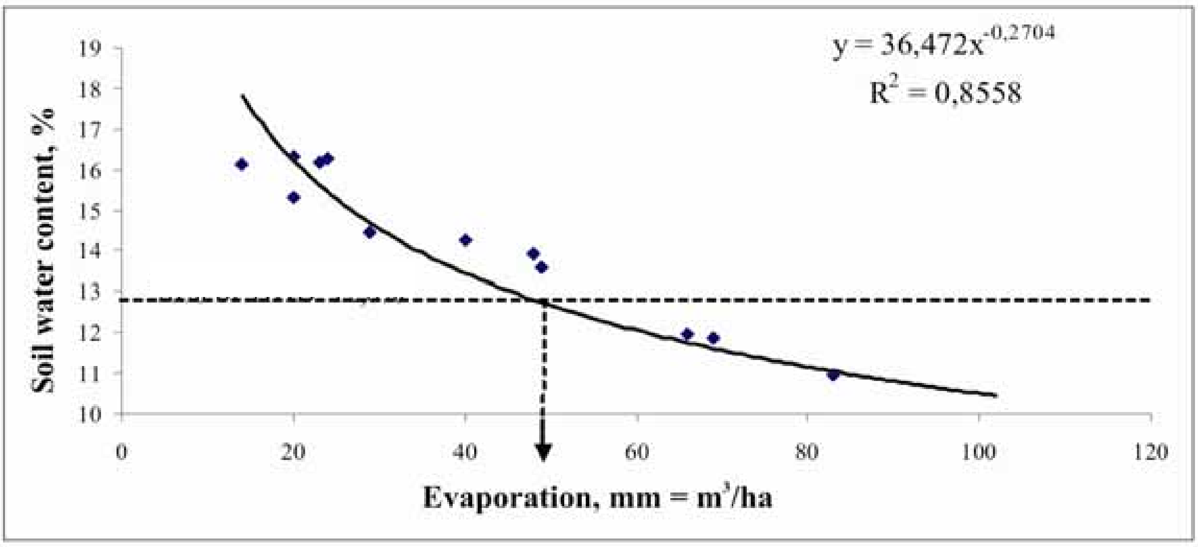



**Figure 5.14 Soil water content as a function of evaporation at the demonstration site "Sayed"**

We recommended this approach for day-to-day forecasting pre-irrigation soil moisture content and timing irrigations if such correlations will be established for each soil-hydrogeological-climatic zone. Under achieving a certain value of daily evaporation (this is happened later in 2003 and earlier in 2004), the soil water content is decreasing up to the level when crops are subjected to water stress (soil moisture deficit). Analyzing the changes in evaporation rates and soil water content has shown that at the project demonstration sites a soil moisture deficit that can cause water stress of crops takes place when total evaporation over an irrigation interval is ranging from 50 to 120 mm, on average. Depending on soil and hydrogeological conditions, the amount of water applied (a net volume of water application in a field) to replenish a depleted soil water storage varies over the range of 500 $m^3$/ha to 1200 $m^3$/ha.

**Adjustment of the irrigation schedule based on analyzing the irrigation practice at demonstration sites:**

Measuring a watertable depth

Reforming the agricultural sector in Central Asian countries resulted in division of large collective farms into small private farms. At that, the system of irrigation water allocation among farms has been changed. In the past, irrigation water allocation based on the principles of crop water requirement zoning and was being carried out by the district water management organizations that were responsible for delivering irrigation water towards the border of a collective or state farm. Irrigation specialists of the collective farm were responsible for irrigation water distribution among the irrigated units (brigades) within these farms. Crop water requirements were established based on area-averaged data and sometimes did not meet the actual requirements of crops in water. Such an approach to irrigation water rate setting was justifiable since irrigation engineers and agronomists were implementing irrigation water allocation within a farm taking into account a flow rate of uniform irrigation water supply specified by the district water management organization. In this case, experienced agronomists and irrigation engineers could adjust the irrigation schedule to actual requirements of specific crops in water.

However, most of farm managers could not adjust the planned irrigation schedule which, on the one hand, was limited by the irrigation water supply rates and, on the other hand, by modified soil and hydrogeological conditions on the given area. As far back as in collective farms, the question regarding the contradiction of the planned irrigation schedule to actual requirements of specific crops in water under modified soil and hydrogeological conditions was being raised. After division of large collective farms into small private farms 10 to 20 hectare in area, decisions on water allocation and specifying the irrigation rates became more problematic. First of all, the methodology for scheduling irrigation water allocation among private farms is absent. Secondly, there are not the well-founded irrigation rates and procedures of scheduling irrigation for specific areas in private farms. Initial studying of water use in private farms has shown that the lack of well-founded irrigation schedules (amounts and timing of water applications) results in stochastic use of irrigation water by farmers during the whole growing season. Wrong use of irrigation water results in water losses, over-irrigation in some areas and insufficient water applied in other areas, as well as in low land and water productivity.

Atmometer (ET gage®)

Therefore, it is important to develop the scientifically grounded irrigation schedules for different crops and soil and hydrogeological conditions, based on which WUAs can develop the well-founded plans of water use, specifying reasonable volumes of irrigation water supply to private farms. In this respect, a key project objective is to study actual crop water requirements at demonstration sites and develop recommendations on scheduling water applications.Project monitoring and evaluation of irrigation water use on demonstration fields that are described in the following sections in detail has allowed to specify the amounts and timing of each water application and to adjust the irrigation schedule for private farms located within the pilot WUAs: “Sayed” in Soghd Province in Tajikistan; “Turdialy” in Fergana Province in Uzbekistan; and “Nursultan-Aly” in Osh Province in Kyrgyzstan. Based on project findings, the modified irrigation schedules were recommended for appropriate WUAs (Tables 5.3; 5.4 and 5.5). The existing (design) irrigation schedule for above-mentioned private farms was developed based on the crop water requirement zoning performed in the 1960s and 1970s. During past decades, water-management, soil and hydrogeological conditions in many irrigated schemes have changed. As a result, the former crop water requirement zoning and design irrigation schedule do not fit with current conditions. For example, irrigated farmlands of the private farm “Turdialy” belonged to Zone II with the automorphic soil formation process[25] according to the former crop water requirement zoning, however, after many years of irrigation and raise of watertable these irrigated farmlands now belong to Zone VII with hydromorphic[26] soil formation process. As a result, the irrigation schedule has to be also changed for the growing season.

**Table 5.3**
**Adjustment of the irrigation schedule for the private farm “Turdialy”**

| | **April** | **May** | | | **June** | | | **July** | | | **August** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ten-day period | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| Design irrigation schedule | 0.00 | 0.0 | 0.0 | 0.5 | 0.5 | 0.6 | 0.6 | 0.8 | 0.9 | 0.8 | 0.6 | 0.5 | 0.5 |
| Recommended irrigation schedule | 0.00 | 0.94 | 0.00 | 0.00 | 0.76 | 0.00 | 0.74 | 0.00 | 0.48 | 0.00 | 0.00 | 0.00 | 0.00 |

As shown in Table 5.3, in practice, water application was needed in the first ten-day period of May. However, according to the irrigation schedule based on the crop water requirement zoning, water application was planned in the third ten-day period of May i.e. the difference between actual and design dates of water application amounts to 20 days. Such a shift in the irrigation schedule results in mismatching of the water use plan and required irrigations. As a result, either reducing crop productivity takes place or modification of WUA’s water use plan and respectively planned water allocation along an irrigation canal as a whole are required.

Comparison of the irrigation schedule based on the crop water requirement zoning and actual irrigation schedule at the demonstration site is illustrated in Figure 5.15. The figure shows that according to the water use plan developed by the WUA, irrigation was not planned for the period since the end of April until the beginning of May, and in July water application rates exceed necessary ones five times; at the same time, irrigation water supply that does not match the real needs of crop in water under existing soil and hydrogeological conditions was planned.

[25] Soil formation without participation (upward recharging) of groundwater
[26] Soil formation with participation of groundwater (according to the classification of Soviet soil scientists)

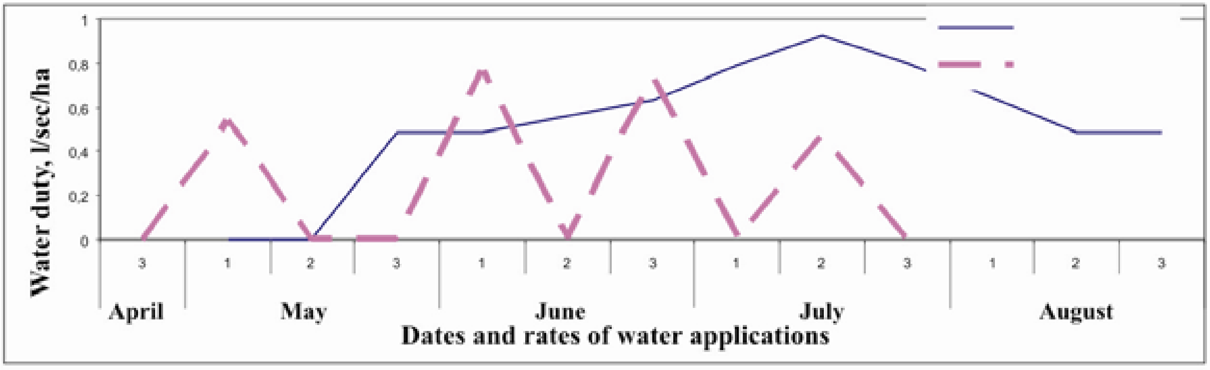



**Figure 5.15 Comparison of the irrigation schedule based on the crop water requirement zoning and actual irrigation schedule at the demonstration site "Turdialy"**

In Soghd Province, the actual number of water applications at the demonstration site was less than according to the irrigation schedule based on the crop water requirement zoning; and crop water requirements were also lower in comparison with design ones (Table 5.4 and Figure 5.16).

**Table 5.4**
**Adjustment of the irrigation schedule for the private farm "Sayed"**

| Month | IV | | | V | | | VI | | | VII | | | VIII | | | IX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ten-day period | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 |
| Design irrigation schedule | 0.13 | 0.51 | 0.13 | 0.0 | 0.29 | 0.61 | 0.7 | 0.8 | 0.91 | 0.99 | 1.1 | 1.3 | 1.03 | 0.82 | 0.72 | 0.36 |
| Recom-mended irrigation schedule | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.63 | 0.0 | 0.99 | 0.0 | 1.07 | 0.0 | 1.41 | 0.66 | 0.79 | 0.69 | 0.91 |

In Osh Province, there are differences in timing, number of irrigations and water application rates for winter wheat (Table 5.5).

**Table 5.5**
**Adjustment of the irrigation schedule for the private farm "Nursultan-Aly"**

| Month | Sep | Oct | | | Nov | | | Apr | | | May | | | June | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ten-day period | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| Design irrigation schedule | 0.93 | 0.0 | 0.0 | 0.33 | 0.33 | 0 | 0.0 | 0.46 | 0.5 | 0.41 | 0.37 | 0.45 | 0.45 | 0.32 | 0.32 | 0.1 |

| Month | Sep | Oct | | | Nov | | | Apr | | | May | | | June | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Recom-mended irrigation schedule | 0.0 | 0.0 | 0.0 | 0.28 | 0.85 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.59 | 0.0 |

Based on the results of comparative assessment, we have adjusted the irrigation schedule, taking into consideration specific soil and hydrogeological conditions on project demonstration fields (Table 5.6).

One of key components predetermining fair water allocation is clear information on actual crop water requirements, taking into consideration time-dependent hydrogeological, soil and climatic conditions. Therefore, in the frame of the IWRM-Fergana Project, the applicability of out-of-date norms and crop water requirement zoning that were approved more than 20 years ago have been analyzed for the whole territory within the SFC command area using the available data in Fergana Province. Analysis has shown that areas with GWT over the range of 1.5 to 2 m increased and, at the same time, areas with GWT over the range of 2 to 3 m decreased and areas with GWT ranging 0 to 1 m appeared; part of areas with a watertable depth more than 5 m has shifted to the range of areas with a watertable depth of 3 to 5 m. Increase in areas referring to Zones VII, VIII and IX (the crop water requirement zoning) practically in all districts is illustrated in Figure 5.16.

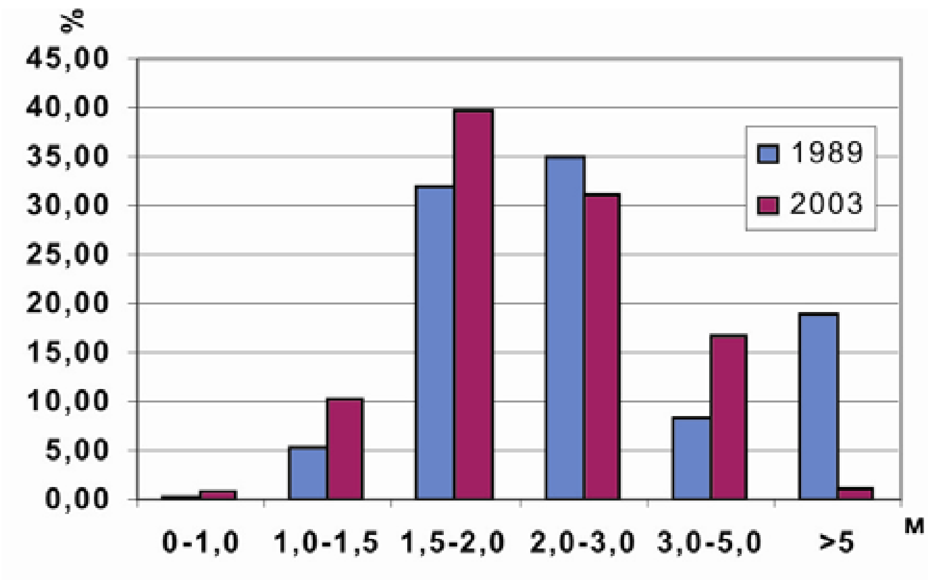



**Figure 5.16 Changes in watertable depth, Fergana Province, Uzbekistan**

**Table 5.6**

**Adjusting the irrigation schedule at demonstration sites under the IWRM-Fergana Project**

| Demonstration site | Water duty zone | Soil characteristics | Irrigation season | Number irrigations | Water application rate, m$^3$/ha | | Water requirement, m$^3$/ha | | Ten-day water duty |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Net | Gross | Net | Gross | liter/sec * ha |
| **Soghd Province** | | | | | | | | | |
| WUA "Obi Zerafshan" (design zoning) | II | Automorphic (GWT > 3 m), medium thick layer, weak-stony loamy sand and sandy-loam soil | IV - IX | 15 | 500-600 | 600-800 | 6566 | 8550 | 0.6-1.3 |
| Demonstration site "Sayed" | II | Automorphic shallow stony sandy-loam underlain with pebble layer | IV - IX | 7 - 8 | 500-600 | 600-800 | 4995 | 6166 | 0.6-1.4 |
| **Fergana Province** | | | | | | | | | |
| Farm "Turdialy" (design zoning) | II | Automorphic (GWT > 3 m) medium thick layer, weak-stony loamy sand and sandy-loam soil | IV-IX | 9 | 500-600 | 600-800 | 5600 | 7500 | 0.5-0.9 |
| Demonstration site "Turdialy" | VIII | Hydromorphic (GWT of 0.5-1.5 m) shallow stony sandy-loam underlain with pebble layer | IV-VIII | 5 | 500-600 | 600-900 | 2976 | 3429 | 0.7-1.0 |
| **Osh Province** | | | | | | | | | |
| WUA "Japalak" ( design zoning ) | 4a | Automorphic (GWT > 3 m) | IX-XI<br>IV-VI | 2<br>4 | | 600-800<br>600-1000 | | 1400<br>3000 | 0.7-0.9<br>0.3-0.5 |
| Demonstration site "Nursultan- Aly" | 4a | Automorphic (GWT > 3 m) thick sandy-loam and loam soils, undulating relief | X-XI<br>IV-VI | 1<br>1 (2) | 900<br>400 | 1200<br>500 | 900<br>400 | 1200<br>500<br>(1000) | 1.4<br>0.5 |

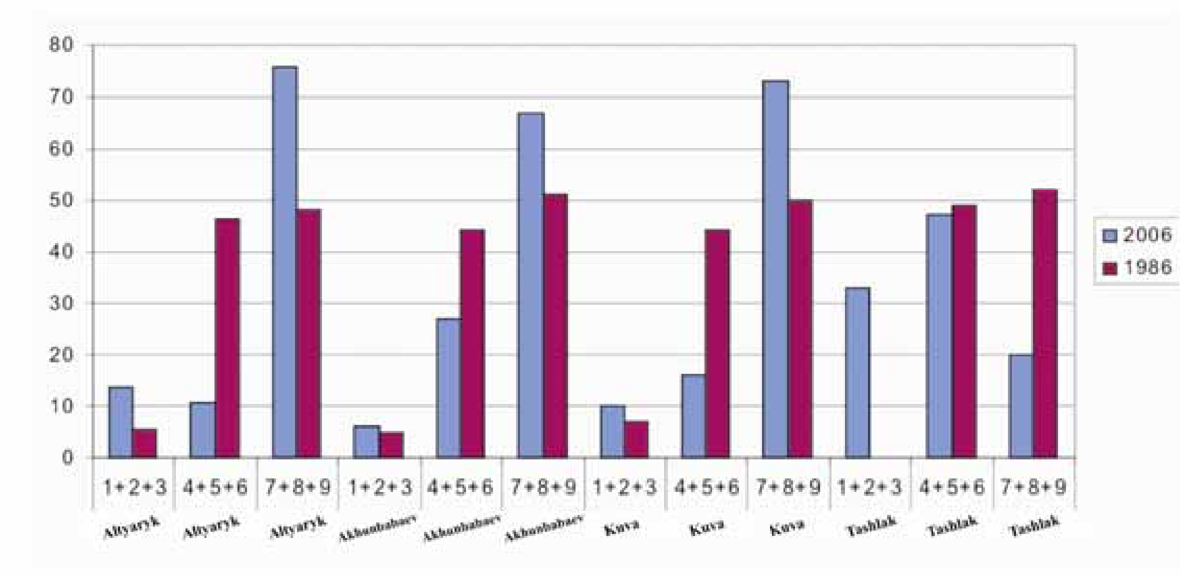



**Figure 5.17 Changes in distribution of irrigated area per the crop water requirement zones in Fergana Valley**

Estimating irrigation water demand for the SFC command area was performed separately for Fergana and Andijan regions, using the following data: areas adjusted to the modified crop water requirement zones; existing crop pattern and areas. The following calculation procedure was employed:

1. Specifying the areas in each modified crop water requirement zone, applying the GIS;
2. Areas under each crop were taken from the database;
3. Percentage of each crop from the total cropped area were calculated since maps of crop pattern are not available;
4. Areas under various crops in each modified crop water requirement zone were calculated proportionally these percentages;
5. Irrigation water demand was calculated as multiplication of an area under specific crop by its water requirement;
6. Crop water requirement is computed for the period since 1st April until 1st October; and
7. Crop water requirement were computed using the program GROPWAT that was calibrated for cotton, new varieties of winter wheat, maize and alfalfa. Water requirements for other crops were specified using the manual “Crop water requirement zoning and irrigation scheduling in Fergana Valley.”

Net irrigation water requirement (without accounting the irrigation system efficiency) computed for the whole SFC command area encompassing all crop water requirement zones in Fergana and Andijan provinces amounts to 522 mln. $m^3$ (Fergana Province – 397 mln. $m^3$, and Andijan Province – 125 mln. $m^3$); and gross irrigation water requirement – 695 mln. $m^3$ (Fergana Province – 529 mln. $m^3$, and Andijan Province – 166 mln. $m^3$).

## 5.4. Water Allocation including On-the-fly Adjusting the Plans of Water Use

**(N.N. Mirzaev, A.I. Tuchin, Alimdjanov A., H. Manthrithilake)**

Establishing Canal Administrations, Canal Water Users Unions, and Canal Water Committees on the pilot SFC, AAC and KBC in the frame of the IWRM-Fergana Project created the background for solving organizational problems of water distribution. However, establishing of these institutional frameworks is not an end in itself. They are needed for creating the environment (openness, transparency etc.) for achieving another key objective – ensuring equitable (uniform), sustainable and effective water distribution. Analyzing the traditional systems of water distribution has shown that not only organizational and technical problems but also technological issues can be mentioned due to the following constraints:

- Lack of proper methods for drawing up the plans of water use (PWU);
- Lack of developed procedures for adjusting the plans of water use;
- Questionable baseline information;
- Lack of the effective process of drawing up the plans of water use; and
- Lack of proper procedures for implementing the plans of water use.

Thereby, the need in the alternative water distribution management system (AWDMS) has arisen [38]. In the broader sense, the AWDMS means the water distribution management system based on the IWRM principles. In the narrow sense, the AWDMS is the system of organizational and technological procedures of water distribution management aimed at observance of the principles of equity, sustainability and efficiency.

The principle of equity should be observed at the stage of planning and adjusting the water use plans, when the key tasks of the CA and CWC are the following:

- to draw up plans of water use and distribution correctly reflecting the water needs of water users;
- to establish the limits (quotas) of water use in the equitable manner taking into consideration available water resources and water users' applications.

The principles of sustainability, uniformity, flexibility and efficiency must be observed at the stage of implementing the water use plans. At this stage, during the growing season, the key tasks of the CA and CWC are the following:

- Enhancing the stability of water delivery from the canal and streamlining operation of pumping stations;
- Providing the uniform irrigation water supply to water users (WUAs and collective farms) and to laterals (groups of laterals) according to established limits during the irrigation season;
- To allow water users to adjust efficiently ten-day water consumption from their canals, in reasonable limits;
- To minimize operational and organizational water losses within the irrigation system.

*Organizational aspects of the AWDMS*

1. Governance of water distribution is implemented with participation of water users through the CWC;
2. The CWC creates the environment of openness and transparency for ensuring the principles of equitable (uniform), sustainable and effective water distribution;
3. Seasonal and ten-day plans of water use are developed and approved by the CA after co-ordination with the CWC;
4. All conflicts and disputes between water users and the CA are discussed and settled by the members of the CWC (Arbitration Board) or with their participation;
5. All information on conflicts and disputes between water users and the CA, as well as water users' proposals on improving the system of water use and distribution should be collected and documented in the CWC;
6. The CWC has to work in close cooperation with the Water Inspection;
7. CWC sessions should be organized both in the CWC office and directly at sites of the irrigation system to rise awareness of water professionals and water users and to discuss topical issues of water distribution;
8. The CWC informs stakeholders and the general public about its activity results.
9. Basic tasks of the CA and CWC:

a) at the stage of planning and adjusting the water use plans:

- to draw up the water use plan (correctly as much as possible);
- to establish the limits of water use in the equitable manner.

b) at the stage of implementing the water use plan:

- Enhancing the stability of water delivery from the canal (streamlining ten-day irrigation water supply and operation of pumping stations);
- Providing uniform irrigation water supply to water users and to laterals (groups of laterals) according to established limits during ten-day periods and over the irrigation season as a whole;
- To provide the flexibility of water distribution; and
- To minimize operational and organizational water losses within the irrigation system by introducing different kinds of water rotation, if expedient.

*Technological aspects of the AWDMS*

1. The following types of managing the irrigation systems are existing:

- Tactical management (running, seasonal and annual);
- Day-to-day management (ten-day period management and daily management);

2. Tactical management of the on-farm irrigation system includes:

- Drawing up the water use plan (for growing and dormant seasons);
- Seasonal adjusting the water use plan.

3. Day-to-day management of the on-farm irrigation system includes:

- Adjusting the water use plan for the next ten-day period (calculation of ten-day water limits and adjusting irrigation water supply);

- Day-to-day adjusting the water use plan (adjusting the planned limits and water delivery into the canal or a group of canals);
- Implementing the modified water use plan.

4. Main canals, laterals and on-farm distribution canals and their groups are the objects of management;
5. Grouping the irrigation canals. Canals are grouped according to their belonging to water users within one irrigation unit (a water-balance site).

## Planning and adjusting the water use plans (schedulining)

***Seasonal planning***

- Water use plans are drafted for different options of water availability in water sources (wet year, average year, dry year) and various weather conditions during the growing season (a rainy spring, hot summer etc.);
- Under seasonal planning, water demand (planned water delivery) of water users (a canal, group of canals etc.) is established for the growing season (April to September) or for dormant season (October to March) taking into account the irrigation schedule and technical parameters of the irrigation system;
- Seasonal planning of water distribution is carried out based on detailed and specified data on:
- water losses within the irrigation system and on a field;
- a carrying capacity of irrigation canals;
- crop pattern and areas (taking into consideration interim and secondary crops);
- availability of internal water resources (return water, irrigation tube-wells, springs etc.);
- an irrigation schedule;
- crop water requirement zoning;
- An option of the water use plan for the coming season is chosen based on the refined forecast of annual water availability.

***Seasonal adjustment***

- Under conditions of water deficit the water use plan may be adjusted for the irrigation season, ten-day period and on the daily base. Non-agricultural water users (the needs of public utilities, industry, nature etc.) exercise a privilege and their water supply rates can not be reduced;
- Adjusting the water use plan should be made due to the following reasons:
  - Changes in irrigated area or crop pattern (based on actual data on areas under crops);
  - Stable difference between water availability in the water sources and planned amounts estimated based on monthly forecasts regarding water availability; and
  - Stable difference between actual weather characteristics and mean annual weather data (abundant rainfalls, higher temperatures etc.).
- Planned quotas for laterals (group of secondary laterals) for a coming season are specified in the process of seasonal adjustment, taking into account the planned quota established by a superior water management organization for the main canal. A quota is an amount of irrigation water (in absolute or relative values) that is prescribed to a water user (canal, group of canals etc.). It is necessary to distinguish a planned quota for the estimated period (a season, ten-day period) and an

actual quota. Limits that are established by the ministry for the SFC or "water allocation percentages" that are used for the KBC are essentially the planned quotas for irrigation water supply;

- A planned quota for the SFC is a seasonal or ten-day limit established by the ministry; for the AAC – a ten-day water withdrawal according to the plan of water allocation; and for the KBC – an estimated (expected) flow during a ten-day period under consideration that is calculated taking into consideration a mean annual discharge of the Khodjibakirgan River and water diversion by Kyrgyz water users;
- A planned quotas for laterals should be specified applying one of two approaches:
  - An approach based on the principle of uniform irrigation water supply (the traditional principle of proportionality when the planned quotas for main canals and their laterals are adjusted for ten-day periods using a single proportionality factor established for the whole irrigation system);
  - An approach based on the principle of equal general water availability (the alternative principle when the quotas are differentially established taking into account a share of industry, water withdrawal from internal water sources and use of groundwater by crops).
- Choice of an approach of calculating the planned quotas for each canal is also the competence of the CWC.

***Adjustment of the Water Use Plan for a Ten-Day Period***

- Initial adjusting the planned quota taking into account the actual irrigation water supply during the previous period;
- Calculation of the planned quotas for laterals (group of secondary laterals) in coordination with applications for a coming ten-day period;
- Secondary adjusting the planned quota when a total irrigation water limit for the main canal is less than the planned quota plus an amount of water according to applications;
- Iterative calculation of the planned quotas in coordination with the secondary adjusted (increased) planned quota with applications for a coming ten-day period for laterals (group of secondary laterals). An application is a planned irrigation water demand of a water user (lateral, secondary laterals etc.) depending on current natural and economic conditions. An application can cover a ten-day period or its part (intra- ten-day period).
- Applications for the following ten-day period should be submitted by water users to the CA three days before the beginning of the following ten-day period, and applications for an intra- ten-day period – one day before changes in water delivery into the canal;
- Lack of an application can be interpreted in two ways: a) as lack of water demand; and b) as compliance with the planned quota. In the first case, submitting of an application is the rule, and the lack of an application is an exception to the rule. This approach is acceptable for the SFC and AAC. In the second case, submitting of an application is an exception to the rule, and the lack of an application is the rule. This approach is acceptable for the KBC;
- After termination of the estimated ten-day period, an actual quota and actual water limit for the canal is specified based on actual data. A limit is an amount of irrigation water (in absolute or relative values) which the CA has to delivery to lateral (a group of secondary laterals) during a ten-day period. It is necessary to distinguish a planned limit for the estimated period (a ten-day period) and actual irrigation water limit.

***Adjusting the Water Use Plan within a Ten-Day Period***

- Redistribution of irrigation water among laterals within a group of laterals in the range of planned limits established for a group of laterals is permissible during a ten-day period. The redistribution is implemented in coordination with downstream subdivisions of the CA (hydro-operational sites) based on the secondary applications (for intra-ten-day periods);

- The possibility to redistribute irrigation water among laterals within a group of laterals complicates the water distribution process but rises the flexibility of water management and water productivity;
- The need of adjusting during a ten-day period can be caused by natural factors (rainfalls, return water) and on-farm production factors (for example, fields are not ready for water application because furrows were not cut or missing of fertilizers took place).

***Implementation of the water use plan***

- At the stage of implementing the modified water use plans, the key task of water managers is to minimize deviations actual irrigation water supply from the planned limits during a ten-day period; and
- A role of the CWC that has to facilitate the compliance with principles of sustainability, uniformity and efficiency of water distribution is especially important.

### 5.4.1 Planning Water Use at the Level of WUAs - the Plan of Daily Water Use based on the Irrigation Schedule

Hundreds and even thousands of private farms with an irrigated area ranging from 0.3 to 20 ha have replaced former collective farms and state farms under reforming the agricultural sector in Central Asian countries. In former large farms, irrigation water was delivered with constant flow rate since the beginning until the end of the growing season to the brigades having an area of 150 ha and more. During the irrigation season, an area serviced by one brigade was being subdivided into several irrigated units (irrigation maps). A foreman, after receiving water for irrigation, was distributing this water with constant flow rate to each irrigation map by turn.

At present, a lot of small farms that replaced former brigades in collective farms and state farms create considerable difficulties for organizing water distribution among new water users.

If a water use plan for continuous water delivery with an estimated flow rate to each water user having small irrigated plot will be developed then unproductive irrigation water losses and duration of water applications will be considerably increased due to small flow rates. But if a water use plan aimed at irrigation of former brigade’s area will be developed then it will be complicated to specify to whom among numerous water users, when during the ten-day period and with what flow rate irrigation water should be delivered.

On the other hand, independently from sizes of their irrigated area, all water users hold an interest in receiving required irrigation water for each water application during a short time period (1 to 5 days). The existing irrigation network was however designed based on a specific water duty specified by the crop pattern (as a rule, for the rotation of cotton and alfalfa and irrigation intervals of 10 to 25 days).

Keeping in mind above-listed circumstances, it was proposed to use the daily planning of water distribution (within a ten-day periods during the growing season) to ensure uniform and equitable water distribution among water users within WUAs. This approach allows to reduce organizational irrigation water losses and to enhance the discipline of water use. Under shifting towards the daily planning of water distribution it is necessary:

- to specify who among water users will receive irrigation water by a continuous flow and who by a discontinuous flow based on the technical characteristics of the irrigation network within a WUA;
- to follow strictly the established irrigation schedule based on the crop water requirement zoning for a given irrigated area under planning terms and rates of irrigation water supply to water users;

A daily water use, as a rule, is planned for one large canal with a command area of 200 to 800 hectares within a WUA or for a few small canals with the total command area more than 200 hectares.

**Procedure for arranging daily water use within a WUA:** It is proposed to plan daily water use within a WUA in four successive steps.

***Step 1: Gathering the information on crop patterns in the command areas of irrigation canals within a WUA***

In the end of February, water users receiving irrigation water directly from irrigation canals within a WUA or leaders of water users groups *(see Step 3)* have to submit their data on crop pattern planned for the forthcoming growing season to the WUA's irrigation engineer.

***Step 2: Specifying the type of water delivery to WUA's irrigation canals and off-takes of water users***

***According to carrying capacity of laterals and off-takes, water users can be referred to two types:***

- water users receiving irrigation water by continuous flow; and
- water users receiving irrigation water in specified periods by discontinuous flow i.e. according to the water rotation schedule.

Sometimes water users associations do not possess any information on a maximum carrying capacity of their irrigation canals and water users' off-takes. Therefore, during the process of planning daily water delivery into water users' laterals (with continuous or discontinuous flow) it is advisable to specify the irrigated areas serviced by these laterals. In case of a relatively small irrigated area (1 to 50 hectares), concentrated discontinuous water delivery into water users' off-takes is advisable. But when an irrigated area exceeds 50 ha[27], water delivery should be provided with continuous flow.

In the future when WUAs will have the actual information on a carrying capacity of their irrigation canals and water users' off-takes it will be necessary:

- to specify the method of irrigation water delivery into canals and water users' off-takes (by continuous flow or by concentrated discontinuous flow); and
- to develop additional measures to enlarge the carrying capacity of laterals and water users' off-takes.

***Step 3: Establishing WUGs on tertiary canals and their laterals***

Following the previous provisions, it is practical to unite water users having an irrigated area less than 50 hectares into water users groups (WUGs) and to deliver irrigation water to their off-takes by concentrated discontinuous flow under organizing the water rotation among water users-members of these groups.

[27] 60 and more hectares can be accepted in newly constructed irrigated schemes

### *Step 4: Planning daily water use in the command area of WUA's irrigation canal*

Under specifying daily irrigation water demand of water users, all calculations are based on the irrigation schedule. Water management organizations (BISA and Rayselvodhoz[28]) have the information on water users' irrigated farmlands belonging to specific crop water requirement zones and the recommended irrigation schedule as well.

***Daily water use in the command area of WUAs irrigation canal is being planned in the following sequence:***

1. At the beginning, daily irrigation water demand of water users receiving irrigation water by continuous flow[29] is being computed;
2. Daily irrigation water demand of water users receiving irrigation water by concentrated discontinuous flow is being computed;
3. In view of the fact that during the growing season, each water user grows two or three crops the irrigation schedules of which differ from each other not only by the number and rates of water applications but also irrigation intervals, daily irrigation water demand of water users should be computed for each crop. Therefore, groups of farmers who grow similar crops are formed within WUAs and WUGs.
4. Further, a period, during which irrigation water demand of water user can be met, is being computed under assuming that irrigation water by concentrated flow is delivered i.e. all water flow necessary for irrigating the first group of crops is directed into his off-take, and the sequence of irrigation water supplies to each farmer who irrigates a given crop is specified;
5. Then, estimated daily irrigation water demand of water users receiving irrigation water by continuous flow and concentrated discontinuous flow is consolidated into the summary table. Required daily flow rates in canals that deliver irrigated water to WUAs are calculated taking into consideration water delivery losses (a canal efficiency factor).

### Seasonal and operational adjusting of the plan of daily water use

***Seasonal adjusting of the plan of daily water use***

A preliminary plan of daily water use in the command area of a WUA's canal for the forthcoming growing season is drafted in the end of February or in the beginning of March based on mean annual weather data. Seasonal adjusting of the plan of water use is made in March-April each year. A water management organization establishes the irrigation water use limits of WUAs for the growing season in accordance with water availability in the current year.

A WUA, being informed about irrigation water use limits, specifies a water availability factor using the following formula:

$$K_{\text{water availability}} = \frac{\textbf{Irrigation water limit for a WUA (000' m}^3\textbf{)}}{\textbf{Crop water requirement (000' m}^3\textbf{)}}$$

[28] District subdivision of the Ministry of Agriculture and Water Resources

[29] Irrigation water by continuous flow is delivered to off-takes of homestead plots or to water users having large irrigated plots

Updating of volumes and flow rates of daily irrigation water delivery to WUAs and water users established in the preliminary plan of daily water use and delivery is being fulfilled based on a water availability factor.

***Operational adjusting of the plan of daily water use and providing the procedures for coordination of water resources management between a WUA and farmers as well as between a WUA and the SFC Administration***

***Actual terms of irrigation water delivery to water users can be changed depending on:***

- Current water availability in a irrigation water source;
- Current meteorological parameters;
- Planting date;
- Crop growth at a given period of the growing season; and
- Progress in implementing land treatment etc.

Above-mentioned factors sometimes are the reason for adjusting the plan of daily water use. In addition, organizing the actual water distribution among water users should be implemented in accordance with their applications for irrigation water. At the same time, organizing of the first water application[30] or the first cycle of irrigation water delivery to water users in line with the water rotation schedule is especially important under distributing irrigation water among water users according to their applications.

Submitting an application for water by a farmer is evidence of his readiness to irrigate crops i.e. the following operations were executed prior to irrigation water delivery:

- His irrigation network was cleaned from weeds and sediments;
- Irrigation furrows were already made;
- An appropriate amount of necessary fertilizers is applied; and
- A sufficient number of irrigators are available.

Operational adjusting of the plan of daily water use and providing the procedures for coordination of water resources management between a WUA and farmers as well as between a WUA and the WMO consist of three mandatory stages:

***Stage 1:*** Collecting, registration and systematization of farmers' applications for irrigation water and scheduling daily water delivery into WUA's canals;

***Stage 2:*** Submitting the WUA's summary application for irrigation water to the Irrigation System Administration (ISA) and receiving the ISA's notification about a possible water delivery according to a WUA's application for a forthcoming ten-day period taking into account forecasted water availability; and

***Stage 3:*** Operational adjusting the schedule of daily water delivery into WUA's canals in accordance with the ISA's notification about a possible water delivery in a forthcoming ten-day period, and implementing the measures for using internal reserves with the purpose to improve water availability in a WUA.

[30] It can be implemented by supplying water to one farmer 3-4 days before a planned date of the first water application and on 3-4 days later to another farmer because such deviations insignificantly affect the crop growth, but further irrigations should more strictly meet the recommended irrigation schedule.

***Procedures for collecting, registration and systematization of farmers' applications for irrigation water and drafting and adjusting the schedules of daily water delivery into WUA's canals***

A WUA's irrigation specialist takes applications filled by water users according to the special format. The following data are filled in the first part of application:

- A name of a private farm;
- An irrigated area;
- Crops to be irrigated; and
- An irrigated area under each crop.

The following data that should be specified and agreed by a water user and WUA's personnel are filled in the second part of application:

- A rate of water application for each crop, m3/ha;
- An agreed flow rate of irrigation water supply into a farmer's off-take, l/sec;
- Duration of irrigation water supply, hrs;
- The beginning and end of irrigation water supply (date and time).

A WUA's irrigation specialist has to register an application submitted by a water user in the registration book of applications for irrigation water supply. Further, based on registered applications for irrigation water supply, the irrigation specialist is scheduling the water distribution process among WUA's members, taking into consideration the following factors:

- Belonging of irrigated farmlands to specific crop water requirement zones;
- An irrigation schedule (duration and rates of water applications); and
- A carrying capacity of irrigation canals and off-takes of water users.

***All these factors closely link each water user with others within WUA's irrigation system.***

4 days before a forthcoming ten-day period, an irrigation specialist submits the WUA's summary application for irrigation water supplies to the WMO. In its turn, the WMO, after reviewing the applications and expected water availability, notifies a WUA about possible irrigation water supply in the forthcoming ten-day period. Along with the total irrigation water demand, the WUA's summary application for irrigation water supplies contains information on volumes of planned irrigation water supplies or water use limits to enable the WUA and WMO to monitor its adequacy to the planned indicators in a forthcoming ten-day period. Big main irrigation canals deliver water for irrigating a hundred and more of thousands of hectares. Volumes of water diversion into the main irrigation canals are established by higher water management organizations based on water availability in the water sources (reservoirs) by the beginning of a next ten-day period.

After receiving information on water volumes allocated to the given main irrigation canal, its administration calculates a water availability factor (relative to the plan or water use limit for a forthcoming ten-day period). Further, the CA specifies irrigation water volumes that can be allocated to WUAs based on water availability in the main canal and makes an appropriate record into the WUA's application.

After allocating irrigation water volumes to a WUA for a forthcoming ten-day period, its irrigation specialist calculates a water availability factor and adjusts the schedule of daily water distribution into irrigation canals within the WUA and makes appropriate modifications in the summary table of daily irrigation water distribution.

**Monitoring water use within a WUA**

Tabulated indicators of planned and actual irrigation water supplies to WUA's canals including the schedules of daily water distribution within WUGs need to be available for monitoring irrigation water allocation and use within a WUA. Monitoring water use in a WUA is carried out in two successive steps:

**Step 1**:

Analyzing actual irrigation water supply by the WMO into WUA's irrigation canals. At this stage the following tasks should be solved:

- Monitoring the implementation of irrigation water delivery relative to the water use limits established and plan:
  - ✓ Over a WUA as a whole;
  - ✓ Over the WUA's major irrigation canals.
- Evaluating the stability of irrigation water delivery to a WUA over a specific period;
- Calculating irrigation water supply by progressive total:
  - ✓ Over a WUA as a whole;
  - ✓ Over the WUA's irrigation canals.
- Evaluating the uniformity of irrigation water distribution between WUA's irrigation canals over a specific period;
- Calculating an efficiency factor of WUA's irrigation canals over a specific period;
- Specification of the water sources (a main canal, irrigation or drainage tubewells, collector-drains etc.) that provide the necessary volume of irrigation water supply over a WUA as a whole and its separate irrigation canals;
- Adjusting daily volumes of irrigation water distribution among water users.

Analysis of the factors of daily and ten-day period's irrigation water delivery into WUA's canals enables to evaluate the stability of irrigation water delivery to WUAs by the WMO relative to the plan/water use limits, applications and agreed volumes and flow rates of irrigation water supply. Actual irrigation water delivery by the WMO into WUA's irrigation canals ranging from 90 to 110% of the plan indicators over a specific period is considered as satisfactory and not affecting adversely crops [21].

**Step 2:**

Monitoring water distribution among water users within a WUA that allows solving the following tasks:

- Keeping track of implementing the plan, water use limit and applications for each WUA's canal;
- Monitoring the number and quality of water applications during the growing season;
- Monitoring the terms and rates of irrigation water supply for each water application during the growing season;
- Record keeping of planned and actual areas under crops that were irrigated;

- Record keeping of irrigation water withdrawn from different water sources (a main canal, irrigation or drainage tubewells, collector-drains etc.) for growing crops in a WUA during the growing season;
- Calculation of actual efficiency factor for WUA's canals;
- Monitoring the uniformity of irrigation water distribution among WUA's water users; and
- Evaluating the infringement of interests of water users whose off-takes are located along the tail section of WUA's irrigation canals.

Shortcomings in water distribution and use are revealed and proper operational decisions for their eliminating are made based on the analysis of a situation after each water application of crops during the growing season. For the purpose of involving water users in the water distribution process and improving access to monitoring findings the basic indicators are demonstrated on special-prepared stands of publicity. Schedules of daily water use per each off-take and group of water users with information on crops, dates of irrigations, flow rates and order of receiving water by each water user are demonstrated on these stands. WUAs' irrigation specialists should daily record and then demonstrate an actual progress in water distribution and use. Based on keeping track of implementing the schedule of daily water distribution and in case of deviation from planned indicators, a WUA's irrigation specialist together with water users adjust the schedule of daily water distribution.

## Participation of WUA's members in the process of water distribution

Participation of WUA's members in the process of water distribution depends on the form of relations of water users with the WUA's management. For example, in Uzbekistan, farmers sign the agreement on irrigation water delivery directly with the WUA's management while owners of plots attached to their houses sign the agreement on irrigation water delivery with the WUA's management through the village administration.

In Tajikistan and Kyrgyzstan, there are isolated cases when some water users sign the agreement on irrigation water delivery directly with the WUA's management, but joint interests of most of small water users (having an irrigated area ranging from 0.04 to 0.6 ha) are represented by dekhkan farms, cooperatives or self-government institutions.

Every year, at the end of February or at the beginning of March, the WUA management collects information on the crop pattern on the command area of each off-take and groups the plots of water users according to their belonging to specific crop water requirement zones. Water users are subdivided into a few groups according to cultivating of specific crops in each crop water requirement zone. If one water user cultivates a few crops then he can be a participant of a few groups, which cultivate those or other crops.

At the end of February or at the beginning of March, WUA's irrigation specialist drafts the schedule of daily irrigation water delivery for each crop. Based on the schedule of daily irrigation water delivery, the WUA's management signs the agreements with each water user or a WUG.

After planting each crop, time and duration of irrigation water supply to water users established in the schedules are adjusted based on their applications and depending on actual water availability. Each water user is informed about a modified schedule of daily irrigation water delivery.

Two approaches to establishing water user groups (WUGs) on tertiary and lower level irrigation canals can be proposed for efficient and fair distribution of irrigation water:

**Under the first approach,** each water user singly signs the agreement on irrigation water delivery with a WUA's management. The WUA's management schedules irrigation water distribution among water users in accordance with the irrigation schedule and irrigation water use limits. A WUA delivers irrigation water up to each water user's off-take according to this schedule. In case of disputes between WUA's irrigation specialist and a water user relative to issues of water use, a WUG's leader elected by water users participates in conflict resolution. A WUG's leader is acting on a voluntary basis. The key tasks of WUG's leader are to act as a mediator between water users and a WUA and to assist a WUA irrigation specialist in implementing the schedule of water distribution established for a WUG.

**Under the second approach,** WUG's members delegate their powers to a WUG's leader. A WUG's leader signs the agreement on irrigation water delivery with a WUA on behalf of a WUG. With technical assistance of a WUA's irrigation specialist, a WUG's leader schedules the sequence of irrigation water delivery to WUG's members. After receiving irrigation water from a WUA, a WUG's leader provides its delivery to an off-take of each water user according to the agreed schedule of water distribution. The upkeep of a WUG's leader and running costs are reimbursed by WUG's members.

***Tasks of the WUG's leader are the following:***

- Gathering information on crops cultivated by WUG's members and submitting this information to a WUA management;
- Collection and systematization of applications for irrigation water supply adjusted for cultivated crops that are submitted by WUG's members;
- Submitting the summary application to a WUA on behalf of a WUG and setting terms and duration of irrigation water delivery into WUG's canals; and
- Operative adjusting the schedule of irrigation water distribution within a WUG.

WUA's personnel fix a flow rate and water delivery duration for each crop at the WUG's off-take, and a WUG's leader starts to distribute irrigation water among WUG's members. For example, if water is supplied for irrigation of vegetables, the WUG's leader supervises in order that only those who cultivate vegetables should receive this water, and if water is supplied for irrigation of cotton only those who cultivate cotton should receive this water etc. In case of infringing the established sequence of irrigation water receiving by some water users, the WUG's leader together with WUA's personnel take measures for community-based correction.

For both types of WUGs, the Makhalla Committee selects one person (irrigator) for the remunerative work related to arrangement of water distribution at each off-take to homestead lands. He should daily receive water at off-take, in WUA irrigation specialist's presence, and distribute water among water users. WUA's irrigation specialist should assist an irrigator of homestead lands to determine a flow rate for the irrigation network of homestead lands and duration of water delivery towards separate plots.

### A role of social initiators in organizing water distribution within WUGs

Under irrigation water distributing, WUA's administration face different problems which require participation of water users for their solving. Specially trained social initiators should be involved in solving these problems. At that, social initiators have to know existing problems and ways for their settling, as well as to enjoy water users' confidence.

At the meetings with water users, social initiators must explain to them the current situation related to water distribution. At the same time, they have to possess knowledge on advanced methods of water distribution and to be able to explain to water users, in a popular and understandable form, their efficiency and mechanisms of introducing new methods of water distribution.

From time to time, a WUG holds meetings for discussing water distribution and other issues and also for electing a WUG's leader or irrigator. Participants of these meetings specify rights and duties of a WUG's leader delegated by water users including the right to sign the agreement with a WUA on behalf of a WUG and to represent the WUG interests at the WUA's sessions.

A campaign of social mobilization for introducing a new method of water distribution lasts until a moment when water users themselves will start to participate in the process of water use planning and implementing in full measure. When specially trained social initiators are absent the WUA's Council takes upon itself the functions of solving water users' problems and appoints one of its members as a person responsible for solving arisen problems jointly with water users.

### Experience of establishing WUGs learnt from the WUA "Akbarabad"

In 2005, water users groups (WUGs) were established on tertiary laterals "Damarik", "Navoi-3" and "Navoi-4" in the WUA "Akbarabad." Homestead lands occupy 10 to 30% of a total irrigated area in each WUG. The number of private farms in groups varies from 7 to 8 with an irrigated area ranging from one hectare (the private farm "Mamajanov") to 40 hectares (the private farm "Nurmat-Otai"). Owners of homestead lands delegated their powers to a representative of the Makhalla Committee.

**Table 5.7 Information on Water Users Groups in the WUA "Akbarabad"**

| No | Name of tertiary lateral | WUG | Irrigated area, ha | Number of off-takes | Including homestead lands | |
|---|---|---|---|---|---|---|
| | | | | | Number of off-takes | Irrigated area, ha |
| 1 | Damarik | «Damarik» | 149.6 | 12 | 3 | 52 |
| 2 | Navoi-3 | «Navoi-3» | 98 | 8 | 1 | 10 |
| 3 | Navoi -4 | «Navoi-4» | 129 | 9 | 1 | 15 |

All private farms and the representative of the Makhalla Committee have signed the agreements with the WUA. In accordance with the agreement, the WUA has organized water delivery to WUGs in line with the irrigation schedule within limits for irrigation water use and provided the uniform distribution of water withdrawn from the SFC among WUA's water users. Irrigation water received under supervision of the WUA's representative was being distributed among owners of homestead lands by the makhalla irrigators (mirabs). WUGs' leaders assisted WUA's personnel in the following fields:

- Implementing the schedule of water distribution among the WUG's members that was drafted according to their applications;
- Cleaning the WUG's irrigation network two times during the growing season based on voluntary participation of community members in these works;
- Collecting payment for WUA's services;
- Preventing and resolution of different conflicts between WUG's members;
- Recommendations on improving the practice of water distribution among WUA's water users;
- Rising of water users' awareness regarding the proper organization of water applications using science-based rates, terms, and duration of irrigation of crops; and
- Mobilizing water users for construction of gauging stations on WUGs' off-takes.

As shown in Table 5.8, the uniform water distribution between water users located along head and tail sections of the irrigation canal was provided last years. While in 2005, water availability ranged from 129% to 135% of planned water delivery along head part of the irrigation canal and from 60% to 75% of planned water delivery along tail part of the irrigation canal, in 2007, water availability in tail part of the irrigation canal (WUGs "Navoi-3" and "Navoi-4") amounted to 100% of planned water delivery and in head part of the irrigation canal – 96% respectively due to the well coordinated work of WUA's personnel and WUGs' leaders that was based on the method of daily water use scheduling.

**Table 5.8**

**Dynamics of Uniformity of Water Distribution (in % of the irrigation water use limit)**

| No | WUG | 2005 | | 2006 | | 2007 | |
|---|---|---|---|---|---|---|---|
| | | Head part of the WUG's canal | Tail part of the WUG's canal | Head part of the WUG's canal | Tail part of the WUG's canal | Head part of the WUG's canal | Tail part of the WUG's canal |
| 1 | «Damarik» | 135 | 60 | 105 | 85 | 100 | 97 |
| 2 | «Navoi-3» | 129 | 70 | 110 | 82 | 95 | 100 |
| 3 | «Navoi-4» | 130 | 75 | 103 | 87 | 96 | 100 |

While in 2005 the number of disputes between the WUA and WUGs' members amounted to 5 in 2006 their number decreased up to 3 and in 2007 only one incident was registered. As a result of the active explanatory work of WUGs' leaders, the considerable progress was made in improving the situation related to collecting of a fee for WUA's services. While in 2005 only 58% of services have been reimbursed in 2007 95% of WUA's services were paid for. Especially it is necessary to mention the practice of collecting a fee for services of the WUA "Akbarabad" from owners of homestead lands (Table 5.9).

**Table 5.9**

**Disputes between WUA's Personnel and WUG's Members and Fees for Services of the WUA "Akbarabad"**

| No | WUG | 2005 | | 2006 | | 2007 | |
|---|---|---|---|---|---|---|---|
| | | Number of disputes | WUA's services paid, % | Number of disputes | WUA's services paid, % | Number of disputes | WUA's services paid, % |
| 1 | «Damarik» | 2 | 56 | 1 | 60 | 1 | 95 |
| 2 | «Navoi-3» | 1 | 55 | 1 | 68 | 0 | 94 |
| 3 | «Navoi-4» | 2 | 62 | 1 | 54 | 0 | 95 |
| Over WUG | | 5 | 58 | 3 | 61 | 1 | 95 |

Table 5.9 shows positive changes in both the situation related to disputes between WUA's Personnel and WUG's Members and in collecting of fees for WUA's services.

## The information-management system "Fergana"

Under drastic increasing in the number of water users, the traditional practice and methods employed by water management organizations cannot undoubtedly provide collecting, processing, and analyzing a huge volume of information formed at all levels of the water management hierarchy for decision-making. Modern technique with its advanced capabilities in the field of computerization and informatics is one of IWRM pillars. Therefore, the information-management system "IMS-Fergana" aimed at evaluating and validating different methods of water resources allocation in the agricultural sector with the purpose to improve the efficiency of water use has been developed in the frame of the IWRM-Fergana Project. The "IMS-Fergana" solves various water management tasks at different stages of managing the water distribution process.

As was already mentioned, the IWRM pillar is the multilevel hierarchy of the water management framework and integrating of all its components. This framework is completely serviced by the set of mathematic models and information flows of the database built-in into the information-management system "IMS-Fergana." Optimal water resources distribution among all stakeholders when each level of water management hierarchy has own efficiency criteria is provided through processing information flows (simulated models and the database) on an annual, monthly and ten-day period basis. An overall target function supports the integrated water management strategy established for the system as a whole.

***The information-management system "IMS-Fergana" allows:***

1. to monitor the following aspects within the irrigation scheme:

- changes in crop patterns;
- modification of crop water requirement zoning;
- modification of the irrigation network structure (water sources, canals);
- variations in parameters of the irrigation network elements.

2. to keep records of actual water withdrawal per off-takes and canals
3. to register the applications for water delivery on the ten-day period basis
4 to simulate different options of water distribution among all water users within the irrigation system taking into account alternative applications and different volumes of water supply into the irrigation system:

- under annual planning;
- under operational planning.

5. to search out optimal options for water allocation:

- taking into account different water sources (annual planning);
- in case of water resources deficit (annual or operational planning).

6. to analyze the efficiency of water distribution:

- to estimate indicators of water distribution efficiency;
- reporting and preparing production documentation.

The information-management system “IMS-Fergana” was developed on the basis of DBMS ACCESS and the modeling system GAMS [4]. At present, Version 3 of “IMS-Fergana” is operated on all pilot irrigation canals. All abovementioned kinds of works (planning, calculation of operational and summarized indicators etc.) are carried out in the real-time mode. On the ten-day period basis, the results of calculations are transferred to the CA, CWUC and CWC for analyzing the water distribution process and decision-making for next ten-day period. A comparative analysis of water resources management level on the pilot canals and in WUAs per years is conducted based on summarized indicators (see Tables 3.2 and 3.3 in Chapter 3).

## Evaluating water distribution

In this case, the evaluation is the process of comparing indicators to reveal deviations in water resources management quality on the regular basis. The process includes comparing of indicators for:

- different time periods (day, ten-day period);
- any estimated period (seasonal, annual, mean annual);
- different irrigation systems;
- different hydro-operational sites (balance sites);
- different water users (a farm, WUA, administrative district, province, republic);
- actual and planned (normative) situations.

If baseline information is reliable the evaluation has both theoretical (scientific) and practical value. The evaluation has a practical value, i.e. actually facilitates improvements in water resources management quality, only in case of when decision makers:

- want and obligated to make assessment;
- are able to make assessment;
- want or obligated to make decisions for improving the water resources management quality;
- have opportunities (financial, technical, human resources) to implement accepted decisions.

***Restrictive factors for improving the quality of evaluation and water resources management:***

- Financial and economic factors:
    - Water professionals are not interested in improving the quality of water management because their wage does not depend on this;
    - Establishing effective monitoring requires considerable investments;
    - Lack of payments for water services;
- Social and organizational factors:
    - Efficiency of water professionals’ activity is evaluated by water professionals rather than water users (deficit of public participation); and
    - Other factors.

Evaluating water distribution can be internal and external. An external assessment characterizes costs and results of irrigation systems' functioning; it allows comparing the functioning of one irrigation system with others. An internal assessment characterizes the processes progressing within the system and resulting in the internal results; it provides the comparison of actual results with planned ones.

In the process of analyzing water distribution it is necessary to find out answers to the following questions: "Whether all my actions are correct?" and "Whether my actions are correct in general?" [17]. Answering to the first question you evaluate the quality of water management (comparing the actual results with planned ones); and answering to the second question you evaluate the quality of water governance (comparing the achieved results with target ones).

Let us assume that indicators of water availability, sustainability and uniformity in the pumping irrigation zone in the SFC command area are adequate (i.e. the actual results are close to planned ones). This assumption results in the fact that irrigation water is correctly supplied; and the SFC administration manages water resources well. However, the internal assessment does not allow finding out whether planning water distribution is correct or whether the water policy is correct? In order to answer to these questions the external assessment should be done. The external assessment (for example, low technical and economic water productivity was revealed) arouses doubts in the expediency of irrigation water supply into the pumping irrigation zone or denotes the need of introducing water saving technologies and cultivation of more valuable crops.

Analyzing operational indicators (on the daily or ten-day period basis) is implemented during the whole growing season; and analyzing summary indicators is made after ending the growing season. It is expedient to evaluate water distribution in the following sequence: 1) calculating indicators per ten-day periods and growing seasons for off-takes, pumping stations, water users, administrative districts and provinces, balance sites, check stations, pilot canals etc.; 2) plotting contrastive diagrams; 3) detection of sharply-divergent values of baseline data or indicators on diagrams (obvious understated or overstated values); 4) studying and explaining why these deviations take place; 5) eliminating errors (if revealed) of baseline information; 6) analyzing the diagrams and evaluating trends (over time and area) in governance and management of water distribution and causes of these trends.

***Considerable deviations can result from errors in baseline information or due to other causes:***

- an efficiency factor more than unity can result from unrecorded lateral inflow etc.;
- abrupt drop in an efficiency factor can result from stealing of irrigation water or lack of assessing tail releases of irrigation water etc.;
- overstated values of irrigation water supply or water availability per an unit area can result from incorrect record keeping of irrigation water transit and other factors;
- understated values of irrigation water supply can result from lack of record keeping of return water in the plan of water use, stealing of irrigation water, unreliable data on irrigated areas etc.;
- higher level of irrigation water supply stability can result from the presence of regulating capacities (reservoirs), unreliable report information etc.;

***Trends and reasons causing them can be revealed in the course of the evaluating process:***

- increase in the values of coefficients of uniformity and stability can result from rise of the ublic participation level in water governance;
- increasing the water availability factor can result from both increased water availability in a specific year and adjusting water demand (decrease in planned irrigation water supply);
- decreasing the water availability factor can result from both lower water availability in a specific year and more exact definition of irrigated areas (taking into account secondary and interim crops), as well as due to introducing payment for water services;

- a relatively high coefficient of physical water productivity in the SFC command area does not mean that a coefficient of economic water productivity is also high. In this case, a major cause is low purchasing prices of cotton (relative to world market prices); and
- lowering the values of those or other indicators of water distribution can result from impacts of external causes on the water sector: social shock, mass participation of water professionals in activities directly not related to their professional duties, as well as sudden meddling in the process of water distribution: stopping water releases from reservoirs etc.

The basic diagrams that illustrate indicators of water distribution along the pilot canals over the period of 2003 to 2007 that show the progress in improving canals' operation based on introducing the IMS are given below (Figures 5.18 to 5.23).

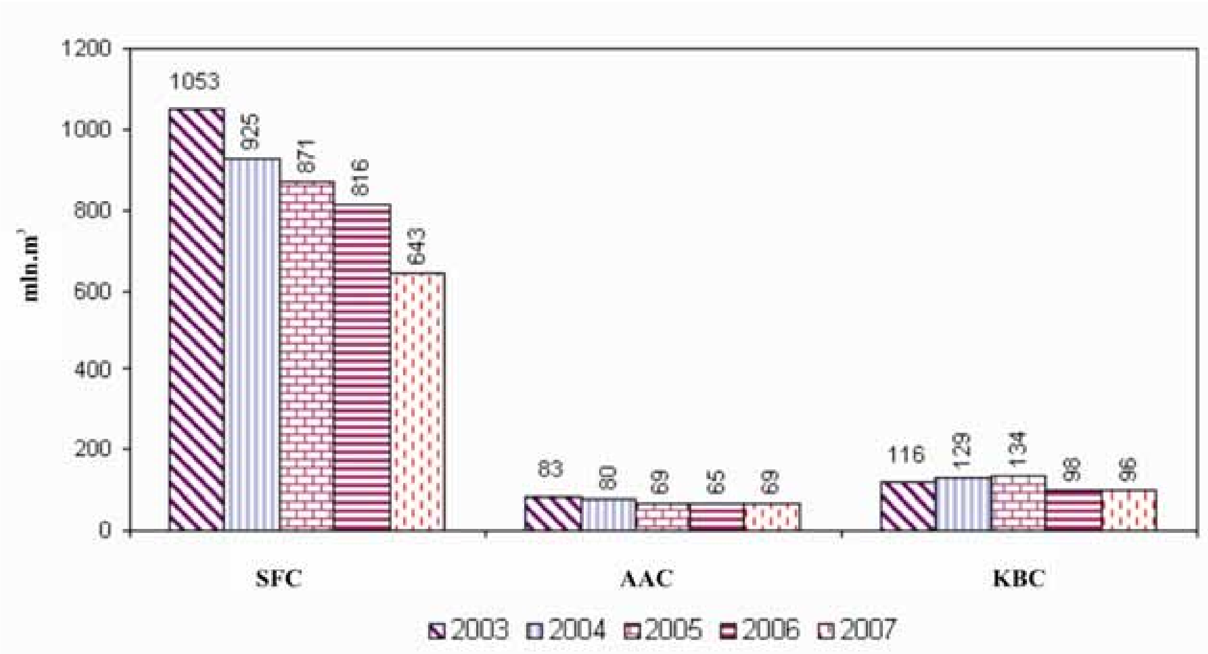



**Figure 5.18 Actual Irrigation Water Supply through Pilot Canals**

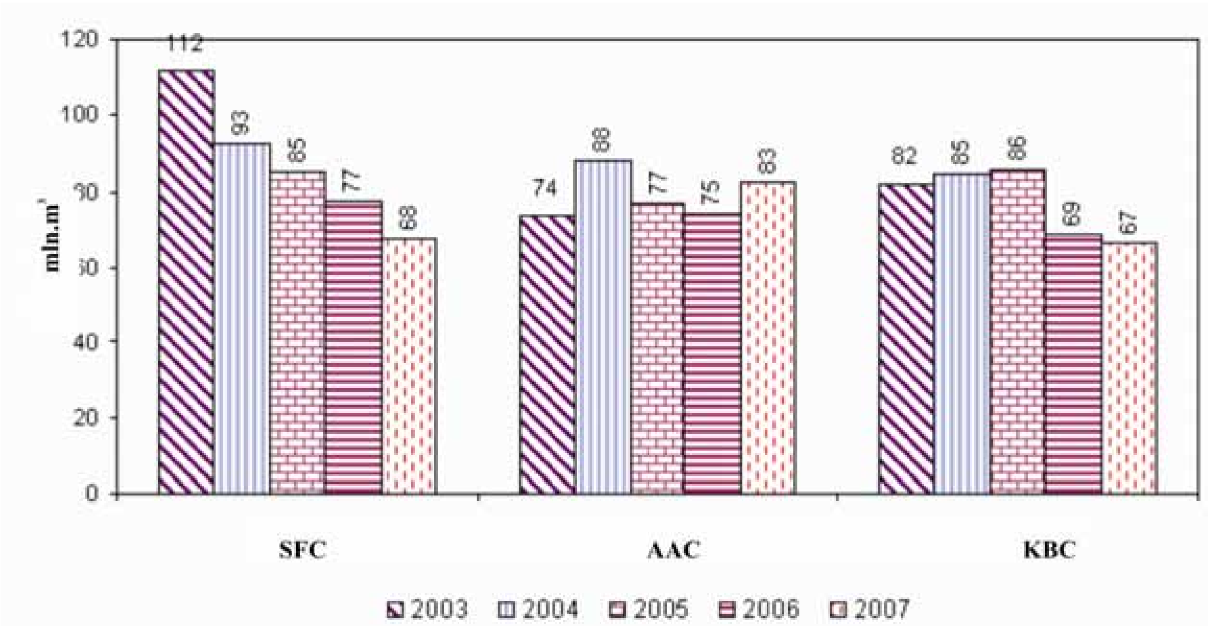



**Figure 5. 19 Water Availability on Pilot Canals**

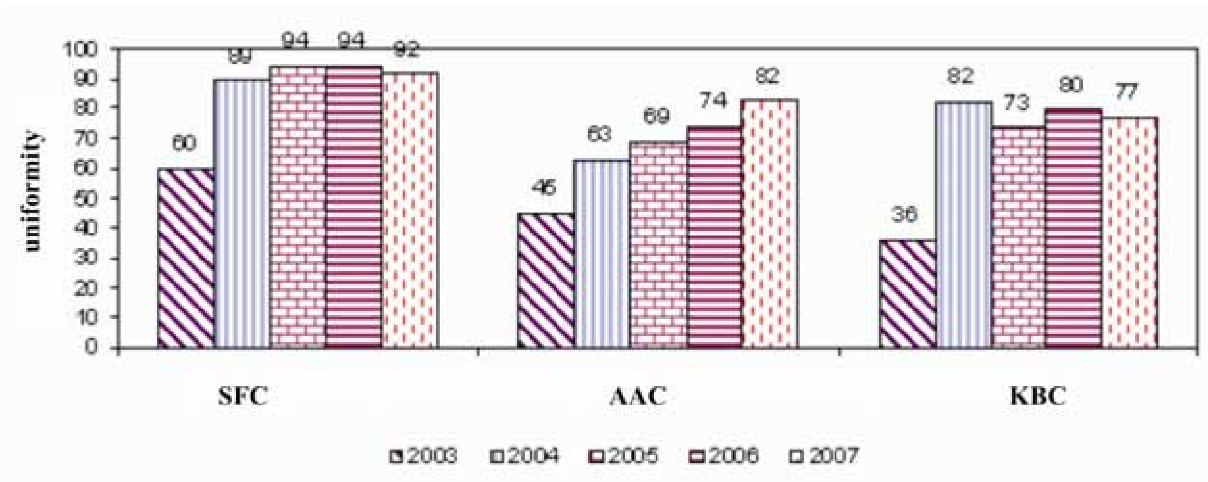



**Figure 5. 20 Uniformity of Irrigation Water Supply**

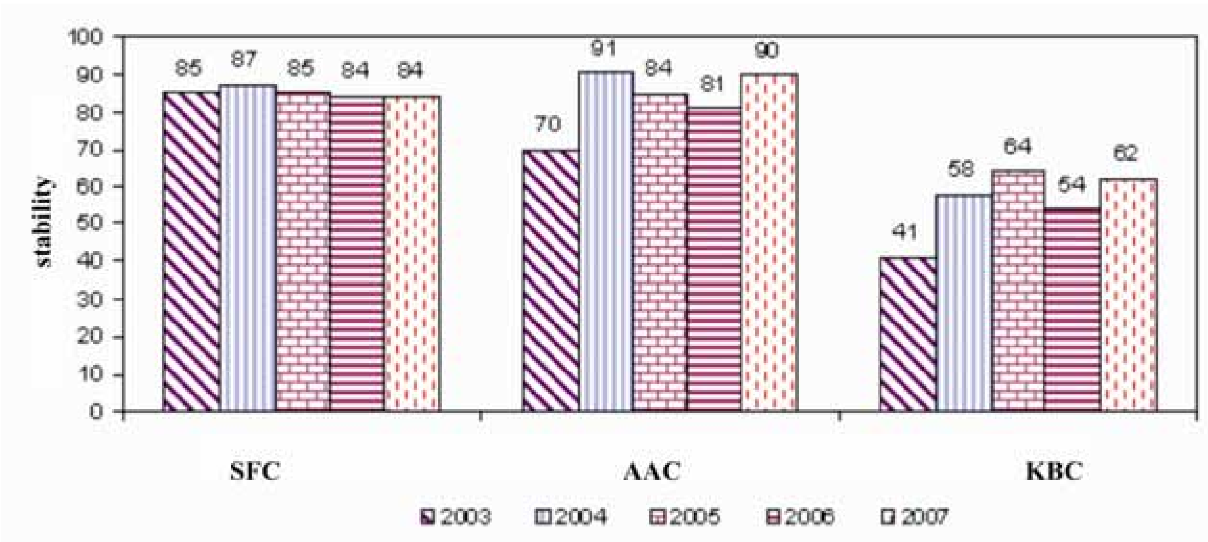



**Figure 5. 21 Stability of Irrigation Water Supply**

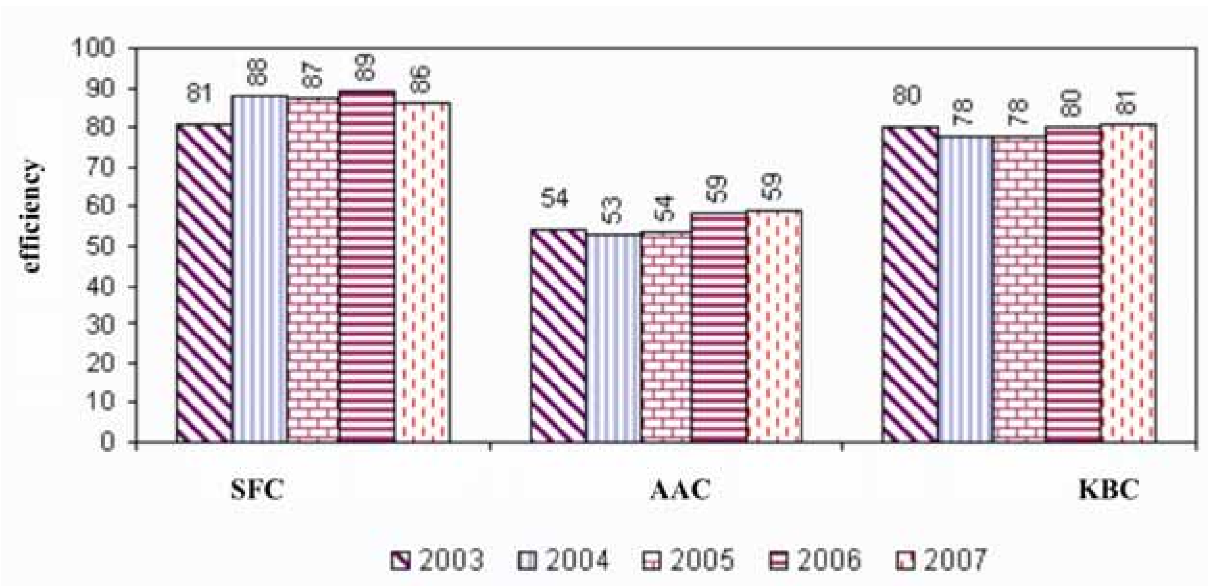



**Figure 5. 22 An Efficiency Factor of Pilot Canals**

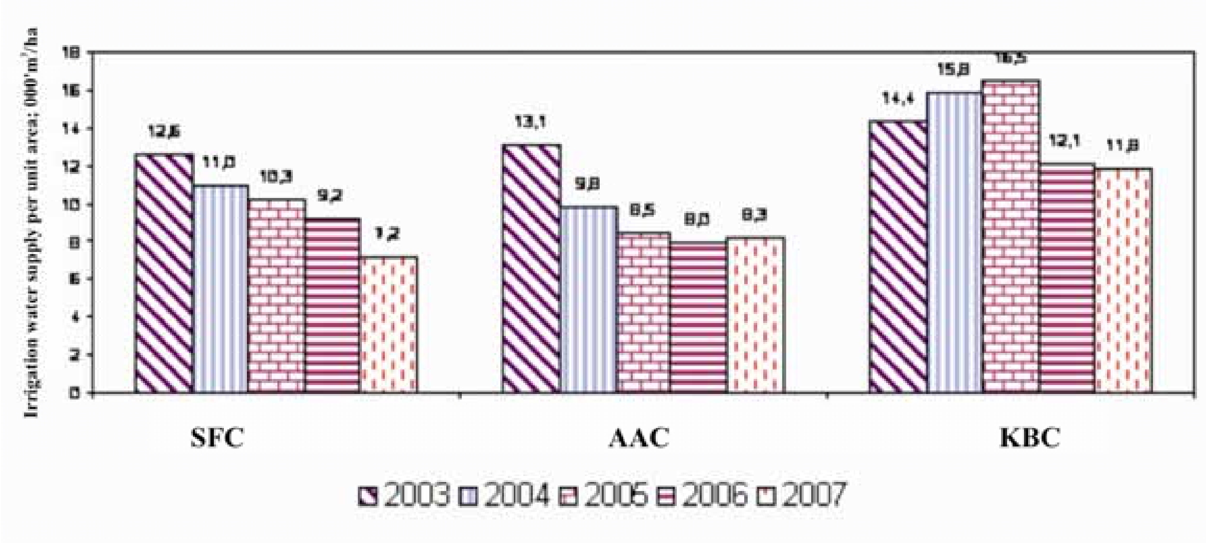



**Figure 5.23 Irrigation Water Supply per Unit Area over the Growing Season**

The similar analysis of WUA's activity (Case Study of the WUA "Akbarabad") was conducted in the following sequence:

- Identification of irrigation water delivery from the SFC into the WUA "Akbarabad"; and
- Assessment of irrigation water distribution diverted from the SFC and other water sources among WUA's members.

Figure 5.24 shows that there is the trend of reducing actual irrigation water supply into irrigation canals of the WUA "Akbarabad" during the growing season over the period of 2003 to 2007. While in 2003 (the beginning of establishing the WUA) irrigation water supply into WUA's canals amounted to 24.6 million $m^3$ in subsequent years (2004 to 2007), irrigation water supply was 23.1, 21.5, 20.3 and 17.6 million $m^3$ respectively [17].

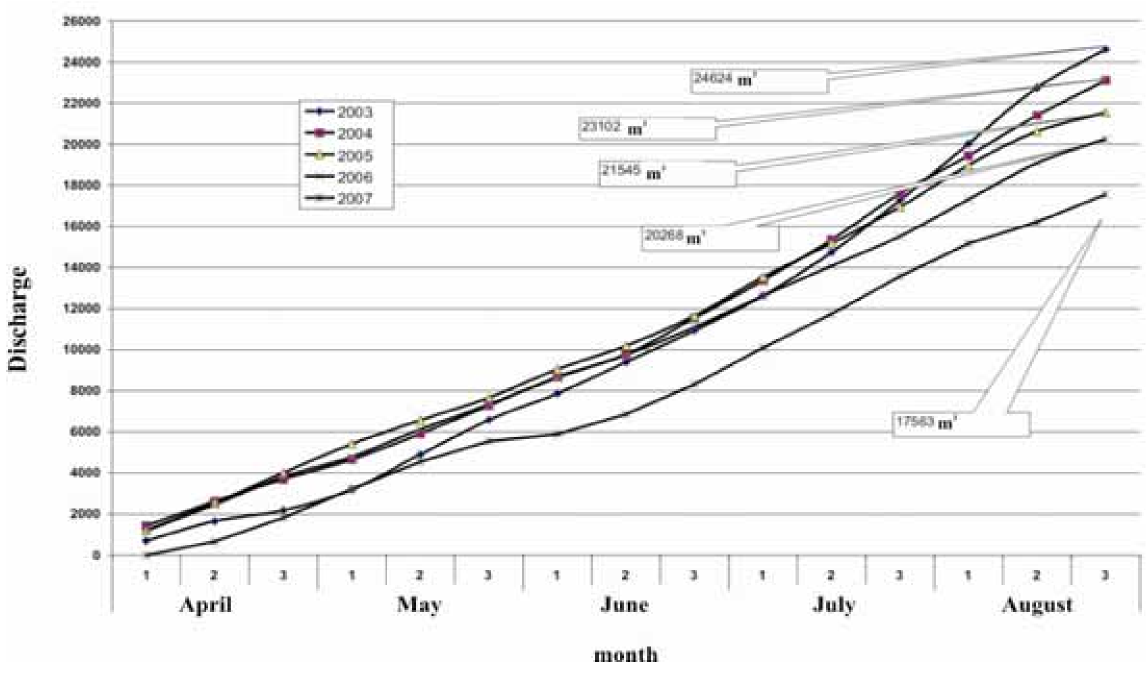



**Figure 5.24 Trends of Actual Irrigation Water Supply into Irrigation Canals of the WUA "Akbarabad" (a Progressive Total over the Growing Season, 000' $m^3$)**

The WUA accounts the use of all kinds of waters; and a positive trend in using a little brackish water for irrigation with reducing water diversion from the SFC is observed. In dry years (2006 and 2007), water availability in the WUA was increased by 15 to 20% at the expense of drainage water.

In addition, daily water distribution through each irrigation canal and collector-drain for each crop was organized in the WUA. After completing each water application of crops during the growing season, WUA's personnel carry out the operational analysis of water distribution among water users in accordance with applications submitted and find out causes of reduction in irrigation water supply against their applications. Analyzing of indicators of delivering irrigation water to farms located along the tail section of WUA's canals confirms that after introduction of the daily planning of water use, the infringement of water users' interests in tail parts of irrigation canals are losing its topicality (see Tables 5.10 and 5.11).

Operative dissemination of adjusted schedules of by-turn irrigation water delivery to water users prevents disputes between water users and WUA's personnel. Water users being informed on terms and duration of receiving specific flow rate of water for irrigation can efficiently plan soil treatment, fertilizer application and hiring additional irrigators for water applications.

The new methodology of daily planning modifies the approach to evaluating water availability i.e. the assessment is conducted based on the results of water application rather than on indicators of a ten-day period and allows objectively evaluating implementation of the plan of irrigations and coordinating water availability of farms with activity of the WUA and WMO.

**Table 5.10**

**Assessment of the Extent of Infringing Water Users' Interests in Tail Parts of Irrigation Canals in the WUA "Akbarabad" during the 2007 Growing Season**

| Irrigation and drainage canals in WUAs | Crop | Average water availability of WUGs located along a head part of the irrigation canal, % | Average water availability of WUGs located along a tail part of the irrigation canal, % | Ratio of water availability of WUGs in a tail part and a head part of the irrigation canal, % |
|---|---|---|---|---|
| Akbarabad 1 and 2 | Cotton | 107 | 130 | 121 |
| | Wheat | 82 | 96 | 117 |
| | Vegetables | 37 | 42 | 114 |
| | Orchards | 74 | 77 | 104 |
| RP - 1 | Cotton | 130 | 132 | 102 |
| | Wheat | 91 | 96 | 105 |
| | Orchards | 105 | 97 | 92 |
| RP - 2 | Cotton | 116 | 93 | 80 |
| | Wheat | 87 | 90 | 103 |
| Gandabulak | Cotton | 87 | 91 | 105 |
| | Wheat | 122 | 118 | 97 |
| | Vegetables | 63 | 63 | 100 |
| | Orchards | 84 | 80 | 95 |
| Okkuduk | Cotton | 111 | 98 | 88 |
| | Wheat | 115 | 104 | 90 |

The system of monitoring water use was also introduced in newly-established WUAs along the SFC and KBC based on the training of WUAs' specialists on matters of monitoring water use including the methodology of daily planning and analyzing water use.

Organization of daily water use and its adjustment in the WUA in accordance with submitted applications for irrigation water has shown their high efficiency. Some water users refused from conducting water applications because of shallow watertable that enabled to reduce volumes of water delivered into the WUA. The timely convenience of irrigation water delivery, water availability of water users and WUA's activity during the growing season can be evaluated based on data on daily water distribution.

**Table 5.11**

**Assessment of Infringing Water Users' Interests in Tail Parts of WUA's Pilot Canals in the SFC Command Area during the 2007 Growing Season**

| WUA | Name of canal | Crop | Average water availability of WUGs located along a head part of the irrigation canal, % | Average water availability of WUGs located along a tail part of the irrigation canal, % | Ratio of water availability of WUGs in a tail part and a head part of the irrigation canal, % |
|---|---|---|---|---|---|
| Ismailiv | K-11 | Cotton | 101 | 102 | 101 |
| | | Wheat | 114 | 94 | 83 |
| | | Orchards | 91 | 109 | 120 |
| Mashyal | Kommunizm | Cotton | 74 | 68 | 92 |
| | | Wheat | 89 | 72 | 81 |
| | | Сады | 109 | 113 | 104 |
| Omad Zilol | Guliston | Cotton | 90 | 87 | 97 |
| | | Wheat | 91 | 100 | 110 |
| Povulgon Obi Khaet | Isokov-2 | Cotton | 72 | 91 | 126 |
| | | Wheat | 94 | 101 | 107 |

Regular monitoring allows revealing shortcomings in the organization of water use on timely basis and eliminating them. Water management organizations, local authorities, research institutions annually need information on irrigation water used by cultivated crops. Prior to introducing the daily planning system, this information was quite approximate and gave rise to doubt its reliability. A daily planning allows collecting reliable information and providing necessary data for strategic planning of agricultural sector development, adjusting the irrigation schedule, and rearranging irrigation lands according to specific crop water requirement zones. A daily planning of water use also allows establishing effective water allocation and reducing water losses in WUA's canals. In 2007, the daily planning of water use introduced in the WUA "Akbarabad" allowed raising the operational efficiency factor of WUA canals from 0.66 to 0.78.

**Table 5.12**

**Water Withdrawal from Different Water Sources and Cumulative Area of Irrigation[31] per WUAs Located along the SFC**

| No | District | Total irrigated area, ha | Total water withdrawal during the growing season, mln. $m^3$ | Including from (in %): | | Cumulative area of irrigation (area* the number of irrigations) | Including area irrigated by water diverted from (in %): | |
|---|---|---|---|---|---|---|---|---|
| | | | | the SFC | other sources | | the SFC | other sources |
| 1 | Khujaabad | 3,450 | 25.35 | **85** | **15** | 15,419 | **84** | **16** |
| 2 | Bulakbash | 8,630 | 59.27 | **68** | **32** | 39,522 | **68** | **32** |
| 3 | Markhamat | 18,624 | 116.3 | **87** | **13** | 43,209 | **91** | **9** |
| 4 | Kuva | 22,037 | 204.4 | **90** | **10** | 121,065 | **89** | **11** |
| 5 | Tashlak | 9,855 | 54.2 | **82** | **18** | 41,781 | **87** | **13** |
| 6 | Akhunbabaev | 4,258 | 40.55 | **87** | **13** | 23,660 | **90** | **10** |
| 7 | Altiaryk | 5,763 | 49.32 | **86** | **14** | 29,640 | **86** | **14** |

The proposed procedure for coordinating activity of the SFC Administration and WUAs in water resources management proved its high efficiency. At the beginning of each ten-day period WUAs receive reliable information on water delivery to WUAs' canals based on the current water availability in the SFC itself. In 2007, the analysis of water use results was being carried out by specialists of WUAs established in the frame of the IWRM-Fergana Project and WUAs that were established in command areas of the SFC and KBC. This analysis has shown that the percentage of water withdrawals from additional sources within WUAs was ranging from 10% (Kuva District) to 32% (Bulakbash District) that were used for irrigating 9 to 32% of irrigated areas in districts.

Table 5.13 shows that only 4 of 46 WUAs in the SFC command area do not have additional water sources; the percentage of water withdrawal from additional sources varies over the range of 1 to 20% of the total water withdrawal in 54% of WUAs, and from 21 to 40% in 37% of WUAs.

**Table 5.13**

**Water Withdrawal from Additional Water Sources**

| Total number of WUAs | Water availability in WUAs at the expenses of additional sources, % | | | | |
|---|---|---|---|---|---|
| | **0** | **1 – 10** | **11 – 20** | **21 – 30** | **30 – 40** |
| 46 | 4 | 13 | 12 | 6 | 11 |

[31] Cumulative area means an area that was irrigated one or a few times according to the irrigation schedule

A part of the SFC command area in Andijan and Fergana provinces has considerable internal reserves of water at the expense of additional water sources that allow raising water availability of irrigated farmland. For efficient use of these water resources the nature of their forming should be studied and specified.

Interrelations of WUAs and the WMO need to be arranged according to the system, which was developed by the Project, providing for informing WUAs, on timely basis, on forthcoming water delivery based on the current situation reflecting water availability within the SFC command area. Conditions for stable operation of the SFC without all-out efforts were established based on the system of submitting well-arranged applications for irrigation water by WUAs.

The IWRM-Fergana Project has suggested to all WUAs a new methodology for planning water use. However, all existing WUAs, as successors of former collective farms, employ the outdated method of the planning (for ten-day periods). Therefore, it is necessary to develop all normative documentation for the office work in WUAs based on the daily planning of water use and to disseminate these documents among the Ministries of Water Resources of countries having irrigation lands in the Fergana Valley to put them into water management bodies' practice.

**The command area of Pilot Khoji-Bakirgan Canal:** the water rotation between two administrative districts was put into practice. A full cycle of water rotation amounts to 6 days (during three days, irrigation water is delivered into Gafurov District and then into Rasulev District). The same order was employed in Rasulev District where the one-and-a-half-day water rotation between WUAs and farms was established. Water users were subdivided into two groups. The first group of water users received water for irrigation during the first time step of three-day water rotation and the second group during the next time step. Daily flow rates of irrigation water supply for each group were separately calculated; and during each time step of water rotation an adjustment coefficient for volumes of water allocated for irrigation of one hectare was calculated based on a ratio of allotted water volumes and daily irrigation water demand. A schedule of daily water rotation was being modified using the adjustment coefficient. The adjusted daily schedule was the basis for monitoring water use within a WUA.

Table 5.14 shows that water availability of farms varies over the range of 27 to 52 % in the command area of the Ak-kalya Canal. However, water availability of farms located in the tail part makes up 93.2% of water availability of farms in the head part of this canal. Additional water resources diverted from the Syr Darya River by pumps and partly-collected tail-water released from irrigated fields were used to improve water availability of farms serviced by the Ak-kalya Canal.

**Table 5.14**

**Indicators of Irrigation Water Supply along Different Sections of the Ak-kalya Canal**

| No | Laterals | Irrigated area, ha | Indicators of water delivery, 000' $m^3$ | | Average water availability, % | Ratio of water availability in tail and head parts,% |
|---|---|---|---|---|---|---|
| | | | Plan | Actual | | |
| **I. Head part of the canal** | | | | | | **(41 / 44) * 100 = 93.2** |
| 1 | Yarmagz | 16.1 | 165 | 58 | 35 | |
| 2 | Khudgif-1 | 14.6 | 153 | 64 | 42 | |
| 3 | Khamadov | 60 | 734 | 300 | 41 | |
| 4 | Yarmagz -2 | 50.7 | 525 | 274 | 52 | |
| | **Total** | **141.4** | **157.7** | **696** | **44.0** | |

| No | Laterals | Irrigated area, ha | Indicators of water delivery, 000' $m^3$ | | Average water availability, % | Ratio of water availability in tail and head parts,% |
|---|---|---|---|---|---|---|
| | | | Plan | Actual | | |
| **II. Tail part of the canal** | | | | | | |
| 1 | Sughd-1 | 16 | 187 | 81 | 43 | |
| 2 | Somon-1 | 46 | 575 | 266 | 46 | |
| 3 | Sughd-2 | 25 | 332 | 123 | 37 | |
| 4 | Sughd-3 | 40 | 463 | 164 | 35 | |
| | **Total** | **127** | **1557** | **634** | **41.0** | |

The pilot WUA "Zarafshan" operates under conditions when the Khoji-Bakirgan Canal does not have a regulative reservoir; and irrigation water supply mainly depends on climatic conditions. The WUA cannot usually meet planned water demand (15 to 16.5 million $m^3$ depending on a crop pattern). Relative increase in irrigation water supply over the period of 2003 to 2006 (from 5,679,000 to 7,256,000 $m^3$) can be considered as the positive tendency, but in 2007, actual volumes of irrigation water supply have decreased up to 5,678,000 $m^3$ due to drought (Figure 5.25).

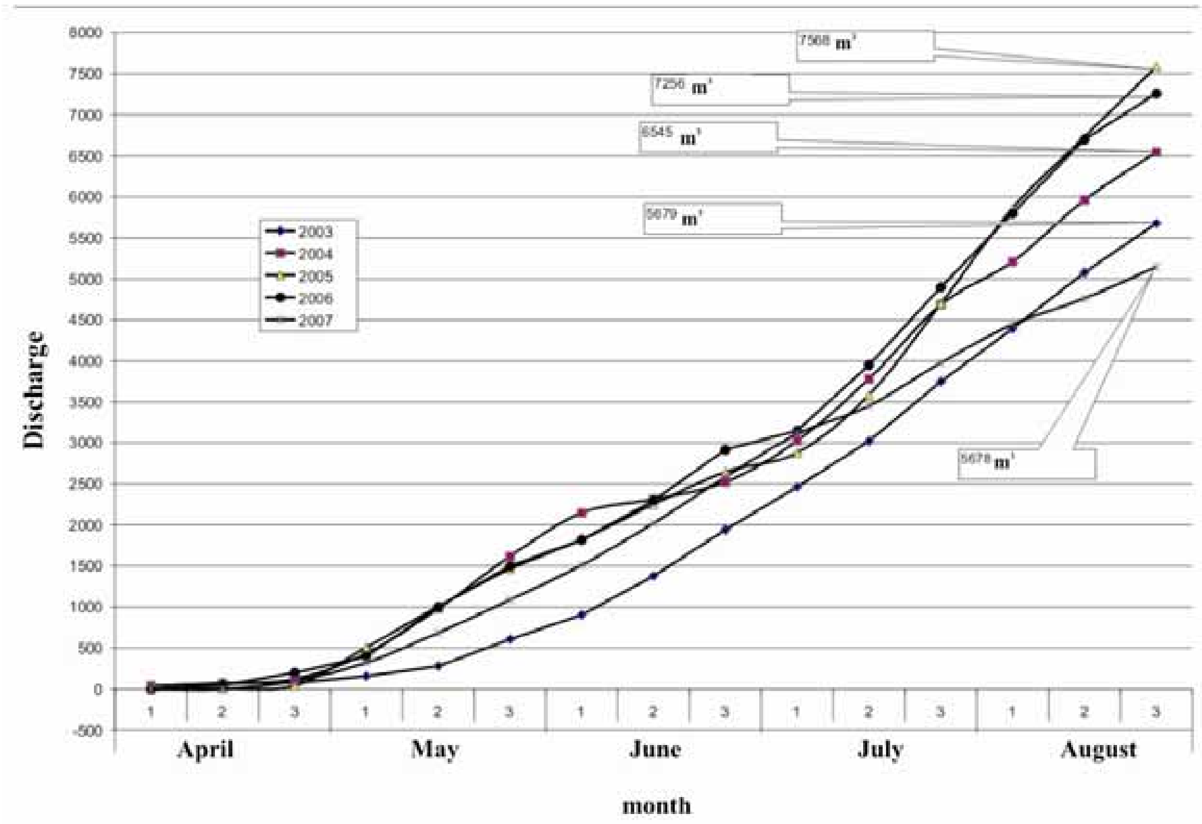



**Figure 5.25 Dynamics of Actual Water Availability in the WUA "Zarafshan"**

**(the progressive total) during the Growing Seasons over the Period of 2003 to 2007**

## 5.5. Automation of the Water Distribution Systems

**(I. Begimov., V.A. Dukhovny)**

A key tool of integrated water resources management is automation of the water distribution system based on introducing the state-of-the-art system of supervisory control and data acquisition (SCADA). This system allows improving the quality, flexibility and reliability of water distribution management and reducing unproductive losses of water resources.

Developing the system of automation and dispatching of the Uchkurgan Hydroscheme was initiated in 2002 simultaneously with launching the IWRM-Fergana Project. The most up-to-date programmable controllers "Decont" manufactured by the company "DEP" (Russia) with home-produced sensors of a water level and gate position were applied in this system.

Introducing the system was funded by the Swiss Agency for Development and Cooperation; and it operates up to now. Specialists of the BWO "Syr Darya", SIC ICWC and SANIIRI monitored this system operation over the period of 2002 to 2007. The framework of archiving and databases were updated to monitor and evaluate qualitative indicators of the system of automation and dispatching of the Uchkurgan Hydroscheme. The system of archiving technological and operational information automatically saves basic values of technological indicators each ten minutes in the form of separated files that can be analyzed to evaluate the quality of system operation.

***The updated database allows solving the following tasks:***

- transferring the SCADA data directly into the database "MS ACCESS" providing storing and processing these data for solving operational tasks;
- averaging and saving values of measurable parameters over a day, ten-day period and month;
- data input of hourly visual observations (the common method), averaging and saving their values over a day, ten-day period and month;
- detecting deviations (errors) in the data of hourly visual observations against the SCADA data; and
- drafting the reports and diagrams that illustrate the telemetry system operation (the prototype of the SCADA) and the data processed.

One of key tasks of automation and dispatching of the Uchkurgan Hydroscheme is to improve the stability of water delivery through the North Fergana Canal (NFC) and the Additional Feeding Canal (AFC) within the system of the Big Fergana Canal (BFC) under fluctuating of water levels in the headrace channel. At present, the system of automation and dispatching of the Uchkurgan Hydroscheme does not directly receive information on flow rates at the gauging station "Uchkurgan" and in the headrace channel of the BFC; therefore a dispatcher of the Uchkurgan Hydroscheme assigns the required parameters for regulating flow rates through the NFC and AFC depending on current flow rates in the river channel and water use limits established.

Figure 5.26 shows the operational regime of the automation system of the Uchkurgan Hydroscheme over the period of 2005 to 2006. As shown in this figure, under fluctuating of water levels in the headrace channel, flow rates through the NFC and AFC are almost stable within the acceptable accuracy of regulation. Stability of water delivery into the NFC and AFC is ensured by the automation system of the Uchkurgan Hydroscheme at the expense of a capacity of the headrace channel and releases of excess water into the tailrace channel.

An average value of deviations of actual flow rates against the established value under automatic regulating does not exceed 2% for the NFC (1.69% for the AFC).

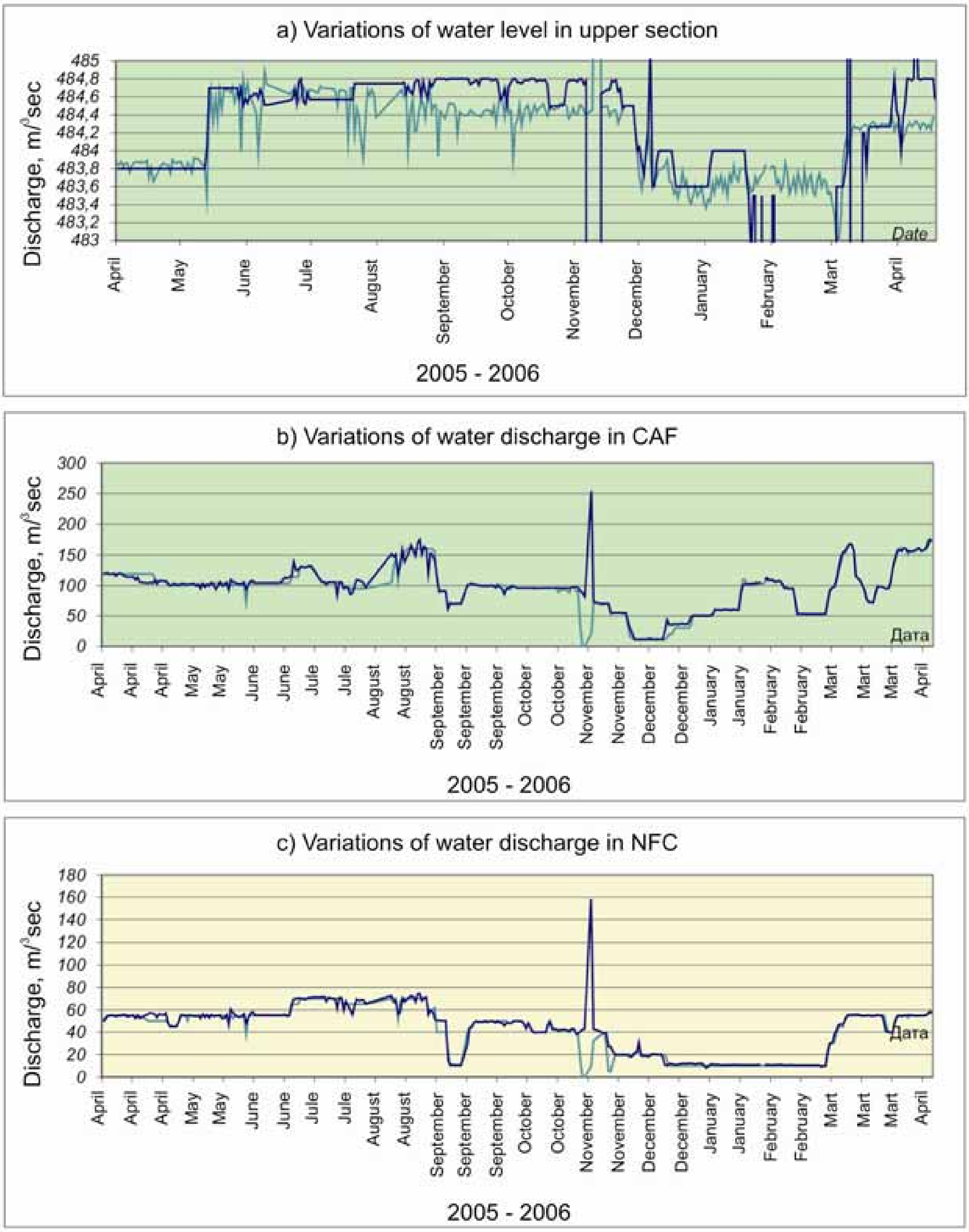



**Figure 5. 26 Operational Regimes of the Automation System of the Uchkurgan Hydroscheme in 2005 and 2006**

A maximum value of instantaneous deviations of an actual flow rate against the established value for automatic regulation of a flow rate in the NFC amounts to 11.2% and 1.77% in the AFC (during the transition period). Analyzing the automation system operation of the Uchkurgan Hydroscheme over the whole period of operation (5 years) shows that the following quantitative and qualitative indicators of water resources management were considerably improved:

- the stability of irrigation water supply through the NFC and FFC in the Fergana Valley was improved at the expense of introducing the system of automatic regulating of water levels and flow rates;
- the measurement accuracy of water levels, flow rates and water salinity, as well as a height of opening the gates of hydraulic structures was raised due to the introduction of the up-to-date technical means for measuring and accounting water resources;
- dataware and the quality of water record keeping was improved based on continuous computerized gathering, storing and processing data on water levels and flow rates;
- the efficiency and accuracy of water resources management were improved at the expense of speed-up of transferring and processing the information on technological processes and the decision-making process; and
- the rapidity of detecting and eliminating failure occurrence in the system equipment and hydraulic structures was increased.

It is necessary to note that the automation system of the Uchkurgan Hydroscheme has raised the O&M level, substantially facilitating activity of operational personnel and improving the quality of water distribution into the NFC and AFC. As a result, the conditions for monitoring the BWO "Syr Darya" and its territorial bodies' activity were created based on the openness and accessibility to information for all stakeholders.

Taking into consideration advantages of the automation system, the project: "Automation of Water Distribution on Pilot Canals in the Frame of IWRM-Fergana Project and the BWO "Syr Darya" Structures" has been proposed as further development of the IWRM-Fergana Project and its tools. This project encompasses:

***The basin level:***

- the BWO "Syr Darya" structures;

***Pilot canals:***

- the Aravan-Akbura Canal (Kyrgyzstan);
- the South Fergana Canal (Uzbekistan); and
- the Khoja-Bakirgan Canal (Tajikistan).

**The project objective** is to put into practice the computer-aided system of regulating and operational monitoring of the water distribution process at the BWO's structures and on pilot canals to ensure supplying of irrigation water to farmers in due amounts and proper time and to establish the system of monitoring of channel inflow, flow rates and water levels at the water-balance gauging stations and water intakes.

**A key task** of automation and monitoring is to establish the system of management and control of canal operation, which allows:

- to improve implementing the plan of water use;
- to create conditions for sustainable, uniform and equitable water distribution excluding unproductive water losses.

Achieving this objective will be provided based on the introduction of the SCADA system on the water intake and check structures, water-balance gauging stations, as well as at the expense of dispatching of all hydraulic structures under management, establishing telecommunications and computerization of transferring, processing and storing information. In addition, special observers who will be provided with communication means and vehicles will monitor the water-balance sites.

***Pilot canals to be subjected to automation have different sources of water supply:***

- the South Fergana Canal is fed from the Andijan Reservoir of over-year regulation;
- the Akbura River, flow of which is regulated by the Papan Seasonal-Storage Reservoir is the water source for the Aravan-Akbura Canal;
- the Khoja-Bakirgan Canal diverts water from the river of the same name with unregulated flow.

The existing situation in water distribution through irrigation canals and the stochastic nature of flow rates in streams impede uniform water delivery to consumers and meeting the established water use limits. Unproductive organizational water releases result from the inopportuneness and unreliability of information gathered at the gauging stations due to the lack or insufficient accuracy of measuring devices that are used for monitoring flow rates and water levels.

Automation of the main waterworks and the system of gathering information on the water-balance gauging stations and monitoring at the water-balance sites conducted by observers who will be provided with communication means and vehicles are envisaged for ensuring sustainable water distribution providing stable and uniform satisfaction of farmers' requirements.

***The system of managing the water distribution process: there are not differences of principle in the system of managing water resources on pilot canals; each republican system is represented by three levels:***

- *basin level* where the BWO "Syr Darya" and republican ministries of water resources carry out management functions. At this level, the ICWC establishes limits of water resources use for the irrigation systems and controls their realization;
- *level of the Basin Irrigation Systems Administration, Fergana Valley Main Canals Management Organization (Uzbekistan) and Provincial Water Management Organizations (Kyrgyzstan and Tajikistan)*. At this level, the plans of water use with allocating water resources per specific irrigation canals are approved taking into consideration the water use limits established and applications of farmers; and
- *level of the Main Canal Management Organization*, at this level, irrigation water distribution over ten-year periods in accordance with the approved plan is being implemented, as well as the monitoring and adjusting of water delivery every ten days, if necessary.

The main dispatching point (MDP) and water-balance sites with local dispatching points were established on each irrigation canal in the frame of operational water distribution system. The Central Dispatching Point (CDP) that is the central element of water distribution management along the canal was established at the Main Canal Management Organization.

**The principle of water distribution through irrigation canals:** a key principle of water distribution through irrigation canals is planned water use that bases on stable and equitable meeting of consumers' demands over the entire length of irrigation canals. Plans are drawn up by water resources management organizations based on applications submitted by water users and water use limits established by the Ministries. Water use plans are approved after joint reviewing by the Irrigation System Management

Organizations (or Provincial Water Management Organizations), Canal Management Organizations, Canal Water Committees and representatives of water users. Water use plans are the basis for plans of water diversion and delivery to consumers that are being drawn up every ten days and adjusted during the irrigation season depending on weather conditions, general water management situation in the river basin and applications of consumers.

**An extent of automation and dispatching of main hydraulic structures and the monitoring system: Headworks of the pilot irrigation canals are equipped with measuring devices of the SCADA system; sensors of water level at upstream and downstream of the structure and position of gates (an extent of their lifting) are installed at all check structures. Dispatching points at headworks are equipped with computers and the system of telecommunication that provides trouble-free communication with the central and local dispatching points and automatic transferring of information according to the established mode. The following components are automatically operating:**

- gates of headworks that maintain designated flow rates under fluctuating of water levels in the headrace channel;
- gates of spillways that are operated in accordance with water levels in the headrace channel;

All information registered by sensors is illustrated at the symbolic circuits; and the protection from emergencies (self-locking of gates, exceeding a maximum level, power cutoff, opening a power switchboard by unauthorized persons etc.) is envisaged.

***The SCADA system at the main structures includes the following equipment:***

- computers (hardware and software);
- programmable controllers;
- input and output modules;
- sensors of water level and position of gates; and
- radio stations with antennas.

**Secondary canal head gates** are equipped and operate similar to pilot main canals' headworks.

***Automation will be introduced on:***

- the South Fergana Canal – 10 main structures and Kirkidon Reservoir's structures (72 gates and 17 dispatching points in total);
- the Aravan-Akbura Canal – 3 main structures (17 gates and 7 dispatching points ); and
- the Khoji-Bakirgan Canal – 7 main structures (43 gates and 7 dispatching points).

**Four BWO "Syr Darya" structures** are also equipped with the SCADA system (46 gates and 5 dispatching points).

**Water-balance gauging stations** are equipped with the SCADA system (sensors of water level). The SCADA system at water-balance gauging stations includes the following equipment:

- programmable controllers; and
- input and output modules, sensors of water level and radio stations with antennas.

Information on water levels and flow rates is transmitted through radio communication to a local dispatching point (LDP) of a hydro-operational site (a hydro-unit) that operates this water-balance gauging station. The following gauging stations will be subjected to automation:

- South Fergana Canal – 10 gauging stations (one at the headworks, 9 at water-balance sites);
- Aravan-Akbura Canal – 4 gauging stations (one at the headworks, 3 at water-balance sites);
- Khoji-Bakirgan Canal – 3 gauging stations (one at the headworks, 2 at water-balance sites); and 7 dispatching points.

**Monitoring at water-balance sites. Objects of automation and computer-aided monitoring on the pilot irrigation canals do not exceed 10% of water distribution infrastructure; therefore, a key role in achieving sustainable and uniform water distribution along the entire length of irrigation canals to meet users' water demands belongs to observers at water-balance sites who monitor off-takes operation.**

For the purpose of efficient water resources management, the irrigation canals are subdivided into water-balance (hydro-operational) sites that are the primary level of management hierarchy. A local dispatching point that will be equipped with computer and telecommunication means was established at each water-balance site. A LDP receives information from main structures and water-balance gauging stations and has the staff of observers who monitors water distribution at all off-takes and water diversion by pumping units. Monitoring at water-balance sites is conducted based on visual read-out of information and its transferring to the LDP by observers via their individual radiophones, and data input into the computers by hand. Off-takes at water-balance sites are divided into two groups: "controllable off-takes" and "accountable off-takes." Off-takes (pumping units), unplanned opening or closing of which can considerably affect canal operation, refer to "controllable off-takes" and are characterized by the following parameters:

- within the SFC system, off-takes with a discharge capacity more than 100 l/sec;
- within the AAC and KBC systems, off-takes with a discharge capacity more than 10 l/sec;

Flow rates for such off-takes can be regulated during a ten-day period; and at the same time, flow rates of off-takes with a lesser carrying capacity are not being adjusted. All off-takes are "accountable ones." Water withdrawal is accounted using water-measuring devices; however, water diversion through small off-takes with a discharge capacity less than 5 l/sec is accounted according to their rated discharge capacity.

Water withdrawal by pumping units is calculated taking into account the number of pumping units (PU) under operation and their nameplate capacity and audited according to registrations of an energy meter.

**Table 5. 15 Structures under Monitoring**

| Irrigation canal | Number of off-takes | | Total water withdrawal | | Small pumping units (Q < 5 l/sec) | | |
|---|---|---|---|---|---|---|---|
| | Total | Including PU | Q, $m^3/s$ | % of $Q_{st}$ | Number | Q, $m^3/s$ | % of $Q_{st}$ |
| SFC | 162 | 67 | 92 | 92 | 68* | 3.89 | 2.95 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| AAC | 62 | 5 | 28.8 | 87 | 108 | 0.54 | 2 |
| KBC | 46 | 4 | 32.6 | 80.2 | 14 | 0.07 | 0.2 |

* Off-takes with a discharge capacity less than 100 l/sec were included into the group of off-takes non-controllable during a ten-day period within the SFC system

The number of daily observations is established depending on the duration of daylight hours: during the growing season – four times a day, and during the off-vegetation period – three times a day. Time spent by an observer at one structure was estimated based on virtual evaluating duration of each elementary procedure:

- at off-takes: i) readout of an indication of a water-level staff installed in the headrace channel; ii) readout an indication of a water meter' staff and determination of a flow rate using the design chart; iii) transmitting data to a dispatcher; and iv) data recording into the field book;
- at the pumping units: i) visual definition of the number of pumps under operation; ii) reading indication of an energy meter; iii) transmitting data to a dispatcher; and iv) data recording into the field book.

Observers are provided with radio-telephones and vehicles (by mopeds, as expected). The number of observers was specified on the basis of a length of water-balance sites, number of off-takes, and normative working hours.

**Functional tasks of monitoring; reliability and exchange of information:** Efficient water distribution based on the proposed system of automation and monitoring should be grounded on reliable accounting of water resources. With that end in view, the IWRM-Fergana Project envisages calibration and metrological assurance of all main structures, water-balance gauging stations and re-attestation and issuing passports of water-measuring devices. The second condition is the efficient interaction of all levels of water management hierarchy. The IWRM-Fergana Project clearly specified functional tasks of participants of management and monitoring activity.

A dispatcher of the LDP is a primary level of gathering, processing and analyzing the incoming information. Data transmitted by observers allow evaluating the uniformity of water delivery to users at the water-balance site, adequacy of water supply against the plan and an amount of unproductive water losses. Key functional tasks of participants of the monitoring process are the following:

***Observers at water-balance sites:***

- strict implementing the dispatcher's instructions relative to flow rates of irrigation water delivery to users;
- monitoring and accounting flow rates of irrigation water delivery through all relevant off-takes and pumping units;
- monitoring and accounting side inflows and water releases through spillways;
- transmission of data on water levels and flow rates through off-takes, pumping units, water escapes and side inflows to a dispatcher of the LDP by a radiophone;
- implementing measurements in compliance with due time and sequence of observations;
- regular data recording into the field book;
- preventing intervention in gates' operation of off-takes by non-authorized persons; and
- safeguarding and maintenance of the flowing-through section of hydraulic structures, mechanical and water-measuring equipment.

***Dispatchers of the Local Dispatching Points (LDP):***

- adjusting flow rates established by the CDP for a ten-day period for all off-takes and pumping stations within the water-balance sites;
- gathering and checking information on actual flow rates at non-automated off-takes transmitted by observers via radiophones four times a day in the interactive mode;
- analyzing a daily balance of water resources at water-balance sites, evaluating the efficiency factor of a water-balance site and unproductive water losses;
- regular entering of monitoring data into the database; and
- calculating an average daily flow rate and discharge for each off-take at the hydro-operational site and water-balance gauging station and submitting this information in the form of reports to the CDP.

***Dispatchers of the Central Dispatching Points (CDP):***

- setting assignments for LDPs' dispatchers regarding flow rates at water-balance gauging stations and all off-takes;
- implementing the planned water delivery by means of instructions to the LDPs and recurrent control of flow rates and discharges over the past periods;
- an everyday reconciliation of reported and actual data on volumes of water delivery to water users with the DP of Basin Irrigation System Management Organization;
- a reconciliation of data between water-balance sites;
- analyzing the daily balance of water resources at water-balance sites and along the irrigation canal as a whole; and
- analyzing water losses and indicators of the water balance at water-balance sites and along the irrigation canal as a whole.

## The telecommunication system of the CDP and LDPs

***Irrigation canals are equipped with the telecommunication system with state-of-the-art facilities for data transmitting and voice-message reports that solves the following tasks:***

- reception and transmitting telemetric information, which is formed by the automation system established in the radio-communication units of the CDP, waterworks and water-balance gauging stations;
- voice radio-communication between the LDPs and observers of hydro-operational sites; and
- provision of the united information system of an irrigation canal based on the computerized network of transmitting, reception, processing and exchanging of information between the CDP and LDPs.

Under the project: "Canal Automation in the Fergana Valley", specifications are set for the following components:

- technological regime;
- analyzing and archiving of information;
- technical means;
- software;
- a telecommunication system; and
- mechanical equipment and power supply.

### Developing and implementing the project: "Canal Automation in the Fergana Valley"

It is planned to implement the project: "Canal Automation in the Fergana Valley" on the pilot canals in two stages and to complete all Works in 2008. At each stage, the project implementation schedule sets the following scope of works: i) the detailed design for each water-balance site; ii) equipment procurement according to the specifications; iii) construction works (cable laying, mounting of equipment, installation of devices and sensors etc.); iv) precommisioning; v) calibration testing, attestation, and commissioning of waterworks, gauging stations and water-metering facilities at off-takes; v) training of operational personnel; vi) software development for automation and dispatching. At the final stage it is planned to implement the following scope of works: i) developing a set of software for operative water distribution management along all main canals; ii) precommissioning of all the automation systems and training of operational personnel.

### The economic efficiency of the project: "Canal Automation in the Fergana Valley"

Indicators of the economic efficiency that resulted from analyzing of this project parameters are the following: i) investments – USD 1,545,000 funded by the SDC and USD 262,000 budgeted by the water management organizations of the republics; ii) operating costs – USD 332,000 and USD 377,360 prior to and after project implementation respectively; iii) annual net profit due to water savings amounts to USD 719,000 (115.27 million m3 at a water price of 0.006 USD/$m^3$); iv) the cost recovery – 6 years; v) the net present value – USD 2,477,000 and IRR = 32%. Results of economic analysis are given in Table 5.13.

**Table 5.16**
**Evaluating the Economic Efficiency of the Project: "Canal Automation in the Fergana Valley"**

| **Objects** | **Operating costs** ,000. *USD* | | **Investments** ,000. *USD* | | **Net profit** | | **Economic indicators** | | |
|---|---|---|---|---|---|---|---|---|---|
| | **before** | **after** | **SDC** | **MAWR** | **Water volume** *mln.m$^3$* | **Cost** ,000. *USD* | **Cost recovery,** *years* | **NPV over 15 years** | **IRR , %** |
| **BWO „Syr Darya“** | 74 | 87.36 | 305 | 40 | 38.8 | 232.8 | **2** | **1039** | **59** |
| **SFC** | 131 | 155 | 725 | 117 | 63 | 378 | **7** | **1224** | **36** |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **AAC** | 59 | 64 | 235 | 30 | 7 | 69.8 | **9** | **121** | **19** |
| **KBC** | 68 | 71 | 280 | 75 | 6.47 | 38.8 | **7** | **93** | **24** |
| **In total** | **332** | **377.36** | **1545** | **262** | **115.27** | **719.4** | **6** | **2477** | |

Based on results of the economic analysis of existing systems operation it can be noted that the introduction of the system of automation and monitoring of the water distribution process within the irrigation systems in Central Asian countries is the cheapest measure for water resources savings in comparing with other technical solutions such as canal lining or other measures preventing water seepage losses.

The small-scale enterprise "SIGMA" (Kyrgyzstan), whose production is comparatively cheap, simple for operation and accessible for procurement, taking into consideration available operational and servicing personnel in the region, was selected as the leading Contractor for constructing the system of automation and monitoring.

**By the mid of 2008, the following works were implemented in the frame of the project:**

***1) BWO structures:***

- The system of automation and dispatching (SAD) was installed at all planned waterworks and operates since June 2006. The system of automation and dispatching was timely put into pilot operation and now is ready for commissioning;
- The systems of data transmission based on the GPRS were installed on all planned structures. Time delay in data transmission from some structures (gauging stations on Uchkurgan HS and BFC) takes place;
- Specialists of the SSE "SIGMA" debug the system of data transmission installed at BWO waterworks; and
- In February 2007, the SDT at BWO structures was put in pilot operation.

***2) AAC structures:***

- Detailed design was completed; equipment of the system of automation and dispatching was installed at all planned waterworks;
- The system of data transmission based on radio communication was installed by the beginning of the growing season 2008; and
- The system of automation and dispatching and the system of data transmission with software for monitoring the water distribution process were put in operation in May 2008.

***3) SFC structures:***

- Mechanical components of main waterworks have been repaired;
- Power transmission lines to waterworks were constructed; and the dispatching points are under construction;
- The detailed design of the system of automation and dispatching (SAD) was completed;
- The detailed design of the system of data transmission (SDT) is in progress; the specifications for equipment are adjusted; and

- Equipment for the SDT was procured, and its assembling and debugging at the Andijan part of the SFC were initiated.

***4) KBC structures:***

- Rehabilitation of KBC structures funded by the Asian Development Bank are being completed;
- Mechanical components of main waterworks have been repaired;
- Power transmission lines to waterworks were constructed; and the dispatching points are under construction;
- The contract for implementing the Canal Automation Project has been prepared; and necessary agreements were signed;
- Realization of the SDT project was initiated and will be completed to the end of growing season;
- Project works related to installing the system of data transmission were initiated; and
- Monitoring of preparatory works is being conducted.

***The system of automation and monitoring of water distribution through irrigation canals allows:***

- enhancing the accuracy of measurements of water levels, flow rates and salinity, as well as opening gates of waterworks due to the introduction of the state-of-the-art tools for measuring and accounting water resources (measurement errors are decreased from 10% to 2%);
- improving the dataware based on computerized and continuous gathering, storing in memory and processing the observed values of water levels and flow rates;
- enhancing the operability and accuracy of water resources management by speeding up transmitting and processing operational information and the decision-making process;
- decreasing unproductive water resources use; and
- timely detecting and eliminating failures of the equipment of the management system and waterworks.

It is necessary to note that the systems of automation and dispatching installed at BWO "Syr Darya" structures have raised the level of O&M substantially facilitating activity of the operational staff and improving the quality of water distribution through main canals such as the SFC, Big Andijan Canal, Khakulabad Canal and Akhunbabaev Canal. At that, the conditions for the real system of monitoring by the BWO and its territorial bodies and receiving reliable information on water resources by all stakeholders were created.

## 5.6. Water Use Aimed at Enhancing Land and Water Productivity

**(Sh. Sh. Mukhamedjanov, S.A. Nerozin)**

At present, extremely excessive amounts of water are used for irrigation of crops over the whole territory of Central Asia. As a result, the environment is serious damaged. The world practice shows that introducing the state-of-the-art water-saving methods is feasible but without incentives for saving irrigation water these measures will be unsustainable. Increase in water productivity with simultaneous rising of crop yields and the application efficiency will be the sustainable solution under conditions of adequate operation of irrigation systems.

Under reforming the existing system of water use the special attention should be paid to a design carrying capacity of irrigation canal because there are not funds for their rehabilitation and increasing their operational capacity. An existing crop pattern was the basis for calculating the canal's parameters; therefore, it is necessary to select an alternative crop pattern that does not result in water delivery volumes exceeding the existing operational capacity of the canal under consideration.

Water allocation among water users being implemented by WUAs should base on the coordination of water demand with each water user, taking into account an overall capacity of irrigation systems. A crop pattern has to be planned based on selecting crops, irrigation of which is adequate to irrigation system's capacity according to timing, volumes and modes of water delivery. Therefore, the technical state of irrigation systems and maximum values of crop water requirement established for the given area should be carefully reviewed under reforming the water use practice.

Providing an optimal crop yield under minimal irrigation water consumption should be a criterion of water productivity rising. Irrigation systems' operation being coordinated at all levels and relying on the rate setting of water delivery that limits excessive use of irrigation water and establishes the water use discipline has to become a key mechanism of enhancing the irrigation water productivity under reforming the agricultural sector. Taking into consideration economic, social and political conditions in Central Asian countries, the first stage of reforming the agricultural and water sector aimed at enhancing irrigation water productivity must follow the following key provisions:

- Planning a crop pattern within the canal command area based on a carrying capacity of this canal;
- Selection of alternative crops, water requirement of which can be provided by the carrying capacity of the existing irrigation system;
- Planning the crop pattern and irrigation schedule based on the mutual agreement of WUAs and the Basin Irrigation System Administration;
- Legal guarantees to water users (under selecting crops), WUAs (under delivering irrigation water to water users) and the BISA, based on the carrying capacity of the existing irrigation systems;
- Transition towards paid water services as the pledge of WUAs existence and incentive for rational use of irrigation water; and
- Establishing the extension services focused on introducing the innovations in irrigated farming.

Taking into consideration above provisions, improvement of the irrigation water and land productivity is achieved covering the following directions:

1. monitoring a current productivity of water used for irrigation in the agricultural sector;
2. managing the agricultural practice to improve the water and land productivity using the methods that were developed taking into account the monitoring findings; and
3. managing the agricultural practice to achieve the sustainability of derived results and broad dissemination of the positive experience among water users.

**Evaluating the existing status of water use and irrigation water productivity at demonstration sites in individual farms**

In 2002, for monitoring irrigation water use, evaluating the actual water and land productivity, and developing the recommendations for enhancing the irrigation water productivity, 10 demonstration sites were selected in the frame of the IWRM-Fergana Project (within the command areas of pilot canals: Khoja-Bakirgan Canal in Soghd Province, South Fergana Canal in Fergana and Andijan provinces, and Aravan-Akbura Canal in Osh Province). Demonstration sites were selected and established in farms located along the upper, middle and lower parts of each pilot canal (Fig. 5.27). Each demonstration site was selected based on its representativeness for the whole command area of pilot canals. 10 demonstration sites that are representative for different altitudinal belts and climatic zones in the Fergana Valley were selected in whole (Table 5.17).

## General description of pilot objects

Regions of the Fergana Valley differ from each other by their altitudinal belts with specific soil and hydrogeological conditions (Table 5.18). A harsh continental climate is observed in this zone. Natural variations of climatic conditions over altitudinal belts are typical for piedmont regions. Overall climatic features are high summer temperatures and the dryness of air; there are sudden changes in daily and seasonal temperatures. Average daily temperatures in January range from -2.5° to +2°C; and an average monthly temperature in July is about 30°C. Annual distribution of temperatures and rainfalls depend on an altitude (an elevation above mean sea level). With increasing the altitude, the amount of rainfalls is also increasing but air temperatures are lowering. Precipitation falls mainly in winter and spring. Summer is arid; and there is not almost a fall of rain since July until September. Annual amount of precipitation ranges from 100 mm to 200 mm on the plain, and up to 450 mm in the piedmont zone.

Soils are the determinative factor under scheduling irrigations. In the growing season 2002, regional group's specialists have surveyed soils and micro-relief of each demonstration site. Soils differ from each other drastically not only in provinces but also in farms depending on the altitudinal belts of their location. A small depth of topsoil underlain by pebble with deep watertable is typical for most of farms in the project area (Table 5.18). Developing irrigation on these lands is complicated by the high soil permeability, ill-made land leveling and non-uniform wetting across irrigated fields. In Osh Province, all three demonstration sites are located in the zone with irregular topography, naturally creating problems for organizing irrigation.

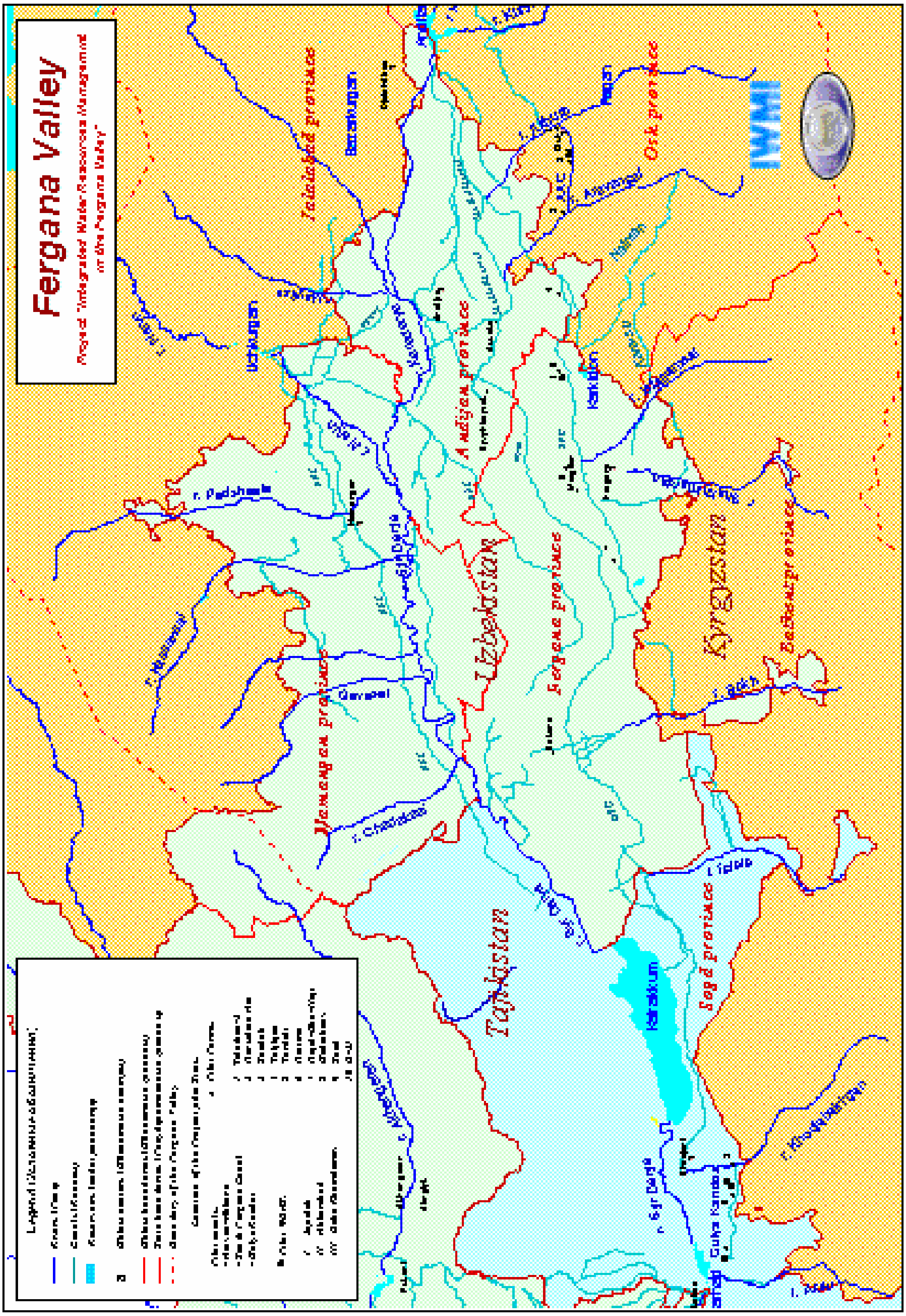



Figure 5. 27 The Fergana Valley: the Pilot IWRM-Fergana Project's Area

**Table 5.18**

**Distribution of Selected Farms over the Altitudinal Zones with Different Types of Soil-Forming Processes**

| Demonstration site | Altitudinal belt | Elevations | Description of soils and underlying layers | Hydrogeological conditions |
|---|---|---|---|---|
| **Osh Province** | | | | |
| PF «Sandyk» | Adyry[32] uplands | 500 to 800 m | Thick topsoil of loam and sandy loam | GWT>5 m |
| PF «Nursultan-Ali» | | | Stony loam underlain by pebble | |
| PF «Toloykon» | | | Stony sandy loam underlain by pebble | |
| **Andijan Province** | | | | |
| PF «Tolibjon» | Inter-adyry depressions | 400 to 500 m | Thick topsoil of sandy loam | GWT>5 m |
| **Fergana Province** | | | | |
| PF «Turdialy» | Inter-adyry depressions | 400 to 500 m | Thick topsoil of sandy loam | GWT = 0.5-1.0 m |
| PF «Nozima» | Sloping plain | up to 400 m | Thick topsoil of loam and clay loam | GWT = 1.0-1.5 m |
| PF «Khojalkhon-ona-Khoji» | Inter-adyry depressions | 400 to 500 m | Topsoil of sandy loam of 0.5 to 0.7 m underlain by pebble | GWT>5 m |
| **Soghd Province** | | | | |
| DF «Bakhoriston» | Inter-adyry depressions | 400 to 500 m | Thick topsoil of sandy loam | GWT>5 m |
| PF «Saed» | | | Topsoil of sandy loam of 0.5 to 0.7 m underlain by pebble | |
| DF «Samatov» | | | Topsoil of sandy loam of 0.5 to 0.7 m underlain by pebble | |

**DF – Dekhan farm**

**PF – Private farm**

[32] Low foothills bordering the Fergana depression

### Assessing impacts of the soil permeability and land surface slopes

Important indicators that need to be considered under designing an optimal furrow irrigation system and evaluating the application efficiency are an infiltration rate and an average slopes. In 2002, during the growing season, regional group's specialists have conducted field investigations to specify infiltration rates and slopes on demonstration fields (Table 5.19).

**Table 5.19 Slopes in Demonstration Farms**

| No | Farm | Longitudinal gradient | Cross gradient |
|---|---|---|---|
| 1 | DF "Samatov" | 0.028 | 0.0112 |
| 2 | PF "Sayed" | 0.025 | 0.0034 |
| 3 | DF "Bakhoriston" | 0.014 | 0.0088 |
| 4 | PF "Khojalkhon-ona-Khoji" | 0.012 | 0.0045 |
| 5 | PF "Nozima" | 0.003 | 0.0022 |
| 6 | PF "Turdialy" | 0.006 | 0.0012 |
| 7 | PF "Tolibjon" | 0.010 | 0.0168 |
| 8 | PF "Toloykon" | 0.045 | 0.0130 |
| 9 | PF "Nursultan-Aly" | 0.060 | 0.0110 |
| 10 | PF "Sandyk" | 0.055 | 0.0260 |

Topographic maps, which clear demonstrate the existing micro-relief by means of contour lines were plotted based on field topographic surveys. These data were included into a passport of each demonstration field and used for designing the optimal layout of field ditches, head ditches and furrows, as well as locations for installing water-metering devices.

The timing and irrigation rates substantially depend on effective available water in the soil. Deficit of effective available water points out the need of irrigation. Field investigations of soil infiltration rates have shown that soil permeability is high on all demonstration fields but especially where there is stony topsoil or topsoil underlain by pebble deposits. Tailwater[33] releases and overwetting of upper part of furrows are unavoidable in the zone with soils of high permeability where the field irrigation efficiency is the lowest one due to water losses related to percolation. According to the classification developed by N. Laktaev [5], project demonstration fields refer to the zone of steep and very steep slopes (0.01 to 0.04). The steepest slopes and high permeability of the soil are observed in farms in Osh Province (Table 5.20).

[33] Tailwater: Applied irrigation water that runs off the lower end of a field.

**Table 5.20 Location of Demonstration Sites**

| Province | District | WUA /DF | Private farm | Irrigated area of a farm, ha | Irrigated area of the DS, ha | Crop cultivated at the DS | Main Canal | Water sources |
|---|---|---|---|---|---|---|---|---|
| Osh | Aravan | WUA "Akbura" | Sandyk | 30.3 | 5 | Cotton | Aravan-Akbura | Akbura River |
| | Karasu | WUA "Japalak" | Nursultan-Aly | 6 | 0.9 | Spring wheat | | |
| | | WUA "Janaryk" | Toloykon | 16 | 4 | Winter wheat | | |
| Andijan | Bukak-bosh | Jura-Polvan | Tolibjon | 10 | 5.6 | Cotton | SFC | Kampiravat Reservoir |
| Fergana | Kuva | Navoi | Turdialy | 10 | 2.7 | | | |
| | Tashlak | Navoi | Nozima | 12 | 8 | | | |
| | Akhun-babaev | Niyazov | Khojalkhon-ona-Khojy | 10 | 5 | | | |
| Soghd | Gafur | DF "Bakho-riston" | Br. 2 | 133.3 | 12.6 | Cotton | Gulyakandoz | Khoja-Bakirgan River |
| | Rasul | Bobokham-damov | Sayed | 70.6 | 4.1 | | | |
| | | DF " Samatov" | Br. 21 | 126 | 6 | | | |

***Crop pattern in pilot private farms***

Crop patterns differ from each other over provinces located in the Fergana Valley. Cotton and wheat occupy about 40% and 30% of a total irrigated area respectively in Uzbek and Tajik part of the valley. In Osh Province, an irrigated area under cotton amounts only 7%, and most of irrigated farmland were sown with wheat (33%). Tobacco, corn and fruits are the most widespread crops according to their sown areas after wheat in this province. Crop patterns in private farms also usually correspond with crops prevailing in the province (Table 5. 21).

**Table 5.21 Crop Patterns in Provinces and Pilot Farms**

| No | Province/Farm | Crop pattern, % of irrigated area | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Cotton | Grains | Alfalfa | Corn | Tobacco | Vegetables | Orchards | Truck crops | Others |
| | **Osh Province** | 8.10 | 31.5 | 5.5 | 10.1 | 6 | 7.99 | 5.9 | 13,9 | 10.9 |
| 1 | PF “Sandyk” | 29.7 | 16.5 | 6.6 | | 1.65 | 4.2 | 39.6 | | 1.75 |
| 2 | PF “ Nursultan-Aly” | - | 65 | 16.7 | 11.7 | - | - | - | - | 6.6 |
| 3 | PF “Toloykon” | - | 87.5 | - | - | - | - | - | - | 12.5 |
| | **Fergana Province** | 33.92 | 27.07 | 3.66 | 2.84 | | 1.48 | 9.58 | 21.45 | - |
| 4 | PF “Khojalkhon-ona-Khoji | 50 | | | | | | | | |
| 5 | PF “Nozima” | 100 | | | | | | | | |
| 6 | PF “Turdialy” | 50 | | | | | | | | |
| | **Andijan Province** | 38.56 | 26.92 | 2.62 | 0.45 | | 0.79 | 10.8 | 14.95 | 4.95 |
| 7 | PF “Tolibjon” | 50 | 50 | | | | | | | |
| | **Soghd Province** | 29.74 | 21.33 | 8.01 | 1.81 | 1.28 | 1.75 | 7.1 | 13.03 | 15.93 |
| 8 | PF “Sayed” | 65.82 | 17.69 | | 4.2 | - | 4.5 | 0.63 | | 7.15 |
| 9 | DF “Samatov” | 57.94 | 28.57 | 7.93 | 4.76 | - | 0.8 | - | - | - |
| 10 | DF “Bokhoriston” | 59.26 | 11.78 | 12 | 7.5 | - | 4.35 | - | 3.6 | 1.5 |

### Monitoring land and water use in selected private farms

Analyzing the actual irrigation practice has shown that considerable losses of irrigation water are observed in farms depending on soil and hydrogeological conditions, topography and the quality of land leveling. In some farms excessive irrigation water losses result from the incorrect selection of a furrow irrigation system and irrigation season duration. A protracted irrigation season (until October) is observed at all three demonstration sites in Soghd Province in Tajikistan. Irrigation on small plots with short furrows (a furrow length ranges from 68 to 98 m on demonstration fields) is typical for Soghd Province. Considerable irrigation water losses in the form of tailwater releases were observed in farms “Sayed” and “Bakhoriston”; and more efficient use of irrigation water takes place in the farm “Samatov.” There is a difference in irrigation water use resulted from the location of farms relative to the main canal. The farm “Bakhoriston” located along the upper part of the main canal with higher water availability uses more amounts of irrigation water than farms “Sayed” and “Samatov” located along the middle and tail part of the irrigation canal. Applying of greater irrigation rates in the farm “Bokhoriston”, due to soil conditions, results in considerable irrigation water losses owing to deep percolation.

**Table 5.22 Zoning of Demonstration Fields according to the Permeability of Soils and Slopes**

| Farm | Soil type | Topsoil depth, m | Underlying layer | Zone index/ Gradient | Zone index/ Infiltration Rate (m/h) |
|---|---|---|---|---|---|
| DF “Samatov” | Sandy loam | 0.5- 0.7 | pebbles | **I – the zone of steepest slopes** | C – average permeability |
| | | | | 0.028 | 0.0042 |
| PF “Sayed” | Sandy loam | 0.5- 0.7 | pebbles | **II- the zone of steep slopes** | A- the highest permeability |
| | | | | 0.025 | 0.036 |
| DF “Bakhoriston” | Loamy sand | 1.5- 2.0 | pebbles | **II - the zone of steep slopes** | A- the highest permeability |
| | | | | 0.014 | 0.0138 |
| “Khojalkhon-ona-Khoji” | Sandy loam | 0.5- 0.7 | pebbles | **II - the zone of steep slopes** | B - high permeability |
| | | | | 0.012 | 0.0102 |
| “Nozima” | Loam and clay loam | Thick topsoil | | **III – the zone of mild slopes** | A- the highest permeability |
| | | | | 0.003 | 0.0198 |
| “Turdialy” | Sandy loam | 1.5-2.0 | pebbles | **III - the zone of mild slopes** | B - high permeability |
| | | | | 0.006 | 0.0102 |
| “Tlibjon” | Sandy loam | Thick topsoil | | **II - the zone of steep slopes** | A- the highest permeability |
| | | | | 0.01 | 0.0198 |
| “Toloykon” | Sandy loam | 0.5- 0.7 | pebbles | **I - the zone of steepest slopes** | A- the highest permeability |
| | | | | 0.045 | 0.012 |
| “Nursultan-Aly” | Loam | 0.5- 0.7 | pebbles | **I - the zone of steepest slopes** | B– high permeability |
| | | | | 0.06 | 0.006 |
| “Sandyk” | Loam and sandy loam | Thick topsoil | | **I - the zone of steepest slopes** | A- the highest permeability |
| | | | | 0.054 | 0.0402 |

In Fergana and Andijan provinces of Uzbekistan, conditions for water applications are different at selected demonstration sites due to different soil and hydrogeological conditions. In some farms, incorrect selecting of the furrow irrigation systems namely the direction and length of furrows (294 to 525 m) and irregular irrigation water delivery results in high consumption of irrigation water since most of irrigation water was lost due to deep percolation.

In the farm “Turdialy”, water applications were conducted taking into account groundwater feeding (GWT up to 0.5 m) and using irrigation rates and intake rates in furrows (0.3 to 0.4 l/sec) that are optimal for these conditions. Water application in accordance with the water-saving mode on selected sites (irrigation only on those parts of the field where plants suffer from water deficit) was conducted in the farm “Tolibjon.” The farmer could use lesser water volume during the growing season if to exclude two first unjustified water applications with high rates (4,400 and 2,500 $m^3$/ha).

Managing of water applications is more complicated in all three farms in Osh Province due to the irregular topography and stony soils. Planned soil wetting is achieved at the expense of higher irrigation rates (private farms “Toloykon” and “Nursultan-Aly”). The most part of irrigation water delivered is forming the runoff from a field. More efficient use of irrigation water was observed in the farm “Sandyk” where shorter furrows and lesser inflow rates in furrows were utilized.

Field investigations of the irrigation technique along with agricultural practice have shown that there are problems in organization of water applications due to the high permeability of soils, ill-made land leveling, steep slopes, insufficient topsoil thickness and incorrect selection of the furrow irrigation system.

## Evaluating the efficiency of irrigation water use in private farms

Analyzing the monitoring data along with appropriate calculations shows that a major portion of irrigation water losses is caused by deep percolation rather than surface runoff. Actual irrigation water losses due to deep percolation in farms exceed normative ones. In some farms such as “Khojalkhon-ona-Khoji” and “Nozima”, irrigation water losses exceed normative ones two times (Table 5.23). In these farms, an application efficiency amounts to 40%. Deep percolation is unavoidable for most of farms where the high permeability of soils is observed and where ill-made land leveling takes place and too long furrows are in use. It is although necessary to note that some farms, having the same soil and hydrogeological conditions, irrigated their plots with minimum irrigation water consumption and small losses of water owing to deep percolation and surface runoff (DF “Samatov”, “Sandyk”, and “Turdialy”). Application efficiency in these farms is the highest one. DF “Samatov” provided this result based on use of short furrows and small inflow rates in furrows. The farm “Turdialy” has provided the high application efficiency as a result of effective accounting the feeding by groundwater under irrigation scheduling. Excepting these three farms, the application efficiency was quite low at other demonstration sites.

**Table 5.23 Basic Indicators of Irrigation Water Use at Demonstration Sites**

| Farm | $WR_{norm}$ | SR | | DP | | AE | $AE = \frac{(WR_{norm} - SR - DP)}{WR_{norm}}$ |
|---|---|---|---|---|---|---|---|
| | actual | norm | actual | norm | actual | actual | |
| | $m^3$/ha | % | % | % | % | % | |
| DF “Samatov” | 8266 | 13 | 10 | 12 | 20 | 70 | 0.70 |
| PF “Sayed” | 7343 | 17 | 21 | 20 | 20 | 59 | 0.59 |
| DF “Bakhoriston” | 12969 | 17 | 20 | 20 | 36 | 45 | 0.45 |

| Farm | $WR_{norm}$ | SR | | DP | | AE | AE= $\frac{(WR_{norm} - SR - DP)}{WR_{norm}}$ |
|---|---|---|---|---|---|---|---|
| | actual | norm | actual | norm | actual | actual | |
| | $m^3$/ha | % | % | % | % | % | |
| DF “Khojalkhon-ona-Khoji” | 16795 | 13 | 19 | 17 | 41 | 41 | 0.41 |
| DF “Nozima” | 6718 | 2 | 0 | 31 | 58 | 42 | 0.42 |
| DF “Turdialy” | 2145 | 10 | 5 | 12 | 11 | 84 | 0.84 |
| DF “Tolibjon” | 9510 | 17 | 13 | 20 | 29 | 58 | 0.59 |
| DF “Toloykon” | 5803 | 1,3 | 32 | 46 | 40 | 28 | 0.28 |
| DF “Nursultan-Aly” | 5120 | 5 | 18 | 27 | 31 | 50 | 0.50 |
| DF “Sandyk” | 6030 | 1 | 26 | 46 | 10 | 64 | 0.64 |

Where: $WR_{norm}$ – normative water requirement; SR – surface runoff; DP – deep percolation; and AE –application efficiency

**Table 5.24. Assessment of Actual and Planned Application Efficiency**

| Farm | Planned application efficiency | Actual application efficiency | Possible increase in the application efficiency, % |
|---|---|---|---|
| DF “Samatov” | 0.76 | 0.70 | 8 |
| PF “Sayed” | 0.63 | 0.59 | 6 |
| DF “Bakhoriston” | 0.63 | 0.45 | 29 |
| PF “Khojalkhon-ona-Khoji” | 0.70 | 0.41 | 41 |
| PF “Nozima” | 0.67 | 0.42 | 37 |
| PF “Turdialy” | 0.84 | 0.84 | 0 |
| PF “Tolibjon” | 0.63 | 0.59 | 6 |
| PF “Toloykon” | 0.53 | 0.28 | 47 |
| PF “Nursultan-Aly” | 0.68 | 0.50 | 26 |
| PF “Sandyk” | 0.64 | 0.64 | 0 |

### Evaluating the existing furrow irrigation systems on demonstration fields

A proper furrow irrigation system is a crucial element that ensures the high application efficiency. Existing furrow irrigation systems were studied on all project demonstration fields during the growing season 2002. As a result of these field investigations, three groups of furrow irrigation systems were distinguished taking into account soil and hydrogeological conditions and local topography:

Satisfactory furrow irrigation systems not requiring any improvements (DF "Samatov", DF "Bakhoriston", PF "Turdialy" and "Tolibjon");

Non-satisfactory furrow irrigation systems requiring the complete remodeling, including reducing a length of furrows and arrangement of additional field and head ditches (PF "Khojalkhon-ona-Khoji" and "Nozima"); and

Furrow irrigation systems on fields with irregular topography where only partial modifications are possible (PF "Sayed", "Toloykon", "Nursultan-Aly", and "Sandyk").

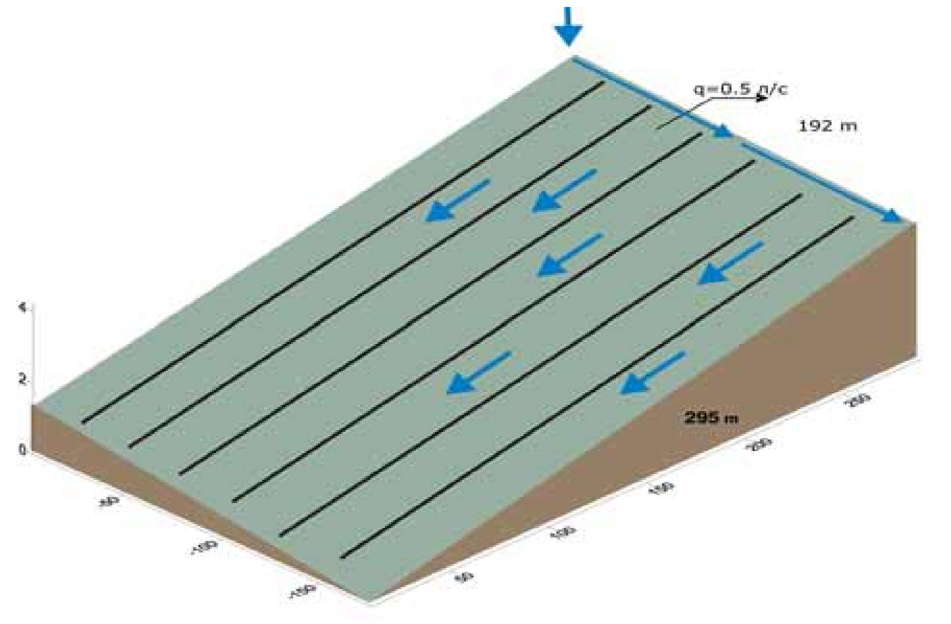



**Figure 5.28 Parameters of the Furrow Irrigation System in PF "Khojalkhon-ona-Khoji" (2002)**

Reducing a length of furrows and arrangement of additional field ditches were recommended for irrigated areas with shallow topsoil underlain by pebble. The length of furrows and division of the irrigated field into four irrigation units in DF "Samatov" can be considered as the most optimal solution. In DF "Bakhoriston", a flow rate in the irrigation canal should be adjusted (up to 40 l/sec instead of 80 l/sec) to be sufficient for irrigating two irrigation units on the field.

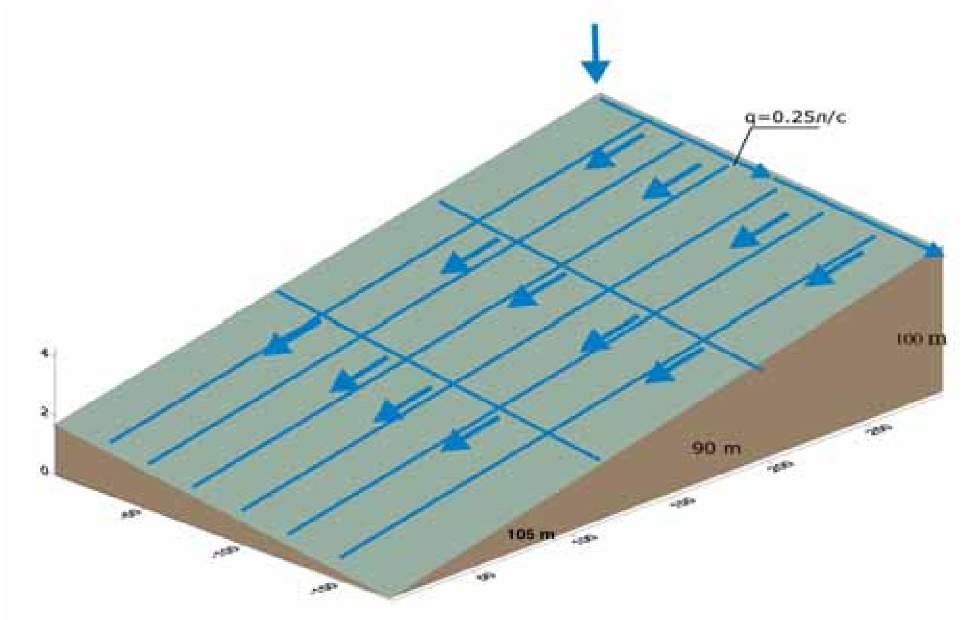



**Figure 5. 29 Parameters of the Furrow Irrigation System Recommended for PF "Khojalkhon-ona-Khoji" (2003)**

A key shortcoming in organization of water applications in the farm "Nozima" is the incorrect selection of furrow irrigation system under lacking of land leveling. In the farm "Tolibjon" water application is conducted on selected irrigation units within fields, taking into account actual crop water demands. It is important to study and develop this approach containing elements of water-saving methods.

Steep slopes, irregular topography and the high permeability of soils cause difficulties in organizing water applications in farms of Osh Province. The furrow irrigation system in all three demonstration farms should be modified by means of arranging additional field ditches. It is recommended to irrigate three sections of a field in turn: an upper section with a gentler slope; middle and lower section with steeper slopes.

## Assessment of the actual irrigation water productivity on the demonstration sites

To assess the irrigation water productivity we have analyzed and evaluated monitoring data on irrigation water use and agricultural practice on all demonstration fields during the growing season. In the process of comparative assessment of irrigation water use it was determined that actual irrigation water supply exceeds required volumes and obviously that rising of irrigation water productivity can be achieved at the expense of reducing the rate and numbers of water applications. The actual productivity of irrigation water ranges from 2400 to 4400 m3/ton in farms of Soghd Province (Figure 5.30). It is necessary to note that water applications in September and October are not effective and even reduce crop yields; therefore, the irrigation water productivity could be much higher without these irrigations and could make up 1900 to 2600 m3/ton. The highest water consumption per unit production is observed in the farm "Khojalkhon-ona-Khoji" (reducing the irrigation water productivity 2.5 times)

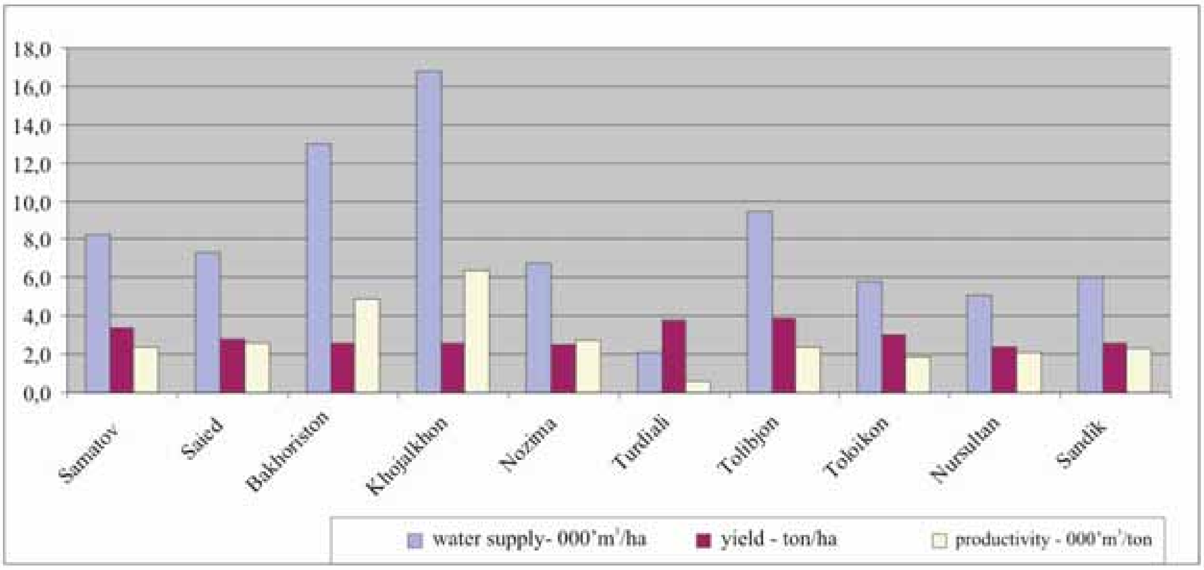



**Figure 5.30 Assessment of the Actual Irrigation Water Productivity**

Note: where Nf – an actual irrigation rate; PY- an actual crop yield; P- the irrigation water productivity.

The least consumption of irrigation water was observed in farms "Saed", "Samatov", "Sandyk", "Nursultan-Aly" and "Turdialy." The highest level of irrigation water productivity was achieved in the farm "Turdialy" (600 $m^3$/ton) as a result of effective water use and feeding by groundwater along with skillfully implementing the land treatment.

### Assessment of the potential irrigation water productivity

Apart from unproductive losses of irrigation water due to deep percolation and tailwater runoff from irrigated fields, reducing of irrigation water productivity is caused by losses of crop yield owing to organizational factors and different bottlenecks in the agricultural practice. Actual values of reducing crop yields caused by different factors were determined based on evaluating of the field monitoring data. Maximum losses of crop yield are caused by an insufficient content of humus in soils over all farms with the exception of the farm "Nozima." Losses of crop yields due to humus deficit amount to 30 to 40% in farms of Osh Province. This reason is also crucial for Soghd Province causing losses of crop yields up to 23%. In Andijan and Fergana provinces the content of humus in soils is higher than in Osh and Soghd provinces; and therefore losses of crop yields caused by this factor make up less than 10%.

Soil salinization is no less important a factor of reducing crop yields. Soils more affected by salinization are observed in farms "Khojalkhon-ona-Khoji", "Nozima" and "Nursultan-Aly" where losses of crop yield due to salinization make up 9 to 13%. Losses of crop yields caused by other factors are negligible. An assessment of the potential water productivity will be incorrect without reviewing losses of crop yields caused by factors related to agricultural practice and soil and hydrogeological conditions since under supplying irrigation water according to optimal timing and norms, the low indicators of irrigation water productivity can be received due to factors that have nothing to do with irrigation water. Therefore, the optimal gross irrigation rate and potential crop yield that was calculated for each demonstration field based on monitoring data were used for evaluating the potentially possible productivity of irrigation water. In case of eliminating step-down factors, a level of irrigation water productivity on project demonstration fields can be, on average, raised on 54% in Tajikistan, 52% in Uzbekistan, and 34% in Kyrgyzstan.

## Financial and economic indicators of the irrigation water productivity

A chief indicator of agricultural production efficiency is the profit from agricultural output, which depends from total production costs, amount of output and its realization. Total production costs and an amount of agricultural output depend on different factors and components of farming, including use of irrigation water.

Production costs in farms from tillage operations and until harvest and sale of output were studied and analyzed based on data of the monitoring on each demonstration field. Total production costs were calculated for each demonstration farm in the local currency based on data on scopes of works and their unit costs. For conducting the comparative assessment, the total production costs were converted to USD. Manual labor, fertilizers and machinery operation are main items of total production costs under cultivating cotton.

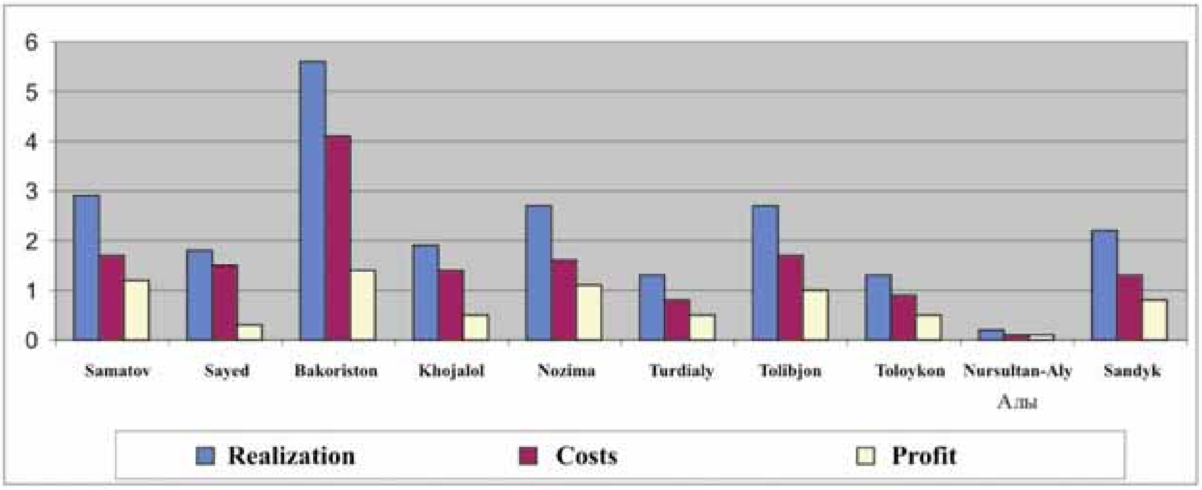



**Figure 5.31 Economic Assessment of Agricultural Production**

The economic assessment of irrigation water productivity was carried out on the basis of collected data on the profit from agricultural output and irrigation water volumes consumed on demonstration fields. Economic indicators of irrigation water productivity vary over the range of 0.02 to 0.26 $/m3 over demonstration farms. The highest economic indicators of irrigation water productivity are observed in the farm “Turdialy” and the least ones in the farm “Khojalkhon-ona-Khoji.” An average economic productivity of irrigation water over all farms, without considering crop pattern, amounts to 0.06 $/m3.

Evaluating the initial monitoring data has shown that the soil and hydrogeological conditions at selected demonstration sites in the Fergana Valley differ from each other drastically, causing different challenges for organizing water applications. The application efficiency at demonstration sites has mainly depended on soil properties, water availability, hydrogeological conditions, and selected furrow irrigation system. Monitoring of irrigation water use and agricultural practice allowed revealing the low efficiency of land and water resources use practically in all farms in three provinces of the Fergana Valley. Major causes of reducing the efficiency of irrigation water use are the following:

- unstable irrigation water availability in irrigation canals;
- lack of the plan of water use adequate to specific soil, climatic, and morphological conditions of irrigated farmlands;
- incorrectly selected furrow irrigation systems and their parameters; and

- low quality of land leveling and preparatory agricultural methods.

**Key indicators of the low efficiency of land and water resources use are the following:**

- considerable losses due to deep percolation;
- considerable tailwater runoff on irrigated fields;
- out-of-time implementing of some land treatment operations and their low quality;
- low application rates of potash and phosphate fertilizers or their complete lack; and
- ineffective methods of weed control and pest control;

Ununiform rates of water infiltration into soil over different parts of an irrigated field and along a furrow length, unsustainable water availability in irrigation canals, ill-made land leveling and incorrect selected furrow irrigation systems result in the considerable consumption of irrigation water during the growing season.

### 5.6.1 Management of Irrigation and Agricultural Practice Based on State-of-the-Art Technological and Engineering Methods for Achieving Efficient Use of Land and Water Resources and Sustainable Crop Yields at the Field Level

The monitoring conducted in 2002 for evaluating the productivity of irrigation water and irrigated farmland allowed revealing the existing status of irrigated farmland, private farms and irrigation water use in the Fergana Valley, as well as existing bottlenecks and opportunities for their eliminating. The monitoring data became the basis for developing the recommendations how to raise the efficiency of irrigation water and irrigated farmland use, how to enhance their productivity and how to improve the management methods in the agricultural sector. The models for irrigation scheduling adapted to conditions of each field were developed based on the analysis of baseline information. So-called agro-ameliorative passports that contain the baseline information on a field and the recommended furrow irrigation system along with recommended agricultural methods were developed for each demonstration site.

As a result of assessment and analyzing of irrigation water use at demonstration sites in 2002, major factors that affected the efficiency of water applications were revealed. In 2003, activity aimed at eliminating existing shortcomings in water application management and improving the efficiency of water application was undertaken. At that, the particular attention was paid to the following measures:

- **Layout of irrigated units:** each demonstration field, taking into consideration its topographic, soil and hydrogeological conditions, was divided into irrigated units with a length of furrows less than 100 m (an optimal length up to 70 m) by the system of longitudinal and lateral irrigation ditches;
- **Improving on-field irrigation water distribution** based on the subdivision into irrigated units: the sequence of irrigation with applying water-saving elements and rational use of irrigation water within a field (a decrease in water delivery into lower irrigated units in accordance with volumes of tailwater runoff from each furrow of an upper irrigated units), taking into consideration a micro-topography and soil texture of irrigated units; and
- Implementing water application in accordance with **terms and rates** calculated by the computer model based on information on actual soil water depletion and evaporation rates.

Implementing the planned measures was started since October-November because it was important to implement tillage in accordance with the developed recommendations during the autumn season. For the purpose of preparing fields for the irrigation season, division of fields into irrigated units was made in March-

April. For calculating terms and rates of water applications, daily field measurements of evaporation and soil water content were started in May.

## Comparative analyzing of irrigation water use to evaluate the water management at the demonstration sites

Analysis of data on irrigation water use has shown that during following years practically all farms have irrigated their plots using water application rates considerably lesser than in 2002. In addition, the number of water applications was reduced in many farms. Although this indicator cannot be considered as an indicator of saving water in the process of irrigation, at the same time, it has certain meaning relative to rational and effective use of irrigation water. For example, in May and June in 2003, farms "Toloykon" and "Norsultan-Aly", using recommendations based on modeling results that took into account actual data on soil water content and rainfalls, have implemented only one water application with a small rate against two water applications with the rate of 2000 $m^3$/ha in 2002. In this case, the reduction in the water application volumes took place according to both the number of irrigations and their rates. However, a different situation was observed in the farm "Tolibjon" where there were four water applications in 2002 and seven in 2003; and the reduction in the water application volumes in 2003 took place due to the reducing in irrigation rates.

In 2004, weather conditions considerably differed from those in 2003; and this fact has predetermined great changes in volumes of irrigation water supply and irrigation scheduling. Table 5.25 shows that in 2004 the irrigation requirements and volumes of irrigation water supply were increased in most of private farms; and some farms increased the number of water applications as well.

The most increase in irrigation water use was observed in the farm "Somatov" in Soghd Province and the farm "Toloykon" in Osh Province. The farm "Somatov" has used more irrigation water on 34% than was recommended. The farm "Toloykon" exceeded the normative volume of irrigation water use because of the first overrated water application in spring (3729 m3/ha) when the drought and high infiltration rates of dry soils in this farm did not allow irrigators to use small irrigation rates. Irrigation rates were adjusted during the following water applications in accordance with the estimated norms.

In farms "Bakhoriston", "Nozima", and "Nursultan-Aly", the increase in irrigation rates was observed only relative to 2003 and cannot be considered as mismanagement, because the Year 2003 is characterized by abundant rainfalls, most of which fell in May and June. The amount of precipitation during these months made up 46 mm in 2004 against 112 mm in 2003, or 660 m3/ha of additional replenishing of soil water content available for plants. The intensity of rainfalls allowed farmers to delay the first water application by 30 to 40 days and even more. As a result, most of farms have reduced the number of irrigations (by one or two) and the total volume of irrigation water supply into fields. The farms that cultivate wheat have managed with one water application in the spring period, as much as possible using wetting of soils by rainfalls. The farm "Nursultan-Aly" that has produced the output of wheat using only one water application (the irrigation rate of 2130 m3/ha) can be mentioned. In 2004, although this farm has increased the irrigation requirement up to 4393 m3/ha, however, it fits the estimated water requirement for this year (with the exception of small surpluses over water application rates). The beginning of irrigation of wheat since April and more intense irrigations in May and June were caused because of the droughty end of winter and the droughty beginning of May. The same can be mentioned regarding irrigation of cotton. Droughty spring did not allow farms to sow cotton using the natural soil water content. Some farms were forced to make irrigation to trigger germination in the beginning of April. Most of farms have used irrigations to trigger germination. Some farms, such as the farm "Turdialy", have made water application for land preparation and were forced to make irrigation to trigger germination due to the deficit of soil water content before the sowing campaign. As a result, the farm has used 1053 m3/ha for water application for land preparation in vain. Although, this farm has rationally used the feeding by groundwater and following the estimated irrigation schedule based on accounting actual soil water content and evaporation, used the irrigation rate less than in 2003.

The farms "Sayed", "Khojalkhon-ona-Khoji" and "Tolibjon" have used irrigation water in limits of volumes used in 2003. The farm "Khojalkhon-ona-Khoji" has slightly reduced the volume of irrigation water use mainly due to accurate implementing the recommendations on irrigation scheduling based on modeling. At the same time, the farm "Tolibjon" has reduced the volume of irrigation water use mainly due to the original water-saving method of water applications over local irrigation units (this method is described in the section devoted to water saving technologies in more detail).

Table 5.25 Basic Indicators of Irrigation Water Use at Demonstration Sites

| Farm | Number of water applications | | | Area, ha | | | Irrigation water supply per unit area (gross), $m^3$/ha | | | Tailwater runoff, $m^3$/ha | | | Irrigation water supply per unit area (net), $m^3$/ha | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 2002 | 2003 | 2004 | 2002 | 2003 | 2004 | 2002 | 2003 | 2004 | 2002 | 2003 | 2004 | 2002 | 2003 | 2004 |
| 1 | 2 | | | 3 | | | 4 | | | 5 | | | 6 | | |
| Samatov | 11 | 7 | 8 | 6 | 7 | 7 | 8,264 | 5,012 | 8,032 | 853 | 468 | 339 | 7411 | 4,545 | 7,693 |
| Sayed | 14 | 7 | 7 | 4.1 | 4.1 | 4.1 | 7,342 | 5,940 | 6,659 | 1,536 | 1,071 | 895 | 5807 | 4,869 | 5,763 |
| Bakhoriston | 8 | 7 | 8 | 12.6 | 12.6 | 4.6 | 12,968 | 7,643 | 8,815 | 2,483 | 1,557 | 1,361 | 10,485 | 6,086 | 7,454 |
| Khojalkhon-ona-Khoji | 10 | 8 | 7 | 5.6 | 5.6 | 5.6 | 18,804 | 12,525 | 10,305 | 3,173 | 3,173 | 2,342 | 15,631 | 9,351 | 7,962 |
| Nozima | 3 | 3 | 4 | 8 | 8 | 4.5 | 6,718 | 3,468 | 4,523 | 0 | 0 | 0 | 6,718 | 3,468 | 4,523 |
| Turdialy | 6 | 5 | 5 | 2 | 1 | 1 | 4,020 | 3,429 | 3,290 | 255 | 510 | 164 | 3,831 | 2,919 | 3,126 |
| Tolibjon | 4 | 7 | 7 | 5 | 5 | 5 | 9,399 | 5,925 | 5,761 | 1,208 | 468 | 1,485 | 8,191 | 5,457 | 4,275 |
| Toloykon | 2 | 3 | 4 | 4 | 2 | 2.5 | 5,803 | 4,569 | 5,495 | 1,855 | 606 | 1,666 | 3,948 | 3,963 | 3,829 |
| Nursultan | 2 | 3 | 3 | 0.9 | 1 | 1 | 5,120 | 2,130 | 4,393 | 942 | 418 | 1,200 | 4,178 | 1,712 | 3,193 |
| Sandyk | 5 | 5 | 5 | 5 | 5 | 5 | 6,030 | 5,540 | 6,236 | 1,554 | 1,170 | 1,139 | 4,476 | 4,370 | 5,097 |

## Assessment of the water use efficiency at demonstration sites

In 2003, the higher efficiency of irrigation water use in comparing with 2002 was observed (it was ranging from 0.53 to 0.83 i.e., on average, 65% of irrigation water delivered was used directly by plants). However, in 2004, the efficiency of irrigation water use was lower than in 2003, although maximum values in some farms were higher (Table 5.26).

For example, in farms "Nozima", "Turdialy" and "Tolibjon" (Uzbekistan) and in the farm "Sandyk" (Kyrgyzstan), in comparing with 2002 and 2003, the growth of the efficiency of irrigation water use was observed. The efficiency of irrigation water use has reduced in all three farms in Tajikistan; although in two farms ("Sayed" and "Bakhoriston") this reduction was negligible, within the allowable variations. Regarding some factors that affect the efficiency of irrigation water use (tailwater runoff from irrigated fields and irrigation water losses due to deep percolation), it is necessary to note that while volumes of tailwater runoff from irrigated fields were higher in 2004 than in 2003, they were lower than in 2002 and most likely reflect the losses of irrigation water inherent for the given soil and climatic conditions. In the farm "Samatov", basic losses of irrigation water are related to deep percolation. The incorrect decision of this farm's manager, who explained his actions by the specificity of cultivating cotton with long-staple fibers, consisted in applying higher irrigation rates without considering the soil and hydrogeological conditions (topsoil with the thickness not exceeding 0.7 to 1.0 m underlain by pebble). Overrated values of tailwater runoff from irrigated fields and irrigation water losses due to deep percolation were also observed in the farm "Khojalkhon-ona-Khoji" in Fergana Province of Uzbekistan and in farms "Toloykon" and "Nursultan-Aly" in Osh Province of Kyrgyzstan. In these farms, topsoil with the insufficient thickness underlain by pebble play a determinative role. High losses of irrigation water due to deep percolation on such soils are unavoidable, but they can be reduced by applying low inflow rates in furrows and simultaneous irrigation only on small irrigated units. However, at that, the problem of elongating a total time of water delivery into a field arises. As a whole, losses of irrigation water due to deep percolation and tailwater runoff from irrigated fields were close to the normative values in other farms. On average, the efficiency of irrigation water use was at the level of 52% in 2002, 66% in 2003, and 62% in 2004. These values show that the relative sustainability in irrigation water management was achieved.

## Assessment of irrigation water productivity at demonstration sites

In 2002, actual volumes of irrigation water supply in farms have exceeded the required volumes, and it became quite obvious that raising the irrigation water productivity can be provided only by reducing the number and rates of water applications. Monitoring at demonstration sites confirmed the correctness of conclusions made in 2002. Assessment of the irrigation water productivity based on the field monitoring has revealed considerable changes at each demonstration site in 2003. In 2004, members of the regional group and local experts organized field works, carefully following the methodological approaches developed in 2003 to achieve the sustainability of gained results. In 2004, according to the monitoring data, irrigation water consumption per unit output ranged from 0.7 to 3.6 $m^3$/kg; these values are lower than in 2003 (from 0.5 to 4.65 $m^3$/kg). In 2002, irrigation water consumption per unit output ranged from 1.14 to 7.12 $m^3$/kg (Table 5.27).

The comparative assessment of irrigation water consumption per unit output at project demonstration sites shows that in 2004, as a whole, most of farms have received the sustainable results relative to the results achieved in 2003, but farms "Samatov" in Soghd Province and "Toloykon" in Osh Province are an exception from them. The farm "Samatov" exceeded the normative irrigation water consumption per unit output by two reasons: the first one is overrated water applications, and the second one is a low productivity of cotton with long-staple fibers in comparing with common varieties. The farm "Toloykon" used the overrated irrigation water consumption under receiving high crop yield (4.5 ton/ha). Farms "Bakhoriston" and "Sayed" in Soghd Province, farms "Nozima", "Turdialy" and "Tolibjon" in Fergana and Andijan provinces, and farms "Nursultan-Aly" and "Sandyk" in Osh Province used their resources as much as possible (Figure 5.32). In these farms, lesser values of irrigation water consumption per unit output have mainly obtained due to raising crop yields. Such farms as "Khojalkhon", "Turdialy", "Tolibjon" and "Sandyk" have raised crop yields using lesser volumes of irrigation water not only relative to 2002, but also relative to 2003. The efficiency of irrigation water use varies over the range of 0.29 to 1.4 kg/$m^3$ over demonstration farms in 2004. As a whole, the productivity has increased in most of demonstration farms, but such farms as "Somatov", "Toloykon" and "Nursultan-Aly" had worse indicators than in 2003.

**Table 5.26 Comparative Assessment of the Efficiency of Irrigation Water Use**

| Farm | Irrigation requirement (gross – Nactual) | | | Losses due to tailwater runoff (TWR) | | | | | | Losses due to deep percolation (DP)** | | | | | | Ea= (Nactual - TWR - DP) / Nactual | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2002 | 2003 | 2004 | 2002 | | 2003 | | 2004 | | 2002 | | 2003 | | 2004 | | 2002 | 2003 | 2004 |
| | $m^3$/ha | | | $m^3$/ha | % | $m^3$/ha | % | $m^3$/ha | % | $m^3$/ha | % | $m^3$/ha | % | $m^3$/ha | % | | | |
| **Samatov** | 8,264 | 5,012 | 8,032 | 853 | 10 | 468 | 9 | 339 | 4 | 1628 | 20 | 674 | 13 | 2364 | 29 | 0.70 | 0.77 | 0.66 |
| **Sayed** | 7,342 | 5,940 | 6,658 | 1536 | 21 | 1071 | 18 | 895 | 13 | 1483 | 20 | 142 | 2 | 575 | 10 | 0.59 | 0.80 | 0.78 |
| **Bakhoriston** | 12,968 | 7,643 | 8,815 | 2483 | 19 | 1557 | 20 | 1361 | 15 | 4604 | 36 | 622 | 8 | 1588 | 18 | 0.45 | 0.71 | 0.67 |
| **Khojalkhon-ona-Khoji** | 18,804 | 12,525 | 10,305 | 3173 | 17 | 1980 | 16 | 2342 | 23 | 7635 | 41 | 3917 | 31 | 3683 | 36 | 0.43 | 0.53 | 0.42 |
| **Nozima** | 6,718 | 3,468 | 4,523 | 0 | 0 | 0 | 0 | 0 | 0 | 3903 | 58 | 1281 | 37 | 647 | 14 | 0.42 | 0.63 | 0.86 |
| **Turdialy** | 4,020 | 3,429 | 3,290 | 255 | 6 | 453 | 13 | 164 | 5 | 430 | 11 | 133 | 4 | 292 | 9 | 0.83 | 0.83 | 0.86 |
| **Tolibjon** | 9,399 | 5,925 | 5,761 | 1208 | 13 | 1685 | 28 | 1485 | 26 | 2679 | 29 | 631 | 11 | 634 | 11 | 0.59 | 0.61 | 0.63 |
| **Toloykon** | 5,803 | 4,569 | 5,494 | 1855 | 32 | 606 | 13 | 1666 | 30 | 2333 | 40 | 2040 | 45 | 1938 | 35 | 0.28 | 0.42 | 0.34 |
| **Nursultan** | 5,120 | 2,130 | 4,393 | 942 | 18 | 418 | 20 | 1200 | 27 | 1597 | 31 | 418 | 20 | 1404 | 32 | 0.50 | 0.61 | 0.41 |
| **Sandyk** | 6,030 | 5,540 | 6,236 | 1554 | 26 | 1170 | 21 | 1139 | 18 | 645 | 11 | 593 | 11 | 686 | 11 | 0.64 | 0.68 | 0.71 |

**Table 5.27 Comparative Assessment of Basic Indicators of Irrigation Water Productivity at Project Demonstration Sites**

| Farm | Irrigation requirement (gross – Nactual) | | | Losses due to tailwater runoff (TWR) | | | | | | Losses due to deep percolation (DP)** | | | | | | Ea= (Nactual - TWR - DP) / Nactual | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2002 | 2003 | 2004 | 2002 | | 2003 | | 2004 | | 2002 | | 2003 | | 2004 | | 2002 | 2003 | 2004 |
| | $m^3$/ha | | | $m^3$/ha | % | $m^3$/ha | % | $m^3$/ha | % | $m^3$/ha | % | $m^3$/ha | % | $m^3$/ha | % | | | |
| **Samatov** | 8,264 | 5,012 | 8,032 | 853 | 10 | 468 | 9 | 339 | 4 | 1628 | 20 | 674 | 13 | 2364 | 29 | 0.70 | 0.77 | 0.66 |
| **Sayed** | 7,342 | 5,940 | 6,658 | 1536 | 21 | 1071 | 18 | 895 | 13 | 1483 | 20 | 142 | 2 | 575 | 10 | 0.59 | 0.80 | 0.78 |
| **Bakhoriston** | 12,968 | 7,643 | 8,815 | 2483 | 19 | 1557 | 20 | 1361 | 15 | 4604 | 36 | 622 | 8 | 1588 | 18 | 0.45 | 0.71 | 0.67 |
| **Khojalkhon-ona-Khoji** | 18,804 | 12,525 | 10,305 | 3173 | 17 | 1980 | 16 | 2342 | 23 | 7635 | 41 | 3917 | 31 | 3683 | 36 | 0.43 | 0.53 | 0.42 |
| **Nozima** | 6,718 | 3,468 | 4,523 | 0 | 0 | 0 | 0 | 0 | 0 | 3903 | 58 | 1281 | 37 | 647 | 14 | 0.42 | 0.63 | 0.86 |
| **Turdialy** | 4,020 | 3,429 | 3,290 | 255 | 6 | 453 | 13 | 164 | 5 | 430 | 11 | 133 | 4 | 292 | 9 | 0.83 | 0.83 | 0.86 |
| **Tolibjon** | 9,399 | 5,925 | 5,761 | 1208 | 13 | 1685 | 28 | 1485 | 26 | 2679 | 29 | 631 | 11 | 634 | 11 | 0.59 | 0.61 | 0.63 |
| **Toloykon** | 5,803 | 4,569 | 5,494 | 1855 | 32 | 606 | 13 | 1666 | 30 | 2333 | 40 | 2040 | 45 | 1938 | 35 | 0.28 | 0.42 | 0.34 |
| **Nursultan** | 5,120 | 2,130 | 4,393 | 942 | 18 | 418 | 20 | 1200 | 27 | 1597 | 31 | 418 | 20 | 1404 | 32 | 0.50 | 0.61 | 0.41 |
| **Sandyk** | 6,030 | 5,540 | 6,236 | 1554 | 26 | 1170 | 21 | 1139 | 18 | 645 | 11 | 593 | 11 | 686 | 11 | 0.64 | 0.68 | 0.71 |

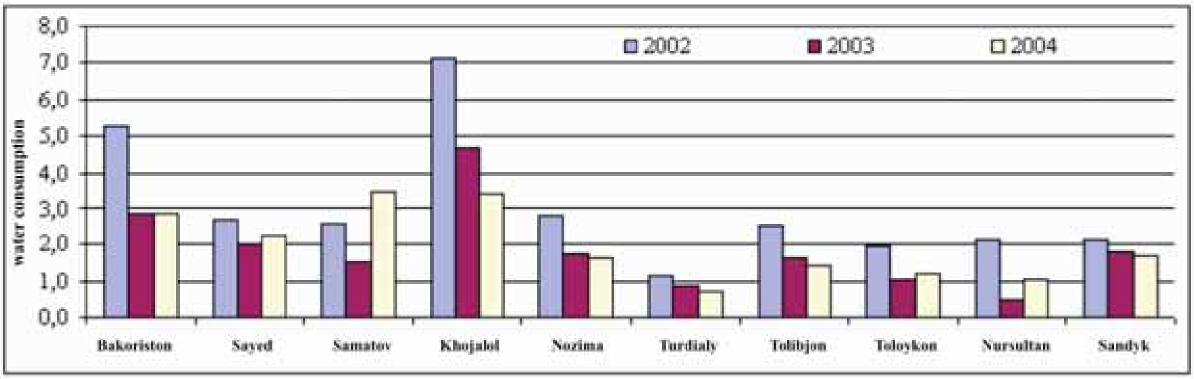



**Figure 5. 32 Irrigation Water Consumption for Crop Growing at Project Demonstration Sites**

Considerable differences in values of the irrigation water productivity over years were observed in the farm "Nursultan-Aly." In this case, abundant rainfalls in May and June in 2003 have played a key role in reducing irrigation water supply and raising the irrigation water productivity. Therefore, the irrigation water productivity observed in 2004 is more realistic for existing soil and climatic conditions; and the increase in the irrigation water productivity in 2003 should be considered as an exception to the rule. In 2004, the irrigation water productivity in this farm has increased two times relative to 2002. A general picture of changes in the irrigation water productivity over all demonstration farms is given in Figure 5.33.

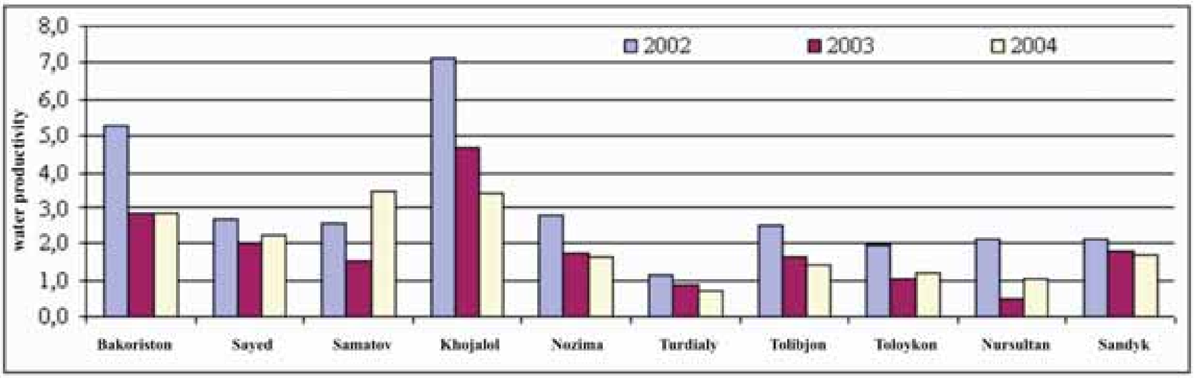



**Figure 5.33 Irrigation Water Productivity**

The comparative assessment of irrigation water use and crop yields has shown that most of farms have managed to raise the level of both the irrigation water productivity and crop yields. In 2004, the overall productivity over demonstration sites has raised by 21 to 135% relative to 2002, excepting the farm "Samatov" where the productivity has lowered by 25%. In comparing with 2003, trends over farms in 2004 are different, for example, in the farms "Sayed", "Khojalkhon-ona-Khoji", "Turdialy", "Nozima", "Tolibjon" and "Sandyk", the raise of the productivity was varying over the range of 2 to 54%, at the same time, in the farms "Samatov", "Toloykon", and "Nursultan-Aly", the productivity has lowered by 55%, 35% and 52% respectively. In 2004, the farm "Bokhoriston" has provided the practically same productivity that was achieved in 2003 (by 1.1% less). In 2003, the weather conditions along with special measures for setting the proper irrigation water supply rates have played a great role in achieving the high level of productivity in all farms. In 2003, the irrigation water productivity has increased by 35 to 95% relative to 2002 against the increase in crop yields by 4 to 54%. In 2004, the irrigation water productivity has increased by 16 to 83% relative to 2002 against the increase in crop yields by 11 to 72% (Table 5.27).

**Table 5.27 The Efficiency of Irrigation Water Use and Crop Yield Relative to 2002**

| Farm | Overall productivity, kg/m$^3$ | | | **Input into raising the productivity,% | | | |
|---|---|---|---|---|---|---|---|
| | | | | According to irrigation water use (relative to 2002.) | | According to the increase in crop yields (relative to 2002) | |
| | (P1) 2002 | (P2) 2003 | (P3) 2004 | IWP1 2003 | IWP2 2004 | ICY1 2003 | ICY2 2004 |
| Bakhoriston | 0.19 | 0.36 | 0.35 | 79 | 55 | 13 | 31 |
| Sayed | 0.37 | 0.49 | 0.45 | 77 | 51 | 21 | 44 |
| Samatov | 0.39 | 0.65 | 0.29 | 97 | 0 | 2 | 0 |
| Khojalkhon-ona-Khoji | 0.14 | 0.21 | 0.30 | 95 | 74 | 4 | 15 |
| Nozima | 0.36 | 0.58 | 0.62 | 100 | 69 | 0 | 21 |
| Turdialy | 0.88 | 1.14 | 1.40 | 56 | 37 | 37 | 51 |
| Tolibjon | 0.40 | 0.61 | 0.71 | 100 | 83 | 0 | 11 |
| Toloykon | 0.52 | 0.97 | 0.83 | 31 | 9 | 54 | 86 |
| Nursultan | 0.48 | 2.02 | 0.98 | 43 | 16 | 24 | 72 |
| Sandyk | 0.47 | 0.55 | 0.57 | 54 | 0 | 42 | 100 |

In 2004, six farms have improved their indicators of the productivity relative to 2003 (both in water saving activity and in raising crop yields). The farms "Sayed", "Khojalkhon-ona-Khoji", "Turdialy", "Tolibjon" and "Sandyk" have obtained the reduction of irrigation water consumption. The farm "Bokhoriston" has achieved the productivity at the level of 2003. The farm "Samatov" has lowered the level of its productivity due to cultivating the low-yield variety of cotton with long-staple fibers. Farms "Nozima" and "Nursultan-Aly" have obtained the productivity that was close to the level of the year with average water availability in respect of both irrigation water use and crop yields, although their values in 2004 were lower than in 2003. The farm "Tloykon", obtaining the maximum possible crop yield, has used overrated amounts of irrigation water during the first water application in spring affecting its overall productivity. Implemented measures allowed improving management of water applications and agricultural activity in the project demonstration farms. As a result, reduction of irrigation water supply on the field level, rising of yields of cotton and wheat, and the growth of the productivity of land and water resources have become possible (Table 5.28).

**Table 5.28. Indicators of Improving Agricultural Production Management**

| Indicators | Tajikistan | Uzbekistan | Kyrgyzstan | |
|---|---|---|---|---|
| | Cotton | Cotton | Cotton | Wheat |
| Reducing irrigation water supply | 33% | 34% | 17% | 40% |
| Raising crop yields | 18% | 21% | 25% | 64% |
| Raising the productivity | 62% | 69% | 52% | 96% |

Analyzing the obtained results over all farms during three years, it is possible to state a fact that the irrigation water productivity at the level of 2003 is rather sustainable.

## Comparative Assessment of Basic Economic Indicators of Agricultural Activity

Mineral fertilizers are one of key factors determining the level of the agricultural productivity; at that, not only the total amount of fertilizers applied to soils but also their qualitative composition (the content of macroelements) affects crop yields. Information on the amounts of nitrogen, phosphate and potash fertilizers applied to soils over the period of 2002 to 2004 is given in Table 5.26 (physical weights were converted into the amount of so-called active nutrients (AN) that allows presenting the extent of availability of nitrogen, phosphorus and potassium for crops N-P-K). A comparative analysis of the actual application of fertilizers shows that almost all farms have considerably increased the application of nitrogen fertilizers in 2004 in comparing with 2002 (the situation in the farm “Nursultan-Aly” has not changed). At that, an average indicator for all farms cultivating cotton made up 171 kg/ha of AN at the beginning of the project implementation and has increased up to 212 kg/ha of AN in the growing season of 2004. An appreciable growth in the amount of phosphate fertilizers applied to soils was observed: in 2002 – 31 kg/ha of AN, on average over farms; in 2003 – 153 kg/ha of AN; and in 2004 – 160 kg/ha of AN. Potash fertilizers were not being applied at all in 2002; and only in subsequent years, these fertilizers started to be applied at demonstration fields. Comparing the reached indicators in some farms shows that not all farmers apply the recommended rates of artificial fertilizers and do not use this substantial potential for raising crop yields. The comparative assessment of agricultural activity allows comparing the results of management of land and water productivity in 2002 (the year when farmers themselves managed their farms under passive participation of project specialists who only monitored and recorded all parameters of agricultural practice) and the results of agricultural activity in 2003 and 2004 when project specialists actively participated in the management process. Basic agricultural and economic indicators over the mentioned period (Table 5.18) confirm that management of agricultural production was considerably improved at the expense of applying the recommendations developed by the project specialists for demonstration fields, use of computer-simulated irrigation schedules, the increase in fertilizer rates applied to soils; use of the individual process charts, and improving the quality of agricultural operations.

Cotton productivity has increased in seven farms from 0.7 center/ hectare (PF “Sayed”) to 7.8 centers/ hectare (PF “Nozima”) in 2004 in comparison with the 2003 cotton yield.

Comparing the results obtained in 2004 with indicators of the initial phase of project activity (2002) is of special interest. All farms cultivating cotton (with the exception of the farm “Samatov”) have achieved the considerable rising of productivity; for example, in the farm “Turdialy” during two years the crop yield has increased by 10.8 center/ha, in the farm “Sandyk” by 7.2 center/ha, in the farm “Bakhoriston” by 6.5 center/ha, and in remaining farms the increase in cotton yields is ranging from 2.2 center/ha to 3.3 center/ha (as was mentioned, in the farm “Samatov” the crop yield has decreased due to cultivating of cotton with long-staple fibers). At the same time, the increase in grain crop production can also be marked: in the farm “Toloykon” for two years of integrated management the yield of winter wheat has increased by 15.8 center/ha and in the farm “Nursultan-Aly” by 18.6 center/ha. In comparing with 2002, the gross output has considerably increased on all demonstration fields due to the rise of crop yields and the substantial growth of purchasing prices of raw cotton. For instance, in the farm “Sandyk”, the cost of sold output from one hectare was by US$ 798 higher; by US$ 974 in the farm “Bakhoriston”; and by US$ 655 in the farm “Turdaily.” The most growth of gross output over the period under consideration was observed in the farm “Samatov” where additional 1369 US$/ha were obtained due to the high purchasing price for cotton with long-staple fibers (789 US$/ton).

**Table 5.29 The Application of Chemical Fertilizers at Demonstration Fields (2002 to 2004)**

| Farm | Nitrogen fertilizers (kg/ha of AN) | | | | Phosphate fertilizers (kg/ha of AN) | | | | Potash fertilizers (kg/ha of AN) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Recommended rate | 2002 | 2003 | 2004 | Recommended rate | 2002 | 2003 | 2004 | Recommended rate | 2002 | 2003 | 2004 |
| «Turdaily» | 220 | 190 | 280 | 225 | 170 | 0,0 | 60 | 100 | 30 | 25 | 0.0 | 25 |
| «Talibjon» | 220 | 230 | 156 | 350 | 170 | 0,0 | 125 | 50 | 30 | 0.0 | 0.0 | 0.0 |
| «Nozima» | 220 | 140 | 131 | 145 | 170 | 25 | 30 | 160 | 30 | 0.0 | 0.0 | 0.0 |
| «Khojalkhon-ona-Khoji» | 230 | 195 | 230 | 220 | 180 | 65 | 230 | 100 | 50 | 0.0 | 100 | 40 |
| «Samatov» | 200 | 160 | 170 | 250 | 180 | 125 | 210 | 240 | 50 | 0.0 | 0.0 | 21 |
| «Sayed» | 200 | 162 | 146 | 185 | 180 | 0,0 | 220 | 180 | 50 | 0.0 | 0.0 | 0.0 |
| «Bakhoriston» | 200 | 165 | 140 | 175 | 180 | 35 | 175 | 250 | 50 | 0.0 | 45 | 18 |
| «Sandyk» | 200 | 130 | 170 | 150 | 180 | 0,0 | 180 | 200 | 50 | 0.0 | 0.0 | 0.0 |
| «Toloykon» | 140 | 100 | 106 | 145 | 140 | 0,0 | 160 | 60 | 30 | 0.0 | 0.0 | 0.0 |
| «Nyrsultan-Aly» | 140 | 50 | 83 | 50 | 140 | 0,0 | 160 | 140 | 30 | 0.0 | 0.0 | 0.0 |

**Table 5.30 Comparative Assessment of Basic Agricultural and Economic Indicators Obtained on Demonstration Fields ( 2002 to 2004)**

| Farm | Nitrogen fertilizers (kg/ha of AN) | | | | Phosphate fertilizers (kg/ha of AN) | | | | Potash fertilizers (kg/ha of AN) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Recommended rate | 2002 | 2003 | 2004 | Recommended rate | 2002 | 2003 | 2004 | Recommended rate | 2002 | 2003 | 2004 |
| **«Turdaily»** | 220 | 190 | 280 | 225 | 170 | 0,0 | 60 | 100 | 30 | 25 | 0.0 | 25 |
| **«Talibjon»** | 220 | 230 | 156 | 350 | 170 | 0,0 | 125 | 50 | 30 | 0.0 | 0.0 | 0.0 |
| **«Nozima»** | 220 | 140 | 131 | 145 | 170 | 25 | 30 | 160 | 30 | 0.0 | 0.0 | 0.0 |
| **«Khojalkhon-ona-Khoji»** | 230 | 195 | 230 | 220 | 180 | 65 | 230 | 100 | 50 | 0.0 | 100 | 40 |
| **«Samatov»** | 200 | 160 | 170 | 250 | 180 | 125 | 210 | 240 | 50 | 0.0 | 0.0 | 21 |
| **«Sayed»** | 200 | 162 | 146 | 185 | 180 | 0,0 | 220 | 180 | 50 | 0.0 | 0.0 | 0.0 |
| **«Bakhoriston»** | 200 | 165 | 140 | 175 | 180 | 35 | 175 | 250 | 50 | 0.0 | 45 | 18 |
| **«Sandyk»** | 200 | 130 | 170 | 150 | 180 | 0,0 | 180 | 200 | 50 | 0.0 | 0.0 | 0.0 |
| **«Toloykon»** | 140 | 100 | 106 | 145 | 140 | 0,0 | 160 | 60 | 30 | 0.0 | 0.0 | 0.0 |
| **«Nyrsultan-Aly»** | 140 | 50 | 83 | 50 | 140 | 0,0 | 160 | 140 | 30 | 0.0 | 0.0 | 0.0 |

In 2004, the growth of output cost value (variable costs) related to some rise in the cost of means of production (costs of mechanized and manual labor, fertilizers, pesticides etc.) was observed in all demonstration farms with the exception of the PF “Khojalkhon-ona-Khoji.” A maximum increase in variable costs was fixed in Tajikistan: by 301.4 USD/ha (more than two times) in the farm “Samatov”; by 155.6 USD/ha in the farm “Sayed”; and by 270 USD/ha in the farm “Bakhoriston.” In 2004, the profitability of farms has substantially changed due to the rise in crop yields and the cost of gross output. For instance, the maximum income was observed in the farm “Samatov” (1298 USD/ha), exceeding the indicator of 2002 on 1067 USD/ha. The high profitability of agricultural activity was also provided in the farms “Bakhoriston” (878 USD/ha) and “Sandyk” (900 USD/ha), exceeding the indicators of 2002 on 705 USD/ha and 712 USD/ha respectively. Over the period under consideration, the least growth of gross income was observed in the farm “Nazima” (only 133 USD/ha). The rise of profitability in farms that cultivate winter wheat made up 279 USD/ha in the farm “Toloykon” and 274 USD/ha in the farm “Nursultan-Aly.” The similar correlation is observed regarding the net income obtained in farms, which has insignificantly changed (after deducting fixed costs from the gross income) and keeps the same trends inherent in the gross income.

## Basic Agro-Economic Indicators over Countries

The indicators of the efficiency of agricultural production mainly depend on the costs for raw materials and agricultural inputs. The data given in Table 5.31, to a large extent, reflects the agricultural policy and reforms conducted in countries that participate in implementing this project.

**Table 5.31 Average Financial Prices of Output and Basic Agricultural Inputs**

| Indicator | Uzbekistan | | | Kyrgyzstan | | | Tajikistan | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2002 | 2003 | 2004 | 2002 | 2003 | 2004 | 2002 | 2003 | 2004 |
| Purchasing prices of raw cotton ($/ton) | 140.7 | 213.2 | 250.7 | 151.3 | 476.0 | 343.9 | 162.7 | 353.0 | 370.0 |
| Price of water ($/000 $m^3$) | 0.0 | 0.0 | 0.0 | 0.58 | 0.83 | 0.98 | 1.36 | 2.73 | 2.06 |
| Land tax ($/ha) | 3.4 | 11.3 | 12.7 | 9.8 | 9.7 | 14.5 | 5.5 | 10.2 | 12.9 |
| Mechanized labor ($/machine-hour) | 2.7 | 2.5 | 2.0 | 5.8 | 6.8 | 3.2 | 2.8 | 2.1 | 2.9 |
| Manual labor ($/man-day) | 1.6 | 1.9 | 1.6 | 1.4 | 1.4 | 1.1 | 0.8 | 1.2 | 1.3 |
| Seeds ($/kg) | 0.35 | 0.51 | 0.48 | 0.15 | 0.31 | 0.25 | 0.13 | 0.16 | 0.21 |
| Selitra (ammonium nitrate) ($/ton) | 63.0 | 68.0 | 140.0 | 105.2 | 153.0 | 180.0 | 119.3 | 119.8 | 170.0 |
| Ammophos ($/ton) | 106.5 | 109.8 | 220.0 | 130.0 | 107.0 | 140.0 | 159.7 | 144.0 | 170.0 |
| Carbamide ($/ton) | 83.1 | 87.5 | 140.0 | 120.3 | 123.1 | 155.0 | 140.7 | 136.9 | 160.0 |
| Superphosphate ($/ton) | 25.3 | 33.7 | 61.0 | 70.5 | 72.6 | 70.0 | 87.4 | 89.2 | 90.0 |

For example, in Uzbekistan, the purchasing prices for cotton, wheat and rice are established by the government, and their production is subjected to the state order along with setting rates for agricultural inputs, irrigation water and machinery, as well as financing farmers through the "goal-oriented crediting" granted by the banks that are managed by the government in fact. There are free markets in Kyrgyzstan and partly in Tajikistan, but even here, the administrative control is kept doing harm because of numerous resellers. The table contains the actual prices used at demonstration sites.

Under analyzing the given prices it is necessary to take into account that a direct fee for irrigation water is not collected; and its cost is included into the agricultural land tax. As a general trend, it can be noted that the least prices of output and some agricultural inputs take place in Uzbekistan where at the expense of understated purchasing prices of agricultural output the government subsidizes and keeps the low level of prices of major agricultural inputs (relative to other countries). The land tax does not differ markedly over the countries and in 2004 made up 12.7 USD/ha in Uzbekistan, 12.9 USD/ha in Tajikistan, and 14.5 USD/ha in Kyrgyzstan. A tax on land over all countries in this region is calculated based on the level of taxation rates and a class of soil fertility. In Kyrgyzstan, the tax for allocation into the Social Fund that equals to 7.6 USD/ha is also collected. It is necessary to note that in comparing with 2002, the purchasing prices of cotton have considerably risen; and at present they are higher by 78% in Uzbekistan, by 127% in Kyrgyzstan and Tajikistan. The prices of nitrogen fertilizers are lower in Uzbekistan than in other countries since this state has four large factories for producing artificial fertilizers. In comparing with prices of 2002, the increase in manual labor cost in Tajikistan (on 0.5 USD/man-day) and irrigation water cost in Kyrgyzstan and Tajikistan can be noted.

**Table 5.32**
**Basic Agro-Economic Indicators of Cotton Production on Demonstration Fields (on average over countries)**

| Indicator | Country | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Uzbekistan | | | Kyrgyzstan | | | Tajikistan | | |
| | 2002 | 2003 | 2004 | 2002 | 2003 | 2004 | 2002 | 2003 | 2004 |
| Irrigation water use (ths.m$^3$/ha) | 8.7 | 6.3 | 5.97 | 6.1 | 5.5 | 6.23 | 9.52 | 6.2 | 7.80 |
| Price of irrigation water ($/ths.m$^3$) | 0.0 | 0.0 | 0.0 | 0.58 | 0.83 | 0.98 | 1.36 | 2.73 | 2.06 |
| Cost of irrigation water consumed ($/ha) | 0.0 | 0.0 | 0.0 | 3.54 | 4.61 | 4.90 | 12.9 | 16.9 | 15.67 |
| Average crop yield (ton/ha) | 3.09 | 3.13 | 3.62 | 2.86 | 3.06 | 3.58 | 2.88 | 2.96 | 2.81 |
| Gross output ($/ha) | 434.8 | 675.1 | 909.2 | 432.7 | 1458.0 | 1230.7 | 545.7 | 1025.6 | 1370.3 |
| Variable costs (production price) ($/ha) | 263.8 | 340.9 | 408.1 | 244.3 | 271.7 | 330.4 | 284.9 | 377.7 | 527.5 |
| Fixed costs ($/ha) | 12.5 | 26.4 | 33.3 | 23.2 | 19.4 | 19.4 | 43.3 | 11.3 | 14.7 |
| Gross income ($/ha) | 171.0 | 334.2 | 501.1 | 188.4 | 1186.3 | 900.3 | 170.8 | 646.9 | 842.8 |
| Net income ($/га) | 158.5 | 307.8 | 467.8 | 165.2 | 1166.9 | 880.9 | 127.5 | 635.6 | 828.1 |
| Irrigation water productivity | 49.9 | 137.5 | 189.3 | 70.9 | 263.1 | 197.5 | 47.8 | 164.5 | 175.7 |

| Indicator | Country | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Uzbekistan | | | Kyrgyzstan | | | Tajikistan | | |
| | 2002 | 2003 | 2004 | 2002 | 2003 | 2004 | 2002 | 2003 | 2004 |
| ($/ths.m$^3$) | | | | | | | | | |

Comparing of basic agro-economic indicators over the period of 2002 to 2004 allows evaluating the existing level of agricultural production and the extent of improving management practice on demonstration fields over the countries. Table 5.32 shows that in Uzbekistan, in 2004, the cotton yield made up 3.62 ton/ha against 3.09 ton/ha in 2002; 3.58 ton/ha against 2.86 in Kyrgyzstan; and remains practically at the same level in Tajikistan.

Costs related to irrigation water supply has somewhat increased due to rising price of water resources (on 0.40 USD/ths.m$^3$ in Kyrgyzstan and on 0.70 USD/ths.m3 in Tajikistan). Changes in purchasing prices of raw cotton conditioned the difference in gross income from output sold; the maximum cost of gross output is observed in Tajikistan – 1370 USD/ha against 545 USD/ha in 2002; in Kyrgyzstan – 1230 USD/ha against 432 USD/ha, and in Uzbekistan – 909 USD/ha against 434 USD. The maximum gross income was observed in Kyrgyzstan – 900 USD/ha (in Tajikistan - 842 USD/ha; and in Uzbekistan – 501 USD/ha). In 2004, high incomes on demonstration fields conditioned the essential increase in the economic productivity of irrigation water use; at that, irrigation water was used in the most productive manner in Kyrgyzstan where the income from consumed irrigation water amounted to 197 USD/ths.m$^3$ against 71 USD/ths.m$^3$ in 2002; at the same time, in Tajikistan this indicator was 175 USD/ths.m3 against 47 USD/ths.m3 in 2002; and in Uzbekistan – 189.3 USD/ths.m$^3$ against 49.9 USD/ths.m3 in 2002.

### Agro-Economic Indicators of Agricultural Production on Demonstration Fields under Purchasing Prices of Agricultural Output Averaged over Countries

In 2004, key economic indicators of agricultural production on demonstration fields were calculated based on the existing financial prices in the republics i.e. actual prices of output, agricultural inputs, taxes etc. were used. In order to assess prospective incomes from the agricultural production and actual irrigation water productivity on the indicator fields, it is possible to carry out the economic analysis, using purchasing prices of agricultural output averaged over the republics (Table 5.30). Such an analysis, with focusing on unit economic prices, allows separating effects of the existing agricultural policy in different countries from the real production indicators.

We have taken an average price over the republics in 2004 that was equal to 350 USD/ton as the unit price of raw cotton; at the same time, variable costs, volumes of consumed irrigation water, and crop yield are the real values obtained on demonstration fields. Under such an approach, the best agro-economic indicators are observed in farms with the rational practice of water use and high crop yields. The farm “Turdaily” had the maximum gross and net incomes under averaged purchasing prices – 1159 USD/ha and 1087 USD/ha respectively; three farms “Tolibjon”, “Sandyk”, and “Khojalkhon-ona-Khoji” also provided the high indicators of profit ranging from 762 USD/ha to 971 USD/ha. The farm “Samatov” where a cotton yield was only 20 centner/ha and many errors in water management were made during the growing season had the lowest indicator of profitability.

The productivity and efficiency of irrigation water use also varied over the farms. Under ranging the demonstration fields according to these indicators, the first rank was given to the farm “Turdialy” where the economic productivity made up 489.4 USD/ths.m3 and economic efficiency of irrigation water use was equal to 352.3 USD/ths.m$^3$. High indicators of irrigation water use were also observed in farms “Tolibjon” and “Nozima” where the irrigation water productivity made up 249.1 USD/ths.m$^3$ and 215.2 USD/ths.m3 respectively. The maximum production profitability, reflecting the ratio of net profit to gross output, is observed in the farms “Khojalkhon-ona-Khoji” and “Sandyk”(about 0.72 $/$); and low levels of production profitability were revealed in the farms “Nozima”, “Sayed”, and “Bakhoriston” (0.54 to 0.49 $/$). Maximum values of the efficiency of investments that is calculated as the ration of gross income to variable costs were observed in the farms “Sandyk” (2.79 $/$) and “Khojalkhon-ona-Khoji” and minimum values in the farms “Samatov” (0.91 $/$) and “Bahoriston” (1.02 $/$).

**Table 5.33 Basic Agro-Economic Indicators of Cotton Production under Conditions of Single Purchasing Price of Raw Cotton (2004)**

| Farm | Nitrogen fertilizers (kg/ha of AN) | | | | Phosphate fertilizers (kg/ha of AN) | | | | Potash fertilizers (kg/ha of AN) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Recommended rate | 2002 | 2003 | 2004 | Recommended rate | 2002 | 2003 | 2004 | Recommended rate | 2002 | 2003 | 2004 |
| «Turdaily» | 220 | 190 | 280 | 225 | 170 | 0,0 | 60 | 100 | 30 | 25 | 0.0 | 25 |
| «Talibjon» | 220 | 230 | 156 | 350 | 170 | 0,0 | 125 | 50 | 30 | 0.0 | 0.0 | 0.0 |
| «Nozima» | 220 | 140 | 131 | 145 | 170 | 25 | 30 | 160 | 30 | 0.0 | 0.0 | 0.0 |
| «Khojalkhon-ona-Khoji» | 230 | 195 | 230 | 220 | 180 | 65 | 230 | 100 | 50 | 0.0 | 100 | 40 |
| «Samatov» | 200 | 160 | 170 | 250 | 180 | 125 | 210 | 240 | 50 | 0.0 | 0.0 | 21 |
| «Sayed» | 200 | 162 | 146 | 185 | 180 | 0,0 | 220 | 180 | 50 | 0.0 | 0.0 | 0.0 |
| «Bakhoriston» | 200 | 165 | 140 | 175 | 180 | 35 | 175 | 250 | 50 | 0.0 | 45 | 18 |
| «Sandyk» | 200 | 130 | 170 | 150 | 180 | 0,0 | 180 | 200 | 50 | 0.0 | 0.0 | 0.0 |
| «Toloykon» | 140 | 100 | 106 | 145 | 140 | 0,0 | 160 | 60 | 30 | 0.0 | 0.0 | 0.0 |
| «Nyrsultan-Aly» | 140 | 50 | 83 | 50 | 140 | 0,0 | 160 | 140 | 30 | 0.0 | 0.0 | 0.0 |

An agro-economic assessment of the efficiency of agricultural production (Table 5.34) allowed making conclusion about the level of production management in private farms in Kyrgyzstan, Tajikistan, and Uzbekistan.

**Table 5.34 Efficiency of Agricultural Inputs Use on Demonstration Fields**

| Republic | Land use efficiency | | | Investment efficiency | | | Water use efficiency | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2002 ($/ha) | 2003 ($/ha) | 2004 ($/ha) | 2002 ($/$) | 2003 ($/$) | 2004 ($/$) | 2002 ($/ths.m$^3$) | 2003 ($/ths.m$^3$) | 2004 ($/ths.m$^3$) |
| Uzbekistan | 171 | 334 | 01 | 0.65 | 0.98 | 1.23 | 50 | 137 | 189.8 |
| Kyrgyzstan | 188 | 1186 | 900 | 0.77 | 4.37 | 2.77 | 71 | 263 | 197 |
| Tajikistan | 171 | 647 | 843 | 0.60 | 1.71 | 1.60 | 48 | 164 | 175 |
| **On average** | **176** | **722** | **748** | **0.70** | **2.35** | **1.87** | **56** | **188** | **187** |

The land use efficiency that is characterized by a profit per a unit area (ha) has increased four times over the republics, on average; the investment efficiency that is calculated as the ratio of gross income to production costs has risen more than three times; and the water use efficiency also increased more than three times – all these facts allowed making conclusion about substantial raising the level of production management in private farms, the increase in the land and water productivity, as well as the farmers' profitability.

### 5.6.2 Water-Saving Methods Used on Project Demonstration Sites

One of the IWRM principles is the introduction of water-saving methods under using irrigation water. Initially, project specialists were planning to introduce water-saving technologies for solving the problems of raising the irrigation water productivity. The methodology of irrigation management in itself contains the elements of economical use of irrigation water in the field. First of all, we would like to show how the methodology developed by the regional group solves water-saving issues. A key indicator of saving water resources is the information on volumes of water withdrawal. Without information about how much irrigation water is delivered into a field it is difficult to plan economical use of irrigation water. At the same time, the lack of knowledge on real timing and rates of water applications that take into consideration the soil and climatic conditions also does not allow us to evaluate the extent, within which we can save irrigation water in the field.

In 2002, the system of water measurement and record keeping was established in each pilot farm and on its demonstration fields by the beginning of the growing season. Information on irrigation water supply and surface runoff, which was being transmitted from each demonstration field allowed us to evaluate the baselessness and nonuniformity of irrigation water delivery during the growing season. Irrigation by overrated norms at the initial stage of plant growth under providing water application for land preparation took place in farms.

Assessment of the existing practice of irrigation water use in 2002 in comparing with the computer-simulated irrigation schedules prepared for each demonstration site based on field investigations of their soil and climatic conditions allowed us to determine the potential opportunities for saving irrigation water. A size of excessive irrigation water supply against the normative amounts was determined for each field. Apart from studying irrigation rates, shortcomings in organization of water applications were specified; for example, use of too long furrows with a high inflow rate results in considerable losses of irrigation water due to deep percolation and large tailwater runoff from a field. The individual furrow irrigation systems that allow to provide efficient management of water application and to use irrigation water rationally were elaborated for demonstration fields in private farms “Khojalkhon-ona-Khoji”, “Nozima”, and “Turdialy.” In 2003 and 2004, after introducing the recommended furrow irrigation systems, the farms have reduced the volumes of irrigation water use: by 33 to 45% in the farm “Khojalkhon-ona-Khoji”; by 15 to 18% in the farm “Turdialy”; and by 33 to 48% in the farm “Nozima.” Apart from a new furrow irrigation system, the farm “Turdialy” has used the water-saving technology that allows taking into account the upward feeding of the aeration zone by groundwater.

The furrow irrigation systems were upgraded in the farms “Sayed”, “Bakhoriston” and “Sandyk.” Although, the existing furrow irrigation systems in these farms had an optimal length of furrows, but, as a whole, they were arranged without detailed considering the soil pattern and slopes of irrigated fields resulting in considerable losses of irrigation water due to deep percolation and tailwater runoff from fields. As a result, water application rates were, first of all, fixed in these farms; and the uniform wetting of soils was provided by organizing water applications on the irrigated units that were specified taking into account the soil pattern and slopes. At that, the following saving of irrigation water was reached: in the farm “Sayed” - 2% in 2003 and 19% in 2004; in the farm “Bokhoriston” – 41% in 2003 and 32% in 2004 “Sandyk” – 8% in 2003 and 17% in 2004 (Table 5.35). In the farm “Sandyk”, we asked the farmer to put special attention to the difference in soil infiltration rates in the upper part of his field with thick topsoil and in the middle part of the field where outcrops of pebble take place. It was necessary to separate out these plots and to irrigate them separately. Prior to adjusting management of water applications, the farmer used furrows 70 to 100 m long but did not take into account the difference in a texture of soils in upper and middle parts of the field; as a result, overwetting of soil and overgrowth of cotton in the upper part and deficit of soil water content and backwardness of cotton in the middle part were observed.

Management of the farm “Tolibjon”, having the experience of using the efficient method of water applications on local irrigated units, did not pay attention to economical use of irrigation water. The project has supplemented the furrow irrigation system employed by the farmer with the system of water measurements and record keeping and setting of irrigation water rates. Project specialists consider that this technology has the great potential for rational and efficient use of irrigated water, which was seldom applied in the region and requires certain experience and skill for its use. A backbone of this technology consists in the subdivision of a field into small irrigated units by arranging longitudinal and lateral irrigation ditches and in conducting subsequent water applications only on those parts of the field where the need of plants in water arises, independently from their location. The first water application is conducted according to the method widespread among the experienced farmers and irrigators in this region. This method allows reducing flow rates due to redistribution of irrigation water between an upper irrigated unit and a next irrigated unit, and owing to managing of water application within each irrigated unit.

**Table 5.35 Basic Indicators of the Water Saving Practice on Project Demonstration Sites**

| Farm | Nitrogen fertilizers (kg/ha of AN) | | | | Phosphate fertilizers (kg/ha of AN) | | | | Potash fertilizers (kg/ha of AN) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Recommended rate | 2002 | 2003 | 2004 | Recommended rate | 2002 | 2003 | 2004 | Recommended rate | 2002 | 2003 | 2004 |
| «Turdaily» | 220 | 190 | 280 | 225 | 170 | 0,0 | 60 | 100 | 30 | 25 | 0.0 | 25 |
| «Talibjon» | 220 | 230 | 156 | 350 | 170 | 0,0 | 125 | 50 | 30 | 0.0 | 0.0 | 0.0 |
| «Nozima» | 220 | 140 | 131 | 145 | 170 | 25 | 30 | 160 | 30 | 0.0 | 0.0 | 0.0 |
| «Khojalkhon-ona-Khoji» | 230 | 195 | 230 | 220 | 180 | 65 | 230 | 100 | 50 | 0.0 | 100 | 40 |
| «Samatov» | 200 | 160 | 170 | 250 | 180 | 125 | 210 | 240 | 50 | 0.0 | 0.0 | 21 |
| «Sayed» | 200 | 162 | 146 | 185 | 180 | 0,0 | 220 | 180 | 50 | 0.0 | 0.0 | 0.0 |
| «Bakhoriston» | 200 | 165 | 140 | 175 | 180 | 35 | 175 | 250 | 50 | 0.0 | 45 | 18 |
| «Sandyk» | 200 | 130 | 170 | 150 | 180 | 0,0 | 180 | 200 | 50 | 0.0 | 0.0 | 0.0 |
| «Toloykon» | 140 | 100 | 106 | 145 | 140 | 0,0 | 160 | 60 | 30 | 0.0 | 0.0 | 0.0 |
| «Nyrsultan-Aly» | 140 | 50 | 83 | 50 | 140 | 0,0 | 160 | 140 | 30 | 0.0 | 0.0 | 0.0 |

## 5.7 Conflicts Resolution: Types of Conflicts and Mechanisms of Their Resolution at the WUA's Level

The availability of efficient mechanisms for settling conflicts and disputes that arise in the process of WUA's activity is one of chief preconditions for sustainable operation of a WUA. In case of their belated resolution, conflicts can result in slowdown of development and even disintegrating of WUAs. The mechanisms of conflict resolution available in Central Asian countries, both as formal ones in the form of the national legislative instruments and informal ones based on customs and traditions of local nations, which do not contradict the national legislation in force play an important role under settling conflicts and disputes.

Various types of disputes that can arise in the process of WUA's activity are described below. A special attention was put on formal and informal mechanisms of dispute resolution that existed on the territory of the Fergana Valley; and the guidelines on involving the alternative bodies for dispute resolution, taking into consideration the national legislations in force, were developed.

### 5.7.1 Conflicts and Disputes among Water Users, between Water Users and WUAs, and between WUAs and Water Management Organizations

As known, water is life. Therefore, no wonder that many various conflicts at all levels of the water management hierarchy and between all stakeholders can arise in the process of water allocation. There are many definitions of the term "conflict."[34] Here, the term "conflict" means a contradiction that arises between individuals or groups in the process of mutual activity related to water allocation due to different interests, lack of understanding and consensus [28].

Since the Soviet times, there is kept an exclusively negative attitude to the word "conflict", although it also contains the positive elements since the progress is impossible without the collision of interests ("struggle of opposites"). It is necessary to consider a conflict as an indicator that points out the presence of problems without the settling of which there is no way for further development.

***Parties of conflicts:***

- Farmers – water users;
- Water Users Associations (WUAs), co-operative farms (CF);
- Water management organizations (at the level of the river basin, province, administrative district or irrigation system);
- Governmental audit and supervision organizations (water inspectorate, land inspectorate, environment inspectorate).

**Types of conflicts**

*By nature:*

- Between individuals;
- Between an individual and a group (between a chief of the WMO and his personnel);
- Between groups.

[34] The Big Soviet Encyclopedia: "Conflict is a collision of opposite interests, views, aspirations, serious disagreement resulting in a struggle."

***By the composition of Parties (groups):***

- Between water professionals (WMOs) of neighboring countries, provinces, districts and irrigation systems;
- Between the WMO and WUAs (co-operative farms);
- Between WUAs (CFs);
- Between the WUA and farmers; and
- Between two or a few farmers.

***By the level of intensity:***

- Conflict of the low level;
- Conflict of the mid-range level;
- Conflict of the high level (Box 1).

***Causes for conflicts:***

- Non-compliance with provisions of the Agreement on irrigation water delivery;
- Nonuniformity of irrigation water delivery to water users along the canal;
- Irregular irrigation water delivery to water users (the daily and ten-day period changes in a canal water level);
- Lack of irrigation water delivery during the growing season due to the emergency on the canal;
- Lack of irrigation water delivery during the off-vegetation period for domestic needs of water users;
- Cut-off of power supply and time-out in operation of pumps;
- Uncertainty in ownership of off-take: organization in the book of which an off-take was registered; or in case of this certainty, a non-agreement of water users to pay for water losses at this off-take;
- Overestimated (underestimated) amounts in the applications for irrigation water submitted by water users;
- Ill-timed setting of water limits by the BISA;
- Inaccurate and unreliable data of water distribution monitoring;
- A low level of collecting fees for water services of the Canal Administration;
- Deteriorating the land conditions caused by irrational water use in neighbor farms;
- Uncertainty in sizes of irrigated area and crop pattern;
- Unauthorized tie-in into discharge pipelines of the pumping stations;
- Unauthorized water diversion from the irrigation canal (theft);
- Unauthorized construction of a new off-take;
- Illegal use of the water protection zone (WPZ) by local population;
- Polluting of the WPZ and water in the canal by local population;
- Others.

The abovementioned only gives occasion for water conflicts. However, profound reasons for water conflicts mainly lie in water governance (Chapter 4). Our experience shows that the view, according to which key reasons of water sector's problems are traditionally related only to technical aspects, is prevailing up to now. Thinking in such a way means "not to see the wood for the trees." From the point of view of followers of this approach, for example, a major cause of conflicts lies in deteriorating of material logistics of the water management organizations resulting in the following:

- Poor communication of the Canal Management Organization with hydro-operational sites, pumping stations and water users;
- Deficit of spare parts and construction materials;
- Lack of water-metering devices;
- Sudden shutdown of pumping stations and pump units due to cut-off of power supply (the instability of flow rates and water levels, the need in water releases, possible water overflows etc.); and
- Lack of vehicles for hydro-operational sites' personnel.

It is necessary to remind this approach's followers while the metering facilities were always at the filling stations, now they became more perfect, we cannot allege that petrol is always filled without fraud. Not in the least underestimating merits of the "engineering" approach, it is necessary to note that at present the understanding that this problem is sooner institutional than technical one is rising. The institutional approach's advantage is that it does not require large investments and aimed not only at settling conflicts but also their prevention.

As shown, there are various types of conflicts and reasons for them. There are accordingly different mechanisms for their resolution. We have considered informal (no legal) mechanisms of conflict resolution under water distribution at the level of main canals in the water sector of Central Asian countries[35].

Conflicts management assumes employing the following set of mechanisms (instruments) that can be systematized according to the next directions:

- Forecast of potential conflicts;
- Developing the preventive measures to prevent conflicts;
- Response to the incipient conflict; and
- Conflict resolution.

The due attention was put to all above directions in the frame of the project, but major emphasis was placed on developing the preventive measures to prevent conflicts. Instead of continually extinguishing "fire" of repetitive conflicts it is necessary to eliminate the profound reasons for water conflicts. Therefore, one of major aspects of IWRM-Fergana's activity is the implementation of institutional reforms including the introduction of principles of public participation and establishing WUAs based on hydro-geographical approaches (Chapter 4). Case studies of some conflicts that took place on the pilot canals are given in boxes below.

[35] In case of the impossibility to reach consensus, the legal procedures including arbitrage should be used but they require more time, finance and efforts in order to reach civil or another liability of one of parties. The practice of water allocation shows that, due to abovementioned reasons, either the formal mechanisms of conflict resolution in the water sector of the CAR do not work (as a rule, a case does not reach the judicial trial) or an judgment of court is not fulfilled. For example, the administration of the KBC went to the law because the WUA "Zerafshan" did not pay for water delivery services. The judgment of court was for benefit of the administration of the KBC (the WUA must pay for water services in terms established by the court), but the WUA "Zerafshan" did not execute the judgment of court, and the administration of the KBC continues to deliver water to this WUA.

| ***Box 1. Conflict on the border between countries*** |
| --- |
| There is the lateral "Kyrkyz-Aryk" upstream of the water intake into the Karkidon Feeding Canal (KFC) from the Andijan part of the SFC. Along its upper section, water from this canal is used by Kyrgyz water users; along the middle section by Uzbek water users; and along the tail section again by Kyrgyz water users. Due to the expansion of irrigated areas along the upper section of this canal, deficit of water for irrigation was experienced by water users along the middle and tail sections. The conflict situation was temporary solved when water for irrigation was delivered through two pumping stations to Uzbek water users from the SFC and to Kyrgyz water users from the KFC. However, in 2007, the conflict has arisen much more intensive (the conflict of the high intensity level: attempts of taking of hostages, destroying of waterworks etc.). |

| ***Box 2. Conflict between provinces*** |
| --- |
| The SFC. Gauging Station 4 "Polvantash." The border between Andijan and Fergana sections of the SFC. It was revealed that the administration of the hydro-operational site has concealed the information on return water inflow from the territory of Andijan Province with a flow rate up to 3 m3/sec. This water was used for mercenary ends. When there was not return water inflow from the Andijan part of the SFC, the administration of the hydro-operational site made a lot of noise about insufficient delivery of irrigation water from Andijan Province. After complete replacement of the administration of hydro-operational site "Polvantash", the conflict situation was temporary settled. However, the recurrence of conflicts has suggested that the nature of conflict was exclusively related to personalities only at first glance. It has become clear that both parties of this conflict were found with "their hands in the cookie jar" - the representatives of Andijan Province have withdrawn water in excess, and at the same time, the representatives of Fergana Province have concealed the information on additional water in the canal due to return water inflow. The conflict was settled after transition towards water resources management based on hydro-geographical principles and establishing the SFC Administration. |

| ***Box 3. Conflicts between administrative districts*** |
| --- |
| 1. In the tail part of the SFC in Fergana Province, upstream of Balance Gauging Station 8, two pumping station located on the territory of Altyaryk District (PS "Fayziabad" with a capacity up to 3 m3/sec and PS "Povulgon" with a capacity up to 1 m3/sec) pump water from the SFC for irrigating lands in Fergana District (joint water use). Water conflicts between Altyaryk and Fergana districts took place in all cases of insufficient water delivery into the tail part of the SFC. Disputes were settled based on the trade-off approach by means of shutdown of one, two or all pump units of first or second pumping station. Sometimes it was impossible to put into operation pump units of the PS "Povulgon" due to water shortage in the tail part of the SFC. From time to time, conflicts again arose, showing that deep-rooted problems were not being solved and put off for the future. The conflict situation was mitigated by means of transferring the hydro-operational site "Fayziobad" under management of the SFC Administration.<br><br>2. There are traditional conflicts between the upstream hydro-operational site "B. Gofurov" and the downstream hydro-operational site "D. Rasulov" of the KBC, as well as between hydro-operational sites "Karasu" and "Aravan" of the AAC. The introduction of inter-district water rotation on the KBC has mitigated the conflict between districts, but not settled it completely; therefore, dozens of water users were forced to put padlocks on gates of waterworks and to watch operation at the upper end of this site to deliver water to the lower end. The conflict was settled by means of establishing the KBC Administration and the AAC Administration and transition towards management based on hydro-geographical principles. At present, there is not the need to put padlocks and to organize watching on the KBC. There is not also the need in the interference of local authorities in water allocation issues: "now akims have not headache…." |

***Box 4. Conflict on small transboundary rivers***

A tail flow of the Aravansay River fell into the SFC and then was conveyed to the Kyrkydan Reservoir. For a number of reasons, including the replacement of the administration of Aravan District in Kyrgyzstan, the Aravansay River's flow was redirected to the Shakhristansay River in bypass of the SFC.

The conflict was settled after the interference of the SFC WC. In the course of negotiations, Uzbek water specialists have reminded (it turns out the Kyrgyz party did not know about this fact) that, according to the Agreement on Water Sharing, 13% of the Aravansay River's flow accumulated in the Kyrkydan Reservoir can be used by Kyrgyz party. At present, without obstructions, the Aravansay River's flow comes in the SFC and then is accumulated in the Kyrkydan Reservoir. It is not difficult to understand the significance of this conflict resolution, taking into consideration that last years there is not the outflow of water from the Andijan Reservoir for its delivering to the associated water users.

***Box 5. Conflicts between the Canal Administration and WUAs***

1. The AAC command area. The WUA has submitted the evidently underestimated applications for irrigation water, planning to supply (sale) water stolen from the canal to local farmers.

This conflict is settled at the sessions of the Board of the AAC's Canal Water Committee.

2. The KBC command area. Due to the low level of fee collection for water services, the KBC Administration was forced to stop water delivery to some WUAs – debtors. The level of fee collection has risen but the conflict was not completely settled due to deep-rooted reasons of external water governance.

3. The AAC command area. Areas of pumped irrigation that are not planned to be irrigated due to high cost of electric power were included into the plan of water use. The conflict was discussed at the general meeting of WUAs, but was not still settled. It is planned to discuss this conflict at the general meeting of the Water User Council of the AAC with participation of representatives of the AAC Administration and the BISA.

4. The SFC command area. Decision-making regarding water delivery to the WUA "Akbarabad" was insufficiently well-timed. The conflict was settled based on the decision of the SFC CWC's session enabling the WUA "Akbarabad" to sign the agreement on irrigation water supply directly with the SFC Administration.

***Box 6. Conflict between the Canal Administration and local authorities***

A high-ranking official gave instructions to open gates of one check structure on the SFC to deliver extra volumes of water to the tail part. Personnel of the Canal Administration were refusing to execute these instructions for a long time, understanding the consequences of these actions. When they executed this order, abrupt breaking of the flow occurred. A water level suddenly dropped in front of this check structure; and the emergency situation was created downstream of the check structure. This is the example of adverse interference of the local authorities' chief, but there are also positive examples. However, the point is that the participation of representatives of local authorities and other economic sectors should be ensured in another manner.

For preventing and settling such conflicts, including cross-sectoral conflicts (agriculture, hydropower generation, water supply, ecology, industrial needs etc.) the Councils of Canal Water Committees with the participation of representatives of local authorities and other economic sectors should be established. At that, direct water users that consume or use water resources (hydropower stations, irrigation sector, water-supply companies) participate in activity of the CWC Council through their representatives in the CWUC, and representatives of indirect water users (local authorities, nature protection organizations etc.) are directly included in the CWC Council.

| ***Box 7. Conflict between the Canal Administration and the HPS's Administration*** |
|---|
| Two small hydro-power stations (HPS) were built on the SFC. HPS 1 does not usually inform about executing maintenance works related to cleaning the trash-racks of intake chambers; and, as a result of the manipulation with gates, flow rates in the canal fluctuate resulting in the conflict situation due to reducing water delivery to its tail part by 3.0 m3/sec, and for rehabilitation of the stable regime of flow rates three hours are needed as minimum.<br><br>Due to sudden power cutoff or reducing of voltage in the power network, the automation system of HPS 2 automatically close the intake gates of diversion canal. As a result, a flow rate at this section of SFC is increasing up to 20 m3/sec, and the canal operates under the emergency regime since its carrying capacity is insufficient for such flow rates. |

| ***Box 8. Conflict between the Canal Administration and the management of PS*** |
|---|
| Sudden power cutoffs cause hitch of pumping stations (PS) often resulting in damage of electric motor shafts and electric motors themselves. The Pumping Station Management Organization bears considerable material losses. At the same time, pumping station's shutdown results in increasing a flow rate in the canal up to 10 m3/sec and its emergency operation. The conflict situation arises since there are not communication with the PS and any possibility to inform about an incident in timely manner.<br><br>The managers of HPSs and power supply companies of Andijan and Fergana provinces were invited on the CWC SFC meeting. A representative of HPS assured the members of CWC SFC and Canal Administration that they are ready to inform the CA personnel at hydro-operational sites in timely manner about the situations causing changes in the canal's operational regime. Representatives of provincial power supply companies did not attend the meeting. The CA and BISA sent the letters to power supply companies, local authorities and the national MAWR with appropriate information and calculations of the amount of damage of pumping stations. Some progress in settling the conflict was reached: there were not sudden power cutoffs in 2005. |

| ***Box 9. Conflict between the Canal Administration and farmers*** |
|---|
| Water users divert water beyond established limits using siphons, small pumps, new off-takes etc. Such conflicts are caused by, on the one hand, the incompetence of farmers and, on the other hand, the WUA's weakness: through ignorance or due to the fact that the issue is not solved at the WUA level, water users themselves try to divert water from the main canal and conflict with the CA.<br><br>Our analysis has shown that for preventing such conflicts it is necessary to enhance works related to establishing WUAs based on hydro-geographical principles and participatory water management at the lower level of hierarchy, as well as to improve the efficiency of joint activity of the CWUC at hydro-operational sites and Councils of WUAs. |

Thus, the most typical situation for water management organizations that were established based on the administrative-territorial principle is the arising of conflicts "head - tail" on borders of the republics, provinces, districts, and small transboundary rivers (STR). At the same time, water users located along the tail parts of irrigation canals persistently suffer from water deficit. Each upstream water user aspires to take irrigation water as much as possible without any concern about the situation of downstream water users. Therefore, it is difficult for water professionals to deliver water (especially in dry years) to the tail section of canal. Transition towards introducing the hydro-geographical principle on the pilot canals at once provided the following results: conflicts on borders of administrative territories (on the borders between Andijan and Fergana provinces, Karasu and

Aravan districts, as well as between districts "B. Gafurov" and "D. Rasulov") were mitigated or practically eliminated (Boxes 2 to 4).

For settling and preventing other types of conflicts the appropriate instruments were created: Councils of WUAs, Boards of the CWUC, and Boards of the CWC. The analysis conducted has shown that the considerable part of disputes is caused by the misunderstandings and incorrect notions resulted from the low level of:

- available information on the water distribution process; and
- the transparency of decision-making.

There are grounds to think that the joint work of the CA with Councils of WUAs, Boards of the CWUC, and Boards of the CWC will facilitate preventing conflicts because all stakeholders are involved into the decision-making process, in the course of which the mutual understanding is growing and the misunderstandings disappear.

The Arbitration Commissions were provided for within the listed bodies, but since their activity was not properly organized, the boards of the CWUC and the CWC themselves settle conflicts. In particular, the participation of the members of SFC CWC in the conflict resolution on the KFC (Box 1, 5, and 8) was quite useful. Here, the following instruments for conflict management were used:

- Organizing the dialogs of conflict parties:
    - to define the essence of the conflict;
    - to identify the interests of conflict parties;
    - to specify the opportunities for conflict resolution; and
    - to reach the agreements on procedures for conflict resolution and settling other possible differences;
- Organizing the training seminars with the participation of conflict parties to rise the level of knowledge and awareness of problems related to water governance and management and to provide the consensus;
- Strengthening the composition of Board of the KFC CWC by involving the representatives of conflict parties (in particular, water professionals and water users of Aravan District);
- Installing the boxes for collecting complaints and suggestion of water users in the CA offices;
- Organizing the reception days by chairmen of the CWUC and the CWC;
- Providing the diaries for record keeping the conflict situations and disputes; and
- Holding the sessions of Boards of the CWUC and CWC to solve the issues related to preventing and settling the conflict situations.

Owing to above activity, the conflict on the KFC was settled. In addition, at the sessions of the SFC CWC the decisions for settling difficulties between the SFC Administration and BISA ("Sokh-Syr Darya" and "Naryn – Kara Darya") related to timing and limits of water supply for off-takes from the SFC were made.

Of course, there cannot be any assurance that conflicts on the KFC will never repeat since the process of water resources management at this site is very complicated. There is only the hope that, under the active work of the Board of KFC CWC, which has the powers to make operating decisions, the search of compromises will be speeded up, preventing the development of disputes into conflicts of the mid-range or high level of intensity.

At present, in the frame of this project the most topical activities, from the point of view of settling and preventing water conflicts, are the following:

- Promoting activity of Boards of the CWUU and CWC;
- Establishing the Boards of the CWUU and CWC and organizing of their activity; and
- Formation of the Arbitration Commissions within the CWUU, CWC and WUAs and organizing of their activity with involvement of women and wise elders into these commissions.

Establishing the WUGs is the important measure to prevent conflicts between farmers. Finally, it is necessary to remind that water conflicts eventually results from the growth of water demand; and reducing water demand will greatly facilitate settling existing problems. It is anything but a secret that a considerable potential for reducing water demand exists in Central Asia. The IWRM-Fergana project promotes activity aimed at revealing and enabling this potential.

One of the most important conditions for WUA sustainable operation is the available mechanisms for settling disputes and conflicts arisen in the process of WUA activity. In case of their belated resolution, conflicts can result in slowdown of development and even disintegrating of WUAs. The mechanisms of conflict resolution available in Central Asian countries, both as formal ones in the form of the national legislative instruments and informal ones based on customs and traditions of local nations, which do not contradict the national legislation in force play an important role under settling conflicts and disputes.

Various types of disputes that can arise in the process of WUA's activity are described below. A special attention was put on formal and informal mechanisms of dispute resolution that existed on the territory of the Fergana Valley; and the guidelines on involving the alternative bodies for dispute resolution, taking into consideration the national legislations in force, were developed. An attitude to the term "conflict" should be careful since this word can frequently be associated with the antagonism and brutality. According to the traditional perception of people of the former USSR, the meaning of the word "conflict" is "almost war"; and, therefore, this word antagonizes many people, who on the question about conflicts usually answer that "there are not conflicts."

The Big Soviet Encyclopedia gives the following definition of the word "conflict": "A conflict is a collision of opposite interests, views, aspirations, and serious disagreements resulting in a struggle." Certain time is needed to reach the perception of this word existing in the contemporary western world, namely "a conflict is the conscious incompatibility of targets: one party considers intentions of another party as harmful ones for own interests."

It is often difficult to realize the nature, type and reasons for local conflicts without understanding the nature of social dynamics. Sometimes the conflicts arise due to ethnic differences, relations within a clan/family, social inequality; sometimes they arise due to a struggle for power, but more often owing to the tangle of all these circumstances. Many people, in bounden duty, follow their "leader" and reluctantly express own views and opinions. At the same time, people prefer not discussing conflict situations with outsiders; and often they do not know how to discern an imminent conflict and how to prevent it.

In the Fergana Valley, water relations among water users within WUAs, between water users and WUAs, and between WUAs and water management organizations are accompanied by the conflicts and disputes that are caused by the following circumstances:

- non-compliance with the agreements signed by water users and WUAs in respect of the schedule and amounts of irrigation water supply and other services granted by WUAs;
- non-compliance with the agreements signed by water management organizations and WUAs;
- infringement of the established schedule of water use by a WUA members (unauthorized water diversion and construction of additional off-takes on the irrigation canals without permission, etc.);
- deteriorating the irrigated farmland conditions of WUA members due to non-compliance with the agreements signed by WUAs and the PHAE and by water users and WUAs;
- damaging of crops or irrigated plots of water users by WUA personnel or neighbor farmers due to careless O&M of on-farm water infrastructure;

- non-fulfillment by WUA member his duties provided for by the WUA's Charter;
- infringement of the WUA member's right to participate in decision-making at the general meeting;
- labor disputes between the WUA administration and its personnel;
- non-compliance with the agreement signed by water user not being a WUA member and the WUA in respect of irrigation water supply and other services granted by WUAs; and
- disputes between water users.

Disputes between WUAs and water management organizations can arise during the irrigation season due to unsettled matters relative to the following aspects:

- changes in volumes and time of irrigation water delivery to a WUA;
- considerable daily deviations from planned water levels in the canal;
- ill-founded reducing the volume of water supply by the Canal Administration to WUAs at the expense of use brackish return water being formed on the WUA's territory;

Water delivery to a WUA or WUGs can be adjusted due to the interference of local authorities of different levels, for example, a provincial or district administration, resulting in disputes and dissatisfaction of water users and WUA personnel. Of course, disputes and conflicts related to water delivery and distribution should be reviewed only under the presence of appropriate documents (a water supply registry, a statement of the case, etc.).

### 5.7.2. Analyzing the Existing Mechanisms for Settling Disputes and Conflicts between Water Users, between Water Users and WUAs, between WUAs and Water Management Organization Coupled with National Legislations in Force in the Fergana Valley

The legislations of all countries in the Fergana Valley, starting from the constitutional regulations and regulations of the civil law and procedural legislation, provide for the opportunity for legal remedy of infringed rights in the process of ownership relations and non-pecuniary relations. The legislations also provide for the mechanisms and detailed procedures of the pre-trial inquiry, preparation and judicial trial, legal decision and appeal against a sentence in accordance with the appellate jurisdiction or review proceedings.

In accordance with the national legislations and WUA Charters, disputes and conflicts between WUA members and the WUA Board can be investigated by the Arbitration Commission of the WUA, the Arbitration Commission of the Canal Water Committee, Aksakals' Courts that were established in the framework of the local administration, and the WUA Controlling Department under the Ministry of Agriculture and Water Resources (was established only in the MAWR in Kyrgyzstan).

The WUA Arbitration Commission may examine all issues related to activity of a WUA and its members, as well as the disputes with water users not being members of the WUA but having contractual relations with the WUA. The issues related to relations of a WUA and the water management organization can be examined by the Arbitration Commission under the Canal Water Committee, members of which are the representatives of water management organization and WUA. Their joint work represents the mechanism that prevents the conflict situations. *In case of the non-agreement of one of conflict parties with a judgment of the Arbitration Commission of a WUA or the Canal Water Committee regarding recovering damages, the case may be tried by the competent court according to established legal procedures.*

Aksakals play a crucial role in settling arisen conflicts. They, as a rule, evaluate those or other incidents and form the public opinion. Their interference in the examination of those or other disputes between WUA members and a WUA or between a WUA and the water management organization, as well as between water users would mitigate the social tensions and stop further development of disputes.

The proposed ways for settling disputes and conflicts without the reference to the judicial authorities have an advantage of fast consideration and resolution and the lack of large financial expenditures that take place under the reference to the judicial authorities. Mechanisms of conflict resolution were considered taking into account the specificity of legal systems in the neighboring countries in the Fergana Valley.

## The Kyrgyz Republic

The judicial system in Kyrgyzstan was established in line with the Constitution of the Kyrgyz Republic. The judicial system consists of the Constitutional Court that executes the constitutional legal procedures and the system of courts of general jurisdiction that execute the criminal procedure, civil trial, and administrative proceedings. In addition, there is the system of arbitration tribunals that execute the public justice in the field of economic relations between economic entities, institutions, and organizations independently from the patterns of ownership and types of economic activity.

The intermediate courts and aksakals' courts are also active in Kyrgyzstan, which consider economic disputes and conflicts in case of reference to them. There are the established procedures for reference to the courts, judicial trial, judgment of court and its execution, as well as the procedures for appealing against a sentence and review proceedings.

The participation of natural persons and legal entities in the civil process and arbitration proceedings is accompanied by the execution of documents under drafting of which the existing legislation and law enforcement practice should be taken into account. In accordance with the existing national legislation, abovementioned types of disputes can be settled by the following entities:

***A number of the disputes between WUA members and the WUA can be examined by the Arbitration Commission of the WUA.***

Under the mutual agreement of parties, the disputes can be considered and settled in the aksakals' courts and in courts of general jurisdiction. The interpersonal conflicts of WUA members can be settled in the same way. In accordance with the Law "On Aksakals' Courts" passed in the Kyrgyz Republic, *the aksakals' courts can examine the documents on disputes and conflicts submitted by the following bodies:*

- local courts for civil cases;
- courts; public prosecutors, investigatory powers with the court order (the documents on criminal cases that were closed for applying the measures of community-based correction in accordance with the procedural criminal law); and
- the appropriate governmental bodies responsible for the control of administrative infringements of the law using the procedures provided for in the Administrative Code.

The aksakals' courts can also try cases according to the written requests of citizens (under the agreement of parties) to resolve the ownership and family disputes for the purpose of conciliating the parties. The aksakals' courts are not competent to deal with the cases, for which there is already adjudication or penalty under administrative law, as well as for which the aksakals' court decision was already made within its competence. After adjudicating the guilt of persons brought to trial, the aksakals' court can give judgment for executing one of the following punishments:

a) to pronounce a warning;
b) obligation to adduce the public excuse to an injured party;
c) to pronounce the public disgrace;
d) obligation of a party at fault to pay the damages;
e) monetary penalty at the rate up to three minimum salary established according to the legislation of the Kyrgyz Republic or forced public works;

If necessary, the aksakals' court has the right to transfer a case to the investigatory powers and court. The aksakals' court has to inform the body (an executive officer) that sent the case within 10 days about measures of community-based correction imposed on the persons who committed administrative infringement of the law. This court does not have the right to pass judgment that disparages the self-respect of people.

*Disputes due to financial payments should be considered in the general jurisdiction court in accordance with established judicial procedure, in case of disagreement of one of the parties and if one of the parties is a citizen.* When parties are legal entities or citizens having the status of an individual entrepreneur gained according to the legitimate procedure, an arbitration tribunal (arbitration[36]) investigates such cases. An arbitration tribunal can also investigate disputes between WUAs and the water management organization regarding the payment terms for services, ill-timed payments and related penalty fees. At the same time, they have the opportunity to reach the consensus through bringing the matter before the Arbitrage Commission of the Canal Water Committee.

*The legislation of Kyrgyzstan also provides for the procedure for adjudication in the extrajudicial bodies – in the arbitration (arbitration tribunal), in accordance with the law "On Arbitration in the Kyrgyz Republic."* Unless otherwise agreed by the parties or the law, provisions of this law are used under transferring a dispute case, in which one party or both parties are citizens, to the arbitration.

An action proceeding related to the compensation of damaging WUA members' crops or irrigated plots due to ill-fulfilled O&M of irrigation systems in WUAs should be considered in the general jurisdiction court, if one of the parties is a natural person (a citizen) and in the arbitration if the parties are the legal entities or one of the parties is a citizen - an individual entrepreneur. Labor controversies between the WAU administration and its personnel can be considered in the general jurisdiction courts. However, the extrajudicial procedure for such controversies in the WUA Arbitration Commission is also possible by mutual consent of parties.

## The Republic of Tajikistan

The judicial authority in the Republic of Tajikistan is being exercised by means of the constitutional, civil, criminal, arbitration and administrative legal proceedings. The legal procedures for proceedings are specified in the laws of the Republic of Tajikistan. The judicial system of the Republic of Tajikistan consists of the Constitutional Court, Supreme Court, Supreme Economic Court, Military Court, Court of Gorno-Badakhshan Autonomous Province, as well as provincial, district and city courts and the courts of arbitration of the Gorno-Badakhshan Autonomous Province, other provinces and Dushanbe City.

The Supreme Economic Court of the Republic of Tajikistan is the major judicial body that decides economic controversies and other cases, exercises the judicial review according to the code of practice and interprets the matters of jurisprudence.

*Some types of controversies, mentioned in the first section, can be resolved by the territorial civil courts and economic courts.* Economic proceedings are regulated by the economic code of practice of the Republic of Tajikistan.

[36] Arbitration is a proceeding in which a dispute is resolved by an impartial adjudicator whose decision the parties to the dispute have agreed will be final and binding.

*In Tajikistan, proceedings and deciding the specific economic controversies are possible in the intermediate court (arbitration) established for treating such cases.* The procedures for proceedings and deciding the specific economic controversies are specified by the Regulations No 426 dated May 15, 1997 was approved by the Majlisi Milliy (National Assembly) of the Republic of Tajikistan.

### The Republic of Uzbekistan

The judicial system of the Republic of Uzbekistan consists of: i) the Constitutional Court, Supreme Court, and Supreme Economic Court; ii) Supreme Civil and Criminal Courts of the Republic of Karakalpakstan; iii) provincial and Tashkent City's civil and criminal courts; iv) inter-district and district (city) civil courts and district (city) criminal courts; v) military courts; and vi) courts of arbitration of the Republic of Karakalpakstan and provincial and Tashkent City's courts of arbitration.

The Supreme Court of the Republic of Uzbekistan is the supreme body of judicial authority in the field of civil, criminal and administrative legal proceedings. The Supreme Court of the Republic of Uzbekistan has the right of supervision over the judicial practice of Supreme Civil and Criminal Courts of the Republic of Karakalpakstan, provincial, city, district and military courts. The Supreme Court of the Republic of Uzbekistan treats the cases as the trial court and exercises the judicial review. The cases that have been treated by the Supreme Court of the Republic of Uzbekistan as the trial court can be treated by as the court of cassation or according to the appellate process.

*The Supreme Economic Court of the Republic of Uzbekistan is the supreme body of judicial authority in the field of economic legal proceedings.* The Supreme Economic Court of the Republic of Uzbekistan has the right of supervision over the judicial practice of the economic court of the Republic of Karakalpakstan, and provincial and Tashkent City's economic courts. The Supreme Economic Court of the Republic of Uzbekistan treats the facts of cases as the trial court and exercises the judicial review and the appellate process.

*All types of abovementioned controversies can be resolved by the territorial civil courts and economic courts.*

Proceedings are regulated by the civil code of practice and the economic of code of practice of the Republic of Uzbekistan. *In Uzbekistan, proceedings and deciding the specific economic controversies are possible in the intermediate court (arbitration) established for treating such cases.*

### 5.7.3. Recommendations and Proposals on Developing Additional Legal Instruments for Dispute Resolution in Fergana Valley's Countries

Alternative methods of dispute resolution that do not require considerable financial expenditures and organizational efforts in comparing with judicially deciding the economic controversies exist in many developed countries along with the judicial procedure of economic dispute resolution. An arbitration tribunal is the kind of the institute of alternative methods for settling the economic controversies and, according to its nature, presents the extrajudicial body. *The principles of voluntariness and confidentiality to the body that decides essentially their controversies are the basis for forming and activity of arbitration tribunals.* These principles are reflecting not only the right of parties to treat an arisen dispute in the arbitration tribunal but also the right to participate in forming a composition of the arbitration tribunal, specifying the procedure for adjudication and dispute resolution.

***An arbitration tribunal is the non-governmental court; therefore it does not possess the tools to enforce the execution of its decisions.***

In Kyrgyzstan, the arbitration tribunals are active since 2001. The fact of passing the law "On the Arbitration Tribunals in the Kyrgyz Republic" confirms that the process of developing and strengthening the institute of arbitration tribunals for settling economic controversies in the national agrarian sector acquires the dynamic nature. The legislations of Tajikistan and Uzbekistan provide for the possibility to treat economic controversies in arbitration tribunals.

Beyond question, the arbitration tribunal has a number of perceived potential advantages over the judicial proceedings.

*Firstly,* the arbitration is often faster than litigation in court. When parties refer to the court they should potentially follow three formal procedures, including appeal and supervision procedures. An arbitration tribunal is the only instance that provides a final and binding decision.

*Secondly,* judges of the arbitration court are appointed by the government, at the same time, the dispute parties have the opportunity to select arbitrators of an arbitration tribunal from the proposed list. Moreover, this list can include not only legal professionals but also arbitrators with an appropriate degree of expertise (economists, financial officers, engineers etc) who are capable to examine the crux of economic disputes.

*Thirdly,* an arbitration tribunal can be cheaper and more flexible for businesses, since it is not necessary to go through three instances as in case of the arbitration court.

***And finally fourthly, there are less potential conditions for corruption in an arbitration tribunal.***

In case of real conflict situations and disputes, there are formal and informal mechanisms for their resolution at the farm level, for example, the aksakals' court legalized in Kyrgyzstan. Aksakals (wise and respected elders) always stood high in population's esteem in Central Asian countries.

Aksakals' courts are the community-based and self-government institutions that are voluntarily established on the basis of election procedures and aimed at the decision of cases, which were submitted to them according to the procedures established by the court, public prosecutor, departments of home affairs and other governmental bodies and their officials in accordance with the national legislation in force. Aksakals' courts are formed from the elders or other citizens who have gained the indisputable prestige, in line with the resolution of citizens' assemblies held in administrative units or according to the resolution of another self-government institution on the territory of villages, settlements and towns.

*Taking into consideration that the national legislations of Uzbekistan and Tajikistan provide for an opportunity to transfer the cases related to commercial and economic disputes to the arbitration tribunals, it would be expedient to entrust the aksakals' courts with deciding these cases*. A procedure of pre-trail in the aksakals' courts being applied in Kyrgyzstan is recommended to disseminate over Tajikistan and Uzbekistan as the model procedure.

The law of the Kyrgyz Republic "On Water Users Associations" provides for the need in Regulatory Department for monitoring WUAs' activity. The Department of Water Resources of the Kyrgyz Republic was entrusted with executing such functions by the appropriate governmental decree. This department should have a sufficient influence on the water authorities and WUAs and has to be the mediator settling their disputes related to water resources management.

The similar regulatory departments for monitoring WUAs' activity would be necessary to establish under the Ministries of Agriculture and Water Resources of Tajikistan and Uzbekistan for resolution of the following disputes:

- between WUAs and the water management organization;
- between WUA's members and a WUA over the matters of rights and duties of parties; and
- between a WUA and water users not being the members of a WUA over the matters of water services.

The recommended mechanisms for settling the different disputes between water users and WUAs, WUAs and the WMO, water users and relevant authorities are given in the table below.

| No | Type of dispute | Dispute resolution bodies | | | |
|---|---|---|---|---|---|
| | | WUA Arbitration Commission | Arbitration Commission of the Canal Water Committee | Aksakals' Courts (under the local authorities) | Regulatory departments under MAWR xx) |
| **1** | **2** | **3** | **4** | **5** | **6** |
| **1** | Non-compliance with provisions of the Agreement on irrigation water delivery and other water services signed by water users and a WUA | **v** | | **v** | **v** |
| **2** | Non-compliance with provisions of the Agreement signed by the Water Management Organization and WUAs | | **v** | | **v** |
| **3** | Breach of the established schedule of water use by a WUA member (unauthorized water diversion, unauthorized construction of a new off-takes etc.) | **v** | | **v** | |
| **4** | Deterioration of irrigated farmland conditions of WUA members due to inactivity or insufficient activity related to O&M of irrigation and drainage systems: | | | | |
| | • WUA | **v** | | | **v** |
| | • Inter-farm drainage network | | **v** | | **v** |
| **5** | Violation of WUA members' rights on the compensation in case of damaging of crops or irrigated plot due to ill-made O&M of on-farm irrigation and drainage systems | | | | |

| No | Type of dispute | Dispute resolution bodies | | | |
|---|---|---|---|---|---|
| | | WUA Arbitration Commission | Arbitration Commission of the Canal Water Committee | Aksakals' Courts (under the local authorities) | Regulatory departments under MAWR xx) |
| 1 | 2 | 3 | 4 | 5 | 6 |
| | | v | | | v |
| 6 | Non-fulfillment of duties provided for in the WUA Charter by a WUA member regarding timely payments for water services; careful use of equipment and machinery belonging to a WUA ; reimbursing expenditures related to repairing or replacement of parts of equipment and machinery belonging to a WUA and damaged due to ill use and maintenance | v | | | |
| 7 | Violation of WUA members' rights related to his participating in the decision-making process in a WUA: to vote at the general meeting of a WUA, to discuss and form the agenda of the general meetings, to use services granted by a WUA, to propose candidates for election to the management bodies of WUA; and to be elected to these bodies. | v | | | v |
| 8 | Interpersonal conflicts | v | v | v | |
| 9 | Labor disputes between WUAs and their personnel | v | | | |
| 10 | Non-compliance with provisions of the Agreement on irrigation water delivery and other water services signed by water users not being WUA's members and a WUA, as well as problems related to the | | | | |

| No | Type of dispute | Dispute resolution bodies | | | |
|---|---|---|---|---|---|
| | | WUA Arbitration Commission | Arbitration Commission of the Canal Water Committee | Aksakals' Courts (under the local authorities) | Regulatory departments under MAWR xx) |
| **1** | **2** | **3** | **4** | **5** | **6** |
| | compensation of damages | v | | | v |
| **11** | Changes in volumes and time of irrigation water delivery within a WUA | | v | | v |
| **12** | Considerable daily deviations from planned water levels in the canal in the process of water use in a WUA | | v | | v |
| **13** | Ill-founded reducing the volume of water supply by the Canal Administration to WUAs at the expense of use brackish return water being formed on the WUA's territory | | v | | v |
| **14** | Disputes due to the interference of local authorities of different levels into WUA water supply (or the group of WUAs) and separate farms (or the group of farms): | | | | |
| | • District administration | | v | | v |
| | • Provincial administration | | v [x)] | | v |
| **15** | Disputes between water users | v | | v | |

[x)] with the participation of a representative of the BISA

[xx)] at present, they are active in Kyrgyzstan and Tajikistan

Disputes due to the interference of provincial administration into the matters of irrigation water supply should be considered by the Canal Water Committee with the participation of dispute parties and under involving a representative of the Basin Irrigation System Administration (BISA).

If the parties cannot reach the consensus in the dispute under consideration they may transfer this case for proceedings at law into the economic court or common law court.

To prevent disputes between water users themselves, between water users and WUAs, and between WUAs and water management organizations it is necessary:

- to install water-measuring devices at water users' off-takes;
- to draw up the scientifically-grounded plan of water use for a WUA as a whole and for each farm – WUA's member prior to the beginning of water applications;
- to enhance governmental and community-based monitoring of irrigation water use;
- to create the environment of transparency and public awareness of activity of governmental water management bodies and water users associations;
- to improve and upgrade irrigation and drainage systems of different levels; and
- to conduct the training seminars for WUA personnel and farmers, from time to time, considering the topics related to the water use practice; water, land and civil legislation; integrated water resources management with involving water users into the water resources management process.

***How the recommendations for resolving the water disputes and other controversies are being practically implemented?***

These matters are described below by way of the case study of the pilot WUA "Akbarabad." In the growing season of 2007, the managers of five private farms brought their complaint to the Kuva District Office of Ministry of Agriculture and Water Resources and the Arbitration Commission of WUA "Akbarabad" about insufficient volumes of water delivered by this WUA for irrigation of cotton. The Arbitration Commission has established facts that water delivered for irrigation of cotton was used by farmers for irrigating secondary crops, an area of which was planned as 20% of the area under cereal crops for this dry year against 80% in the average year. Nevertheless, farmers have irrigated all their areas under secondary crops and caused the water stress of cotton. Farmers were notified about the gross violation of water use rules.

WUA's personnel with the assistance of the public have established facts that the farms "Isomidinov" and "Gulirano" practiced unauthorized water diversion from the WUA canal. The formal report about these violations was drawn up by the WUA personnel; and this document was brought to the WUA's Arbitration Commission. The WUA's Arbitration Commission decided to reduce irrigation water delivery to some farms and temporarily to suspend irrigation water delivery to these farms. In addition, the administration of WUA "Akbarabad" has addressed to the Provincial Water Inspectorate with its request to penalize the farmers who violate the irrigation schedule established for the irrigation canal "RP-1". By the resolution of the Provincial Water Inspectorate, these farmers were penalized in accordance with the established procedure.

Private farms having the state order for cotton and wheat were debtors of the WUA. The WUA, which has the right in accordance with the Charter to suspend granting its services when it members do not pay for services in timely manner, is going on with the notification about their arrears. In the case under consideration, farmers were informed that water services of the WUA will be discontinued if they will not pay off debts in the established terms.

According to the farmers' complaint, under distributing water through the WUA canals "Akbarabad-2" and "RP-1", the volumes of water delivered to private farms were two times less against their applications and the planned volumes of water use. A reasonableness of this complaint was established in the course of field audit; and by the decision of the WUA Council and administration, managers of hydro-operational sites who breached the procedure of water use were deprived 50% of their monthly bonus.

The private farm "Malika" brought its complaint to the Kuva District Office of Ministry of Agriculture and Water Resources (KDO MAWR) about the lack of irrigation water delivery by the WUA. The commission consisting of representatives of the KDO MAWR, District Association of Private Farmers, Arbitration Commission, Council and administration of the WUA "Akbarabad" has established that in 2007, the private farm "Malika" did not conclude the agreement on water delivery with WUA at all. After concluding the agreement on irrigation water supply between the WUA and the private farm, water delivery to this farm was started.

The private farm "Sayfutdinov" brought its complaint to the Council and Arbitration Commission of the WUA "Akbarabad" with the information that over the period of 6 to 10 August this farm had to receive irrigation water by a flow rate of 50 l/sec according to its application and the plan of water use. However, the private farm "Mamatkhon" during two days (7 to 8 August) practiced unauthorized water diversion from the canal by a flow rate of 30 l/sec, resulting in the dispute between these two farms. The Council and Arbitration Commission of the WUA "Akbarabad" have resolved this conflict situation: the private farm "Sayfutdinov" has received the planned volumes of irrigation water; and the private farm "Mamatkhon" was strictly notified that in case of repeated unauthorized water diversion from the canal it will be penalized. Thus, private farms and WUAs address not only to the WUA's Arbitration Commission but also to the Provincial Water Inspectorate and WUA Council and administration to resolve arisen disputes related to water use.

Figures 5.34, 5.35, and 5.36 give the trends of different types of disputes arisen in pilot WUAs "Akbarabad" (Uzbekistan), "Zerafshan" (Tajikistan) and "Japalak" (Kyrgyzstan) that were treated by WUA's Arbitration Commissions over the period of 2005 to 2007.

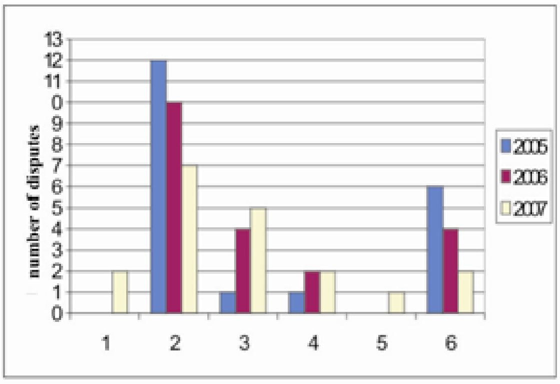



**Figure 5.34 Trends of Disputes Resolution in the Arbitration Commission of the WUA "Akbarabad" (2005 to 2007)**

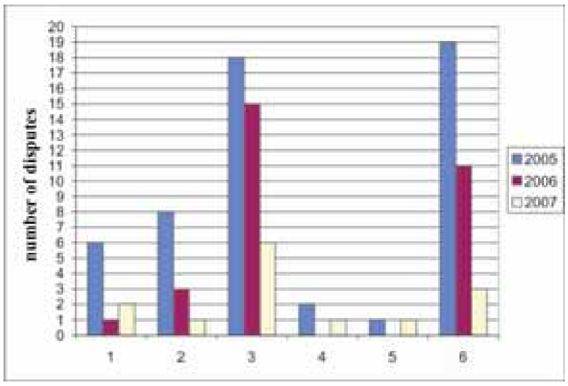
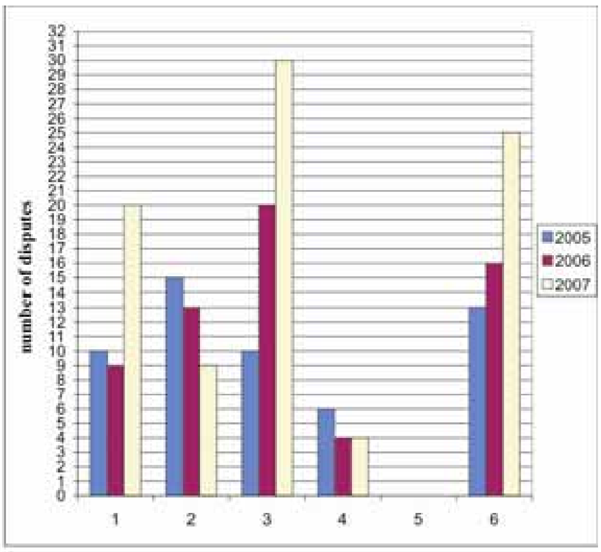



**Figure 5.35. Trends of Disputes Resolution in the Arbitration Commission of the WUA "Japalak" (2005 to 2007)**




**Types of disputes:**

1 – breach of irrigation water delivery;

2 – breach of the water use plan;

3 – ill-timed fees;

4 – labor disputes;

5 – relations with non-members of a WUA;

6 – relations between water users.

**Figure 5.36 Trends of Disputes Resolution in the Arbitration Commission of the WUA "Zerafshan" (2005 to 2007)**

Diagrams show that each WUA has own "painful points" that require those or other efforts in order to resolve and eradicate them and how WUAs managed to do this. There are trends of appreciable reducing the number of disputes in the pilot WUAs "Akbarabad" and "Japalak."

As regards the pilot WUA "Zarafshan," the increase in the number of disputes related to breaches of irrigation water delivery, violations of water use rules by water users, and ill-timed fees for water services of the WUA is observed here. This fact may be, to a large degree, explained by the process of increasing the number of water users in the WUA. Dispute resolution by the Arbitration Commission with involving the interested parties is the factor of stabilizing the general situation in the WUA that promotes strengthening the discipline of water users and WUAs in different fields of their activity.

## 5.8. Financial and Economic Instruments

**(V.A. Dukhovny, M. M. Pinkhasov)**

Financial and economic mechanisms are the most important tools for supporting the activity and development of any economic sector or enterprise. At that, the efficiency of their activity mainly depends on how these mechanisms were correctly selected and used. Undoubtedly, this refers to the water sector in the field of both operation and development including new construction, rehabilitation, nature protection and other aspects. At the same time, in the water sector these mechanisms also play an important role of regulating water demand and promoting the saving of water resources.

Unfortunately, during the Soviet period the economic mechanisms and financial system have suffered from the certain one-sided approach. The governmental financing of the water sector at all levels of the water resources management hierarchy up to the farm level did not create the incentives for saving water and funds. While under planning and constructing water infrastructure, the system of economic indicators ("a profit against costs" and "cost recovery" that are similar to such indicators as the NPV and IRR in the western practice) was used for evaluating the feasibility of constructing those or other waterworks, the method of "planning based on reached results", with some corrections depending on development trends in the national economy, has dominated in the field of O&M. Economic indicators were mainly used under designing and very rarely under evaluating the reached results, basically under auditing. Insufficient attention to the actual efficiency of construction, inability to use completely economic mechanisms in the process of O&M, the lack of record keeping of financial responsibility of water users under different conditions, ignoring of the environmental profits and losses have resulted in many shortcomings of water resources management in the former Soviet Union including Central Asian republics. At the same time, the level of financial support of the water sector was considerably higher.

In spite of the lack of the integrated mechanism of planning operational costs and investments in the practice of water management and financial organizations, the upgraded system of standards on O&M of irrigation and drainage systems has provided better financial status of the water sector.

Trends of technical and economic indicators of the water sector in three Central Asian countries (Uzbekistan, Kyrgyzstan and Tajikistan) over the last twenty years (in the Soviet period since 1987 until 1991 and in the post-Soviet period since 1992 until 2006) are given in the table below.

This table shows that in the Soviet period the government spent considerable funds for O&M and development of water infrastructure (from 200 to 325 USD/ha) under the ration of O&M and investments into development of water infrastructure – 39.2% and 60.8% respectively, on average.

After independence, abrupt drop in new construction and even reducing irrigated areas took place in Kyrgyzstan and Uzbekistan, which were accompanied by drastic reducing of operational costs – by 60% in Uzbekistan, ten times in Kyrgyzstan, and a few times in Tajikistan. However, the indicators of Uzbekistan do not reflect the fact that expenditures for power make up about 70% of all operational costs; although formerly they did not exceed 20%. A situation related to capital investments much worse; since investments in developing water infrastructure were reduced in many times.

**Table 5. 36 Technical and Economic Indicators of the Water Sectors in Central Asian Countries**

| No | Indicator | Units | Averaged over the periods: | | | |
|---|---|---|---|---|---|---|
| | | | 1987 to 1991 | 1992 to 1996 | 1997 to 2001 | 2002 to 2006 |
| | ***Uzbekistan*** | | | | | |
| 1. | Irrigated area | 000' ha | 4141.9 | 4219.4 | 4228.9 | 4209.3 |
| 2. | Total water withdrawal | billion.m3 | 48.2 | 52.4 | 52.8 | 56.4 |
| | Including for irrigation | billion.m3 | 42.1 | 46.1 | 46.3 | 48.8 |
| | % of total water withdrawal | | 87.3 | 88.0 | 87.7 | 86.5 |
| 3. | Expenditures for the water sector, in total | mln. USD | 1347.7 | 413.5 | 333.9 | 389.1 |
| | Including O&M of water infrastructure | mln. USD. | 527.7 | 410.7 | 322.3 | 321.4 |
| | For development | mln. USD. | 820 | 2.8 | 11.6 | 67.7 |
| | **Indicators per unit area (ha)** | | | | | |
| | Water withdrawal for irrigation | 000' $m^3$/ha | 10.2 | 10.9 | 10.9 | 11.6 |
| | Expenditures for the water sector | USD/ha | 325 | 98 | 79 | 92.4 |
| | Including O&M of water infrastructure | USD/ha | 127 | 97.3 | 76.2 | 76.4 |
| | For development | USD/ha | 198 | 0.7 | 2.8 | 16.0 |
| | ***Kyrgyzstan*** | | | | | |
| 1. | Irrigated area | 000' ha | 434 | 414 | 405.5 | 401.6 |
| 2. | Total water withdrawal | mln. $m^3$ | 4936.5 | 4882.3 | 3676.6 | 3632.7 |
| | Including for irrigation | mln. $m^3$ | 4694.0 | 4673.5 | 3536.1 | 3512.3 |
| | % of total water withdrawal | | 95.1 | 95.7 | 96.2 | 96.7 |
| 3. | Expenditures for the water sector, in total | mln. USD | 87.2 | 41.7 | 2.61 | 4.88 |
| | Including O&M of water infrastructure | mln. USD | 87.2 | 22.4 | 1.97 | 4.18 |
| | For development | mln. USD | – | 19.3 | 0.64 | 0.7 |
| | **Indicators per unit area (ha)** | | | | | |
| | Water withdrawal for irrigation | 000' $m^3$/ha | 10.8 | 11.3 | 8.7 | 8.7 |

| No | Indicator | Units | Averaged over the periods: | | | |
|---|---|---|---|---|---|---|
| | | | 1987 to 1991 | 1992 to 1996 | 1997 to 2001 | 2002 to 2006 |
| | Expenditures for the water sector | USD/ha | 200.9 | 100.7 | 6.5 | 12.2 |
| | Including O&M of water infrastructure | USD/ha | 200.9 | 54.1 | 4.9 | 10.4 |
| | For development | USD/ha | – | – | 1.6 | 1.8 |
| ***Tajikistan*** | | | | | | |
| 1. | Irrigated area | 000' ha | 667.2 | 678.2 | 676.5 | 690.2 |
| 2. | Total water withdrawal | mln. $m^3$ | 11128 | 11014 | 11159 | 11179 |
| | Including for irrigation | mln. $m^3$ | 10190 | 10184 | 10237 | 10147 |
| | % of total water withdrawal | | 91.6 | 92.5 | 91.7 | 90.8 |
| 3. | Expenditures for the water sector, in total | mln. USD | 148.4 | 9.56 | 12.68 | 53.5 |
| | Including O&M of water infrastructure | mln. USD | 45.1 | 6.82 | 12.68 | 53.5 |
| | For development | mln. USD | 105.3 | 2.74 | 0 | 0 |
| | **Indicators per unit area (ha)** | | | | | |
| | Water withdrawal for irrigation | 000' $m^3$/ha | 15.3 | 15.0 | 15.1 | 14.7 |
| | Expenditures for the water sector | USD/ha | 222.4 | 14.1 | 18.7 | 77.5 |
| | Including O&M of water infrastructure | USD/ha | 67.6 | 10.1 | 18.7 | 77.5 |
| | For development | USD/ha | 157.8 | 4.0 | 0 | 0 |

*) Data of the project «CAREWIB» without accounting investments into the hydropower sector and urban and rural water supply

It can be mentioned that in the post-Soviet period, the budget allocation for the water sector was considerably reduced in all three countries, but especially in Kyrgyzstan and Tajikistan where a fee for water use was introduced. The table reflects the expenditures at the expense of the national budgetary funds.

At present, financing of the water sectors in Uzbekistan, Tajikistan and Kyrgyzstan has different sources depending on the resources to pay for water in the agricultural sector. The national budget is the major source of financing the water sector in the Republic of Uzbekistan. Here, additional sources of financing are the payments being received by the water management organizations for their services to water users, WUAs or other customers related to repairing irrigation and drainage systems or other works in the course of O&M of water infrastructure.

Nowadays, substantial additional sources of financing the water sector in Kyrgyzstan and Tajikistan are the payments for water services to agricultural customers.

The current financing of the water sector in the Republic of Uzbekistan is linked with the pricing policy in respect of major crops (cotton and wheat) cultivated under the state order with purchasing prices that are considerably lower the real market prices. In other words, the established prices (under state orders) include "free of charge" water services.

***However, the existing system of financing the water sector in the Republic of Uzbekistan does not allow:***

- to establish the mechanism of economic relations between water management organizations and water users and to stimulate saving of financial and water resources;
- to attract water users' funds for financing the water management interventions and to enhance the mutual liability of water suppliers and water consumers under implementing their duties;
- to establish the national water market as a key factor of redistribution of water resources from low-effective water users to high-effective ones and to create the mechanisms of overall and personal incentives of water users and water professionals in saving water; and
- to develop economic incentives for improving the environmental situation under using water resources.

*Moreover, the lack of the efficient encouragement mechanism of rational use of allocated funds for financing water-related interventions is also the shortcoming of the existing system of financing*. At present, in the system of financing O&M of the public water infrastructure, a share of payments for electric power together with a personnel salary makes up about 80%, and a share of repairing works is only about 20%. Such financing takes place under the current technical status of water infrastructure when a design operational life of 70% waterworks (especially, pumping stations) was exceeded 1.5 to 2 times.

Most of waterworks needed to be reconstructed, and consequently considerable investments are needed for implementing these interventions that are quite capital-intensive. Of course, all these issues should be solved not only by introducing water charging but also by providing the governmental support in the form of direct participation in financing the water sector and establishing the system of preferential crediting and taxation.

The all above said refers to the irrigation network within the former on-farm irrigation system. In the past, financing of the former on-farm irrigation and drainage systems (now serviced by a WUA) at the expense of farms was considerably lesser than financing the inter-farm irrigation and drainage systems by the government (about two times). At present, a share of the WUA's budget for these purposes makes up a negligible amount (from $2.5/ha to $7/ha). Issues of financing WUAs are one of major aspects of the economic mechanism, which will be described below.

### *The foreign experience of water charging*

There is not the overall approach for setting up the payment rates for different categories of water users in the world practice. Practically everywhere, water charging is based on reimbursement of expenditures related to water withdrawal, transportation and distribution among water users, as well as is the factor facilitating the improvement of water resources management and use in the national interests. Water sector's expenditures can be reimbursed in different ways:

- payment for volumes of consumed water;
- payment for water use per an accounting unit (per a person, irrigated hectare etc.);
- payment for water overuse against established limits;
- payment for water pollution;
- sale of water rights (payment for a license);

- a tax that includes a fee for water and water services; and
- a joint-stock right for water.

Practically everywhere, the highest payments for water are observed in the industrial and water supply sectors where a share of water sector's expenditures related to water services is completely paid for. Agricultural water users are in the preferred position because of the government subsidies covering expenditures of the water sector. In developing countries, where the introduction of water charging is at the initial stage, the encouraging arrangements for agricultural water users are being applied in the form of:

- liberalization of agricultural output markets;
- preferential crediting of farmers;
- preferential taxation; and
- involving water users in works that are related to maintaining water infrastructure on the paid base.

The government is completely financing (sometimes with use of local budget funds and financial input of water users) development of the water sector, large-scale construction of water infrastructure and land reclamation works. The following principle general statements can be mentioned:

- most of countries set up a water price for industrial and municipal use taking into account the self-repayment of the systems plus a certain profit share;
- most of countries have introduced the block-incremental system of pricing[37] when *a payment is minimum* for limited normative water consumption, but with the progressive growth of water prices under increasing of water consumption; and
- rural and municipal water supply is mainly self-supporting. Only water supply through the kilometers-long water pipelines can be exception. In this case, the government subsidizes part of expenditures.

A level of subsidies mainly depends on population incomes and institutional types of organizations that supply water and maintain the irrigation systems. According to the review of the International Commission on Irrigation and Drainage (ICID), in 1997, organizations that operate in the water sector all over the world were represented by governmental organizations (44%), community-based organizations (23%), private companies (6.7%) and joint-stock companies (13.5%). Therefore, most of large-scale water infrastructure is mainly maintained at the expense of national budgets; at the same time, some governmental and municipal participation is observed in maintaining smaller waterworks being the private or mixed ownership. On average, the cost of $1m^3$ of water in the water supply systems in the developed countries ranges from $\$2/m^3$ to $\$13/m^3$. Payments of water users and governmental subsidies under financing investments and operational costs in the water sector are given in Table 5.37.

[37] The tiered block rate schedule

**Table 5. 37 Shared Financing of Investments and Operational Costs in the Water Sector, %**

| Country | Investment for water sector development | | Operational costs | |
|---|---|---|---|---|
| | Government | Water users and municipalities | Government | Water users and municipalities |
| Spain | 70 | 30 | 50 | 50 |
| France | 50 | 50 | 0 | 100 |
| Canada | 75 | 25 | 50-70 | 30-50 |
| Japan | 100 | 0 | 0 | 100 |
| the USA | 70 | 30 | 50 | 50 |

Table 5.37 shows that a share of the governments ranges from 50% to 100% for investments; and correspondingly a share of water users makes up 25-50%. As regards the operational costs, the governments bear 50 to 70% of expenditures or all operational costs are repaid by water users and municipalities (France and Japan). Indicators typical for some countries are given below:

***Israel***: under an average production cost of water in the public company "Mehorot" that equals to $0.35/m$^3$ to $0.40/m$^3$, the differentiated water tariffs are applied: for drinking and municipal needs – $1/m$^3$; for industrial needs – $0.60/m$^3$, and irrigation needs – $0.19/m$^3$. Water use in excess of the established limits is being penalized at the rate of tenfold tariff. The government subsidizes the public company "Mehorot" at the rate $0.20 per each cubic meter of water delivered to the agricultural sector.

***The USA***: the water tariffs for municipal and industrial water consumers vary from $40 to $2500 per 1000 m3. At the same time, water tariffs for agricultural water users amount to from $19 to $120 per 1000 m3. As a whole, the government spends about $ 1 billion for supporting the water sector including $500 million of subsidies allocated to the US Bureau of Reclamation. The going public of water rights and sale of water stocks are widespread in the USA in the recent years along with an abrupt growth of their price. The practice of the North Colorado Agricultural Water District in Colorado can be an example. In 1980, one stock that provides the right of eternal receiving one acre-foot of water has cost about $1000; in 1990, its cost has raised up to $15,000; and in 2000, its cost has reached $20,000. At the same time, water prices differ drastically over the states and even over counties.

**Canada:** CAD 5.3 billion38 from the federal and municipal budgets are subsidized into the water sector, including CAD 2.2 billion for O&M and CAD 3.1billion for development and rehabilitation. Water deliveries for irrigation are paid as a constant fee per one hectare in production. Owners of irrigated farmland pay CAD 110 per one hectare in production, on average.

***Spain:*** a payment for urban municipal water supply amounts to $0.75/m3; rural water supply - $0.25/m3; industrial water supply up to $2/m3; and water supply for irrigation from $0.02/m3 to $0.20/m3. Irrigation and rural water supply are subsidized by the government through its participation in maintenance of river basin organizations and through the municipalities.

[38] CAD – Canadian dollar

***Developing countries:*** in accordance with the review jointly prepared by the World Bank and Asian Development Bank, a share of payment for irrigation amounts to only 5% of revenue in Nepal; 6% in Pakistan; 8% in Indonesia; 9% in Thailand; and up to 26% in the Republic of Korea. There is the typical example of China, where while the industrial sector pays from $0.06/m3 to $0.10/m3, the irrigation sector only $0.008/m3 to $0.015/m3 under gravity irrigation and up to $0.02/m3 under pumped irrigation. Chinese economists consider that the payment for water shouldn't exceed 2 to 4% of gross annual revenue.

**At present, the situation in the agricultural sector in Central Asian countries is the following:**

*Two types of payment for water were established in Kazakhstan:*

1. in the form of a tax on each used cubic meter of surface water resources (payment for a resource) - Kaz Tiyna 3.02/m3[39] or $0.00021/m3;
2. in the form of services granted by water management organizations to the agricultural sector – Kaz Tenge 148.65 per 1000 m3 or $0.00105/m3.

*In Kyrgyzstan, the payment for water by agricultural water users is differentiated over seasons: B*

- during the growing season - Kyr Som 30 per 1000 m3 or $0.00069/m3; and
- during the off-vegetation period - Kyr Som 10 per 1000 m3 or $0.00023/m3 (as of 1.01.1999).

**Collected fees cover about 40% of O&M costs and a remaining part is subsidized by the government.**

*In Tajikistan* the payment for 1 $m^3$ supplied to agricultural consumers amounts to Diram 0.6 or $0.00205/$m^3$; for industrial use – Diram 1.2 or $0.00415/$m^3$ (as of 1.01.2004). Expenditures related to pumped irrigation are covered at the expense of budgetary funds - $16/ha, on average.

*In Turkmenistan* the payment for water delivered to industrial enterprises and other water users amounts to Manat 28.8/$m^3$. A coefficient of 1.7 is used in case of lifting water for irrigation. Water for irrigation is free of charge within established limits for water use. Water use in excess of the established limits is paid at the rate of threefold tariff.

Introducing the system of water charges has facilitated reducing volumes of water use by 10% in Kazakhstan, 21% in Kyrkyzstan, and 6% in Tajikistan. The main principles of water charging should be the following:

- incentive water pricing to achieve more efficient water use by water users;
- establishing the free market prices of agricultural output, enabling water users to be capable to pay for water services;
- enhancing the responsibility of water management organization for water delivery to water users in proper volumes and in a timely manner; and
- equipping the irrigation systems with advanced water measurement devices for monitoring flow rates.

[39] The national currency

***The following options and phases of the introduction of water charging are possible:***

- transition towards water charging is implemented simultaneously over the whole country. In this case, the thorough preparation of legal documents and the irrigation network that should be equipped with all necessary off-takes and gauging stations and matching of the prices of major crops (cotton and wheat) with the system of water charges are needed; and
- phased transition towards water charging, employing the block-incremental (tiered) system of water charges.

The backbone of block-incremental system of water charges consists in arranging three blocks of tariffs for water services:

***The first block****:* a tariff for water supply (per 1 m3) according to the rates corresponding to the advanced technology of water use or, in case of irrigation, according to the rates necessary to meet biological needs of crops. This kind of tariffs (the first block) established for agricultural water consumers has to be covered by the government at the first transition stage because of the difficult economic situation of agricultural producers and the existing policy of pricing in the agricultural sector.

***The second block*****:** a higher tariff rate for the amounts of water used in excess of biological needs of crops but within the established limits of water use.

***The third block****:* the highest tariff rate for the amounts of water used in excess of the established limits of water use. Tariffs of this block can be also considered as a penalty for water use exceeding the established limits; and a size of water charges should stimulate water users towards saving water, including the introduction of state-of-the-art irrigation methods. The penalties for unproductive discharges of irrigation water and unauthorized water diversion from the irrigation canals have to be also considered here. The system of penalties for the wasteful way of water use may be effective only when the size of penalty will be “painful” for the water user’s budget. The system of penalties should also cover the issues related to water pollution.

As was mentioned before, in most countries all over the world, the payment for water use is established based on partial or complete reimbursing the operating costs taking into consideration the capability of water users to repay these costs.

## Principles of Establishing Tariffs for Water Services

***Tasks to be solved under transition towards water charging:***

1. Developing the mechanism of financing the water sector and land reclamation projects based on the market principles and parallel establishing the basis for sustainable operation and development of the water sector;
2. Forming the economic relations in the frame of the water sector that create the enabling environment and direct and indirect incentives for saving all resources and reducing unit costs under water governance, O&M and development of water infrastructure; and
3. Water charges as the incentive and priority for saving of water and water resources conservation.

***Pricing of water and land reclamation services***

In the water sector under establishing the mechanism of pricing, it is necessary to differ the following:

- the price of water as a renewable natural resource;
- cost of services related to water delivering and distribution;
- operating costs for O&M of drainage systems;
- costs for both simple and extended reproduction of the water sector and its assets;
- costs for compensation (or prevention) of damage possible under different kinds of water use, especially in the environment sector; and
- difference in costs for land reclamation activity on lands belonging to different natural fertility classes.

### *The pricing factors and the state policy*

Undoubtedly, the natural aridity affects water demand in Central Asian countries. At the same time, the state policy predetermines the tendencies of developing the water sector and hence forming water deficit (or its absence).

The former USSR's policy aimed at developing the irrigated farming to meet the national needs in raw cotton and also the development of the Central Asian region oriented on production of raw materials have resulted in the man-made deficit of water resources, although the integrated development aimed at profound processing the total output of the agricultural sector (as, for example, in Japan or South Korea) would prevent the arising of this deficit. In addition, target investments and the protectionist policy in the water sector (as in the USA and other developed countries all over the world) have created the large-scale water complex consisting of costly engineering irrigation and drainage systems that were not designed to be self-supporting. Most of these systems built in recent years had quite low economic indicators. Hence there are complexities that should be taken into consideration under transition towards water charging, namely: diversity of systems being built over the centuries that at present are rehabilitated and developed, creating the extreme differentiation of production costs and water productivity, as well as causing the complicated consequences of different social and ecological factors.

At that, it is necessary to keep in mind that investments for forming capital assets were made in the different periods (during tsarist and Soviet periods and nowadays in the period of transition towards the market economy).

The introduction of water charges requires pricing of water, which, to a considerable extent, depends on operational costs for O&M of water infrastructure, however, nobody never asked and does not ask now whether water users agree with a price of supplied water or not. Hence, sometimes we face the systems where costs for water supply are higher than the increase in water productivity. However, the government compels the land users to participate in maintaining and developing the irrigation practice to solve social problems related to the employment and supplying foodstuffs to the population.

At present, there are considerable differences in approaches to the problem of financing the water sector in different countries: in Turkmenistan, the government completely finances the national water sector; in Kazakhstan, Kyrgyzstan and Tajikistan, water users cover mainly O&M costs. The position of Uzbekistan is quite cautious for the time being, although water charging was introduced in all economic sectors with the exception of irrigated farming.

**Table 5.38 Financial Input of the Governments and Water Users in O&M of Irrigation Canals, %**

| # | Country | Government | | | | | Water users | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2003 | 2004 | 2005 | 2006 | 2007 | 2003 | 2004 | 2005 | 2006 | 2007 |
| 1 | Kyrgyzstan(Som) | 16 | 25 | 36 | 19 | 45 | 84 | 75 | 64 | 81 | 55 |
| 2 | Tajikistan (Somoni) | | 10 | 11 | 12 | 9 | | 90 | 89 | 88 | 91 |
| 3 | Uzbekistan (Sum) | | 100 | 100 | 100 | 100 | - | - | - | - | - |

Shares of governments and water users in financing O&M of the former inter-farm systems (now the systems that serve several WUAs) are given in Table 5.38. It is obvious that 90% of financing O&M of irrigation systems in Tajikistan is incurred by water users, and as a result, the farms hardly cover these considerable expenditures that amount to 16% of their revenue. In Kyrgyzstan, a share of the government varies from 16% to 45% and cannot provide the sustainability of financing.

***Models of tariffs for water services***

There are three kinds of tariffs for water services:

- volumetric tariff (per cubic meter of delivered water);
- fixed-area tariff (per a hectare under irrigation); and
- combined two-part tariff (per cubic meter of delivered water and per a hectare under irrigation).

The method of volumetric pricing has three options: i) a fixed price that is independent of a volume of water consumption; ii) a subside price that is reducing with the increase in a volume of water consumption; and iii) an incremental price that is rising with the increase in a volume of water consumption. The last option is usually used under conditions of water deficit (California, some regions of India)

One of options of the incremental tariff for water is a penalty for water used in excess of the established limits of water use.

***Factors Conditioning the Pricing***

In principle, there are not considerable divergences in factors of pricing, but some aspects should be kept in mind:

- changes in water availability over years that require establishing the insurance fund;
- it is obligatory to take into account water as a resource under establishing the mechanism of water charging if a task of reproduction of water resources is set or under assessing a new investment project;

- a tariff should take into account depreciation in case of simple reproduction (it is necessary to keep in mind that sometimes under the current economic policy the depreciation rates are erroneously underestimated resulting in depreciation of the water sector's assets);
- assessment of repairing costs under calculating tariffs should be made according to the norms rather than actual data (it is necessary to keep in mind that the policy of pricing on the basis of the reached level is always fraught with deteriorating the existing status of O&M); and
- assessment of normative profit.

Analysis of changes in annual water availability is based on evaluating the variability of water availability from year to year under relatively stable water demand in both the agricultural sector and other economic sectors. Under establishing tariffs for water delivery, calculating the cost of water delivery is made for a year with the 50% water availability. Therefore, a cost of water delivery will be different in years with different water availability. For example, in years with 75%, 90%, and 95% water availability, a cost of water delivery will be higher because a volume of water supply will be lesser and a level of conditionally-constant flow rates will not change with the alteration of water supply volumes.

To provide the sustainability of the water sector it is necessary to take into account this factor in the price model in the form of the insurance fund. A size of the insurance fund is computed according to the following procedure: a sum of conditionally-constant costs per 1 m3 of water supplied at off-takes is calculated and then multiplied by a value of the deficiency in water supply in a dry year in comparing with a year with mean annual water availability.

As known, under conditions of budgetary financing of the water sector, depreciation charges on capital assets were not being assigned. Under water charging and the need in reproduction of capital assets due to the self-repayment of costs, depreciation charges on capital assets are assigned. However, prior to specifying depreciation charges, it is necessary to receive evidence that the cost of capital assets corresponds to its real value. This can be done by means of reappraising capital assets.

In Kyrgyzstan the water management organizations have assumed 8% of water services costs as a scheduled profit under establishing tariffs. Prior to transition towards water charging this value of the scheduled profit can be accepted.

Without sufficient justification many specialists propose to assume a scheduled profit as 12% of costs of production. However, any percentage of a scheduled profit with respect to a production cost of water services will be disputable if to proceed from the assumption that the extended reproduction of irrigation and drainage assets will be provided at the expense of sectoral incomes. A high capital intensity of construction of new waterworks and water reservoirs, development of virgin lands, and rehabilitation of irrigation and drainage systems all over the world has forced the governments to subsidize the water sector even under conditions of developed infrastructure and high productivity.

***Pricing for water services should base on optimal satisfaction of requirements inherent in transition towards water charges:***

- a paying capacity of water users;
- stimulating of the public perception of water resources and water infrastructure as personal property, as well as of the responsibility for their sustainable development; and
- enabling environment for introducing the market mechanisms.

Pricing for water services should also base on the fact that a normal price provides for the "normal water quality." If a water quality does not meet primary standards, water price should be reduced. Under certain conditions it is necessary to pay "incentive bonuses" to water consumers for using brackish water i.e. drainage water, water abstracted from drainage tube-wells etc.

As yet, *three hierarchical levels can be distinguished in the framework of water management organizations.*

**Level I** – the inter-republican level: Basin Water Organizations (BWO) “Syr Darya” and “Amu Darya” that assess water resources forming within the basins and distribute them among consumers in the aggregated manner (for different economic sectors) through republican and provincial water authorities. Expenditures at this level can be referred to the category of water charge “payment for a resource”, and have not to be taken into account in tariffs for water services being granted to water users.

**Level II** – the national level: water allocation to provincial water authorities taking into account local water sources. Under establishing differentiated tariffs for each province, expenditures related to water services are aggregated in the manner that allows referring part of expenditures incurred at the inter-provincial level to the municipal budget in proportion to water volumes diverted by this province.

**Level III –** the level of intra-basin systems and canals where the finite output of the national economic sectors is produced under using services on conveying and distribution of water, land reclamation and repairing water infrastructure.

**Models of tariffs for water services** can be presented as follows.

*For non-agricultural water users, a water price ($S_{nau}$) can be computed using the following formula:*

$$S_{nau} = \frac{\sum U_w + \sum C_f + \sum P_p}{W_{tlwu}} + P \text{, Sum/m}^3, \qquad (5.1)$$

where:

| | |
|---|---|
| $\sum U_w$ | = total annual operational costs of the water sector related to water supply, Sum; |
| $\sum C_f$ | = insurance fund, Sum; |
| $\sum P_p$ | = profit per water volume supplied, Sum; |
| $W_{tlwu}$ | = total limit of water use, m3; |
| P | = amount for extended reproduction per 1m3, Sum/m3. |

The total annual operational costs of water management organizations ($U_w$) related to water supply are made up of costs at all existing hierarchical levels and represent the sum of annual costs including a salary of personnel, social insurance tax and unemployment insurance tax, expenditures related to network cleaning, power supply, depreciation charges on capital assets (for full replacement), a sum of capital and running repairs, transportation costs and other expenditures.

*A one-part (volumetric) tariff for agricultural water users ($S_{ir}$) can be computed using the following formula:*

$$S_{ir} = \frac{\left(\sum U_w + \sum Cf\right) * K_{li} + \sum U_{lr} + \sum P_{wu}}{W_{ILW}}, \text{ Sum/m}^3, \qquad (5.2)$$

where:

| | |
|---|---|
| $K_{lr}$ | = share of the limit for irrigation that equals to the ratio of $W_{lwi}$/ $W_{lio;}$ |
| $\sum U_w$ | = total annual costs of the water sector, Sums; |
| $W_{lwi}$ | = limit of water withdrawal for irrigation, $m^3$; |
| $\sum U_M$ | = total annual costs of water management organizations for ameliorative works, Sums; |
| $\sum P_{wu}$ | = normative profit of agricultural water users, Sums; |
| $W_{lio}$ | = limit for irrigation at off-takes of water users, $m^3$. |

Models of tariffs for water services being granted to different water users can be considered according to different options.

*Let us consider a two-part tariff for agricultural water users. The first part represents a payment for each hectare under irrigation, and the second part is a payment for each cubic meter of water delivered.*

*The first part* includes only costs related to land reclamation constituent with an appropriate share of profit; and *the second part* represents all other price-forming constituents with an appropriate share of profit.

***I. Formula for computing a payment for each hectare under irrigation:***

$$S_{ha} = \frac{\sum C_{lr} + \sum P_{lr}}{\omega}, \text{ Sum/ha}, \qquad (5.3)$$

where:

| | |
|---|---|
| $\sum C_{lr}$ | = total costs related to land reclamation constituent (a prime cost); |
| $\sum P_{lr}$ | = profit related to land reclamation constituent; |
| $\omega$ | = irrigated area, ha |

***II. Formula for computing a payment for each cubic meter of water delivered:***

$$S_{m^3} = \frac{(\sum O + \sum C_f) * K_{ir} + \sum P}{W_{wli}}, \text{ Sum/m}^3, \qquad (5.4)$$

where:

| | |
|---|---|
| ∑Oв | = total operational costs related to water supply, Sum; |
| ∑Cф | = insurance fund related to water supply, Sum; |
| Kпр | = share of the limit for irrigation; |
| ∑P | = profit related to water supply, Sum; |
| $W_{wli}$ | = amount of water limit for irrigation, $m^3$. |

Reimbursement of costs related to water supply to consumers can be provided according to the following proposed way. Covering costs by agricultural water users should be linked with the opportunity to sell their output at free market prices. In addition, agricultural water users should have the opportunity to cover their costs related to irrigation water supply and land reclamation activity at the expense of their incomes being gained under conditions of the financial sustainability.

The case study of the SFC demonstrates the results of establishing tariffs for water services using the proposed models for two options. According to undertaken assessment for the SFC command area, a water price under computing according to the one-part tariff model amounts to 6.65 Sum/m3 ($0.0051/$m^3$); and under computing according to the two-part tariff model, the first part (*a payment for each hectare under irrigation*) amounts to 4,984 Sum/ha and the second part (*a payment for each cubic meter of water delivered*) makes up 5.98 Sum/ha. In the case when the crop water requirement amounts to 7,500 $m^3$/ha, the costs related to irrigation water supply per unit area (ha) makes up $38.25/ha (7.500 $m^3$/ha * $0.0051/$m^3$).

**Table 5. 39**

**Computing the Tariffs for Irrigation Water Supply and Land Reclamation Works for the SFC Command Area**

| No | Indicator | Unit | Amount | Design formula, notes |
|---|---|---|---|---|
| 1 | Irrigated area served by the SFC | 000' ha | 85.5 | |
| 2 | Total annual limit of water supply (in a year with mean annual water | mln.$m^3$ | 841.06 | $W_{tot} = W_o + W_{industry}$ |

| No | Indicator | Unit | Amount | Design formula, notes |
|---|---|---|---|---|
| | availability) | | | |
| | including: water for irrigation | mln.m$^3$ | 641.06 | $W_o$ - volumes of water for irrigation according to established limits for water use |
| | water for industrial needs | mln.m$^3$ | 200.0 | $W_{industry}$ - volumes of water for industrial needs according to established limits for water use |
| 3 | Share of irrigation water supply | – | 0.762 | $K_{ws} = \frac{W_o}{W_{tot}}$ |
| 4 | Capital assets in the SFC system without drainage facilities | mln.Sum | 24,657.7 | Shares of the BISAs “Syr Darya-Sokh” and “Naryn-Karadarya” BDSA for the FV, Andijan Reservoir, PSA of Fergana and Andijan provinces |
| 5 | Capital assets of drainage systems in the SFC command area | mln.Sum | 1,165.6 | Share of PHAE in Fergana and Andijan provinces |
| 6 | Total capital assets of irrigation and drainage systems in the SFC command area | mln.Sum | 25,823.3 | P.4 + P.5 |
| 7 | Total costs of the irrigation sector (TCIS), including: | mln.Sum | 4,247.7 | $TCIS = OC + DC_M = 2768.2 + 1479.5$ |
| | operational costs | mln.Sum | 2,768.2 | |
| | depreciation charges | mln.Sum | 1,479.5 | $DC_M = 24657.7 * 0.06 = 1479.5$ |
| 8 | Total costs of the drainage sector (TCDS), including: | mln.Sum | 394.54 | Share of PHAE in Fergana and Andijan provinces |

| No | Indicator | Unit | Amount | Design formula, notes |
|---|---|---|---|---|
| | operational costs | mln.Sum | 324.6 | |
| | depreciation charges | mln.Sum | 69.94 | DC = 1165.6 * 0.06 = 69.94 |
| 9 | Conditionally -variable costs of the water sector in the SFC command area | mln.Sum | 1276.16 | CVC = power + cleaning = 1217.76 + 58.4 = 1276.6 |
| 10 | Conditionally -constant costs of the water sector in the SFC command area | mln.Sum | 2,971.54 | P.7 – P.9 = 4247.7 – 1276.16 = 2971.54 |
| 11 | Insurance fund | mln.Sum | 445.73 | IF = P.10 * 0.15 = 2971.54 * 0.15 = 445.73 |
| | including a share of irrigation systems | mln.Sum | 399.64 | $SI_o$ = 445.73 * 0.762 = 339.64 |
| 12 | Profit related to the irrigation constituent | mln.Sum | 258.94 | Pi = P7 * 0.762 * 0.08 = 4247.7 * 0.762 * 0.08 = 258.94 |
| 13 | Profit related to the land reclamation constituent | mln.Sum | 31.56 | P.8 * 0,08 = 394,54 * 0,08 = 31,56 |
| 14 | Costs of the land reclamation constituent taking into account the profit | mln.Sum | 426.1 | P.8 + P.13 = 394.54 + 31.56 = 426.1 |
| | ***Water tariffs*** | | | |
| 15 | **One-part tariff for irrigation and land** | Sum/m$^3$ | 6.65 | $S_{ir} = \frac{(\sum U_w + \sum Cf) * K_{li} + \sum U_{lr} + \sum P_{wu}}{W_{ILW}}$ |

| No | Indicator | Unit | Amount | Design formula, notes |
|---|---|---|---|---|
| | **reclamation** | | | $S_{ir} = \frac{(4247.7 + 445.73) * 0.762 + 426.1 + 258.94}{641.06} = 6.65$ |
| 16 | **Two-part tariff for irrigation and land reclamation:** | | | |
| | - a tariff part that reflects a payment for each hectare under irrigation | Sum/ha | 4,984 | $S_{ha} = \frac{\sum C + \sum P_{lr}}{W_o} = \frac{394.54 + 31.56}{85.5} = 4984$ |
| | - a tariff part that reflects a payment for each cubic meter of water delivered | Sum/m$^3$ | 5.98 | $S_{m^3} = \frac{(\sum O + \sum C_f) * K_{ir} + \sum P}{W_{wli}}$ <br> $S_{m^3} = \frac{(4247.7 + 445.73) * 0.762 + 258.94}{641.06} = 5.98$ |

In respect of reimbursing the expenditures related to water supply of consumers the following can be proposed:

Covering costs by agricultural water users should be linked with the opportunity to sell their output at free market prices. In addition, agricultural water users should have the opportunity to cover their costs related to irrigation water supply and land reclamation activity at the expense of their incomes being gained under conditions of the financial sustainability. The international practice shows that water fee usually makes up 5% of gained profit.

Let us review the potential of private farms that grow different crops to pay for water under the conditions of irrigated farming in the SFC command area and the assumption that water fee makes up 5% of profit. Data on the crop profitability and capabilities of the private farms in the SFC command area to pay for water under average and maximum crop profitability are given in Table 5.40.

**Table 5.40**

**Assessing the Capability of the Private Farms in the SFC Command Area to Pay for Water**

| No | Crop | Crop profitability, $/ha | | Water fee, $/ha | Capability to pay, $/ha | |
|---|---|---|---|---|---|---|
| | | Average | Maximum | | Average | Maximum |
| 1 | Cotton | 150 | 420 | 38.25 | 7.5 | 21 |

| No | Crop | Crop profitability, $/ha | | Water fee, $/ha | Capability to pay, $/ha | |
|---|---|---|---|---|---|---|
| | | Average | Maximum | | Average | Maximum |
| 2 | Cereal crop | 160 | 500 | 38.25 | 8.0 | 25 |
| 3 | Orchards | 700 | 1200 | 38.25 | 35 | 60 |
| 4 | Vineyard | 1510 | 2200 | 38.25 | 75.5 | 110 |

The table shows that the capability to pay for water at the rate of $38.25/ha occurs under average profitability of orchards and vineyards when 5% of profit make up from $35/ha to $60/ha and from $75.5/ha to $110/ha respectively.

Now let us consider the expenditures of the pilot WUAs (the IWRM-Fergana Project) and profitability of farms serviced by these WUAs (Table 5.41).

**Table 5. 41**

**Trends of Costs per Unit Area in WUAs and Farmers' Profits (2003 to 2006), $/ha**

| Indicator | Year | | | |
|---|---|---|---|---|
| | **2003** | **2004** | **2005** | **2006** |
| ***Uzbekistan*** | | | | |
| WUA expenditures | 3.2 | 3.3 | 4.3 | 4.7 |
| Farming's profitability | 48.6 | 48.4 | 88.3 | 107 |
| WUA expenditures as percentage of profit, % | 6.6 | 6.8 | 4.9 | 6.3 |
| ***Kyrgyzstan*** | | | | |
| WUA expenditures | 2.14 | 2.44 | 8.95 | 2.83 |
| Farming's profitability | 365.2 | 401.0 | 302.4 | 288.5 |
| WUA expenditures as percentage of profit, % | 0.6 | 0.7 | 2.95 | 1.0 |
| ***Tajikistan*** | | | | |
| WUA expenditures | 3.5 | 2.13 | 3.43 | 4.49 |
| Farming's profitability | 207.4 | 32.9 | 106.8 | 27.2 |
| WUA expenditures as percentage of profit, % | 1.7 | 6.5 | 3.2 | 16.5 |

As shown, in Uzbekistan, farmers pay for WUA's services up to 5 to 7% of net profit; and according to the world experience this is quite realistic. In Kyrgyzstan, the overall payment of water users to WUAs and WMOs amounts to 5 to 6% of net profit, and this is also rather reasonable. There are absolutely unrealistic payments in Tajikistan (fees collected by WUAs have reached 15% of farms' net profit). However, this payment percentage from net profit is a result of low average revenues of farms serviced by WUAs – 100 to 200 $/ha (only in Kyrgyzstan – 300 to 400 $/ha).

Average and maximum water productivity that was reached on project demonstration fields (Table 5.25) shows that it can be risen without special investments only due to implementing good agricultural practice (the increase in productivity of cotton and wheat almost two times, and correspondingly the growth of net profit up to 420 to 500 $/ha). This means that an average acceptable fee for services of WUAs and WMOs can be at the level of 21 to 25 $/ha in the case of a fee at the rate of 5% from gained profit. A higher fee is possible if the same approach is employed for orchards and vineyards. Here, an acceptable size of fees can be increased up to 60 to 110 $/ha.

***What conclusions can be done based on this analysis?***

- The government should fix the limiting fee for services of WUAs and WMOs at the rate of 5% of net profit. This fee of farmers, first of all, covers the WUAs' operational costs;
- The government should encourage farmers in every possible way in order to reach higher productivity and profit, and for this purpose to finance O&M of inter-farm water infrastructure providing sustainable agricultural production. In line with the growth of irrigated farmland productivity and profit, the government will start to reduce its share of financing; and
- WMOs have to conclude the agreements with WUAs, and the latter with farmers, which should include the provisions with strict requirements to provide the compliance with the irrigation schedules.

## Creating material incentives for water management organizations and water users associations

Matters of creating material incentives for water management organizations (WMOs) and WUAs are quite topical, keeping in mind that water is scarce natural resource. At that, supplying of water to water users in proper time and in proper volumes with appropriate quality requires considerable investments and operational costs. As was mentioned, water supply for irrigation of one hectare in the SFC command area requires about 40 $/ha only for running costs.

***What measures should be stimulated?***

1. Encouraging the water-saving practice, first of all, in WUAs and private farms should be considered as the most important issue. For this purpose, the special funds ("Water-Saving Fund") should be established in the framework of WMOs and WUAs. Inpayments due to use of water in excess of the allowed maximum should be deposited into this fund in the WMO, and then water users who saved a part of water supplied according to the limits of water use should receive a bonus at the expense of this fund, i.e. the WMO transmits money to the WUA's account to give this bonus that is equivalent to payment for unused water volumes according to established tariffs.
2. As far as the reclamation of irrigated farmland is one of major factors of the increase in water and land productivity, it is necessary to encourage personnel of WUAs and the Hydro-Ameliorative Expedition to improve soil and hydrogeological conditions in farms serviced by WUAs for enhancing the crop productivity. Incentive criteria should be agreed with farmers and WUAs, for example, such criteria as shifting irrigation lands from the category of heavy and medium saline lands into the category of slightly and non-saline lands; lowering watertable and the level of groundwater salt content; improvements in drainage network operation; and rise of crop yields.
3. Well-organized service of water users by WUAs can be characterized by uniform water distribution over private farms in accordance with the established irrigation schedule. Such

services promote reducing the number of disputes and conflicts between WUAs and water users and between WUAs and WMOs, and hence WUA personnel also needed to be encouraged.

4. Personnel of WUAs and WMOs should be encouraged both in the case of implementation of planned scopes of repairing works in full and in the case of reducing operational costs.
5. Incentives are also necessary under implementing other measures: i) saving water due to improving organizational and technical efficiency of irrigation canals serviced by WUAs and WMOs; ii) introduction of efficient technologies of water distribution between WUAs and water users; iii) improving of water availability of the irrigation schemes at the expense of use internal water resources, etc.

## Economic incentives for water saving in Central Asia

**(N. Mirzaev.)**

It is clear that one of causes of water deficit in Central Asia is the growth of water demand; and naturally reducing water demand facilitates water problems resolution. *Institutional measures,* including specially developed systems of regulations and incentives are used in the frame of demand management. The systems of regulations and incentives affect individual behavior of people forcing them to do those things which otherwise they would never do. These systems have different forms. One of them is a financial influence that envisages *"compulsion"* by means of payment for water services and penalties for water use in excess of the established limits and *"incentive"* through the right to sell saved irrigation water at market prices to other water users etc.

Only *penalties,* although with low effect, are active under the centralized water governance. Numerous unsuccessful efforts to introduce the *water charge principles* in the Soviet period have shown that it is difficult to provide successful reforms in the water sector without reforming the agricultural sector as a whole by means of transition towards market relations in rural areas.

After independence, Central Asian countries try to reform their economy, including water and agricultural sectors. Matters of saving water become more and more *economically important matters* in the course of reforming water and agricultural sectors. Since, under transition towards market relations, a major target of water users is a maximum income rather than a maximum possible crop yield at any cost (as in the Soviet time), water users are interested in water-saving methods in that extent in which they are profitable for water users under existing natural and economic conditions. Therefore, transition towards the decentralized methods of management, in particular in the water sector, as a rule, is accompanied by the introduction of water charges and granting the right to sell saved irrigation water that are the most important instruments for improving management of water use and water conservation.

At present, all Central Asian countries consider it necessary to introduce water charging, however, since the strategies of market reforms are different, the water charging system is operative only in three of five Central Asian countries.

Water use based on water services for a fee is not practiced in the agricultural sector in Uzbekistan and Turkmenistan. At present, the cost of water services is taken into account in the form of the water tax that is included in the land tax in Uzbekistan. In Kyrgyzstan and Kazakhstan, reforms were initiated during the period of 1992 to 1994 by introducing water charging.

Further, in 1995 to 1996, after issuing the appropriate decrees by Presidents, the mass privatization of land through its free of charge distribution was started. In Tajikistan, water charging was introduced later than in neighboring countries in 1996. In Tajikistan, liberalization of prices on agricultural output took place also later than in Kyrgyzstan and Kazakhstan after issuing the Decree of the President of the Republic of Tajikistan "On the Provision of Rights for Land Use" in 1998.

It is impossible to say definitely that the introduction of water charging has substantially increased the efficiency of water use in Central Asian countries but certain positive results and trends are already observed.

Effects of the introduction of water charging in Kyrgyzstan are the following (according to expert appraisal):

- Reducing water consumption;
- Reducing areas with pumped irrigation;
- Changes in the crop pattern (a share of crops that need less water has increased – cereal crops, tobacco, sunflower);
- Soil and hydrological conditions have become worse over the whole area insignificantly, but in some places they were even improved due to reducing water supply.

The above said about the introduction of water charging in Kyrgyzstan, although in the lesser extent, is true also for Tajikistan. With respect to Kazakhstan, it is still early to speak about positive affects of the introduction of water charging, but its necessity is beyond doubts.

The experience of economic stimulating of the rational water use in Central Asian countries shows that the introduction of water charging is the condition *necessary* but *insufficient* for improving the efficiency of water use. Additional conditions for improving the efficiency of water use are the following:

- Adequate water measurement and accounting, especially at the "bottom" level of water distribution. However, the all-out privatization of land in Kyrgyzstan and Kazakhstan has resulted in abrupt rise of the number of private and dekhkan farms (PFs and DFs), caused problems in establishing the adequate water measurement and accounting systems at the on-farm level and reduced the effect of introducing water charging.
- The financial sustainability of PFs that pay for water services of WUAs and WMOs (Canal Administration and District Water Authorities). Liberalization of the agricultural sector and strengthening the financial status of water users should precede the introduction of charging for water services. In practice, as shown above, the reverse sequence of reforms in Central Asian countries has led to incapacity of numerous water users to pay for water services of WUAs and WMOs. The financial inability of water users has resulted from the inability of authorities not only to support them but also to protect them from resellers under selling agricultural output.
- A proportionality of water tariffs and penalties to operational costs and damages due to infringement of the water discipline[40]. A tariff policy should promote water saving and improve collecting fees for water services both at the level of main canals and at the level of WUAs.

This publication deals with problems of improving the tariff policy and was prepared on the basis of analyzing data collected under implementing the IWRM-Fergana Project. The project covers the pilot main irrigation canals in the Fergana Valley: the SFC (Uzbekistan), AAC (Kyrgyzstan), and KBC (Tajikistan), as well as WUAs in the command areas of these pilot canals.

## The fee collection rates for water services

***Two kinds of water services are considered in this publication:***

- services related to water delivery by the Canal Administration to WUAs; and
- services related to water delivery by WUAs to farmers.

[40] The fact is that too low or high tariffs for water services and penalties cannot act as factors facilitating water saving

In the first case, a water supplier (WS) is the Canal Administration (CA), and in the second case –WUAs. At the same time, in the first case a WUA is a water user (WU), and in the second case – a private farm. However, it is necessary to keep in mind that the end water user that pays for services of the CA and a WUA is a private farm; and a WS's future depends on its financial status.

Diagrams that are presented in Figures 5.39 to 5.42 show that although the fee collection rate for water services is increasing from year to year in the command areas of the KBC and AAC where water charging was put in practice, however, the growth rates of fee collection are quite low due to the difficult financial situation in WUAs and adversely affect the financial status of the CA and correspondingly the quality of O&M.

One of the reasons of low growth rates of fee collection for water services (if to set aside the reasons related to the policy of transition towards the market relations in the water sector and the procedure for writing off WUAs' debts) is the fact that the computing method of tariffs for water delivery need to be improved.

Water users served by the KBC Administration (WUAs) don't hurry to pay as well because from time to time rumors about writing off of their debts that were "fastened" under restructuring the collective farms (on their territory WUAs were established) are being widespread among water users. In 2004, for example, all debts as of January 1, 2003 were written off. Writing off is a positive process, but the adverse fact is that, as a rule, among "winners" those who never paid. The collective farm that had only a 10% debt has lost. It comes to ridiculous things, after writing off of water users' debts the District Water Authorities became the debtor of non-payers.

Payment for services should be made on the monthly basis. The agreement envisages a penalty at the rate of one percent per each overdue day, but no more than 100%. This provision, as a rule, fails. A prepayment should amount to 40% but this provision, with the rare exceptions, are not also implemented[41]. Water users, first of all, pay to the District Water Authorities that provide pumped water supply and according to the leftover principle to the KBC Administration. There is the following explaining of this fact: water users understand that without timely payments the District Water Authorities will not be able to repair pump units, affecting water supply immediately and adversely.

The agreement on irrigation water supply at the rate of 90% from the planned irrigation water supply is signed by the KBC Administration and water users (WUAs). There are two types of agreements that are signed depending on whether water users have investors (mediators) or not (most of water users have investors signing the futures agreements with them). Since 2007, if water users have the investor, the trilateral agreement (the KBC Administration - a water user - an investor) is signed. The agreement with an investor is concluded on water supply only for irrigation of cotton, at the same time, water users pay for water supply for irrigation of other crops. Specialists consider that there is some effect due to the trilateral agreement but insignificant.

The fact is the financial status of water users having investors is worsening from year to year, because these investors (mediators) mainly use the barter payment system (supplying fuel, fertilizers, etc., at that, at high prices) instead of the mutual settlement in cash. Therefore, in Tajikistan, the decision was made (Resolution No 10/13-3 issued by the Government) to finance farmers through the banks (preferential micro-credits). At present, transition towards the new system of financing is in progress.

*(Sources: the minutes of KBC WC's meeting of 23.04.2008)*

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[41] Penalty per each overdue day is provided for but there are not incentives for prepayment.

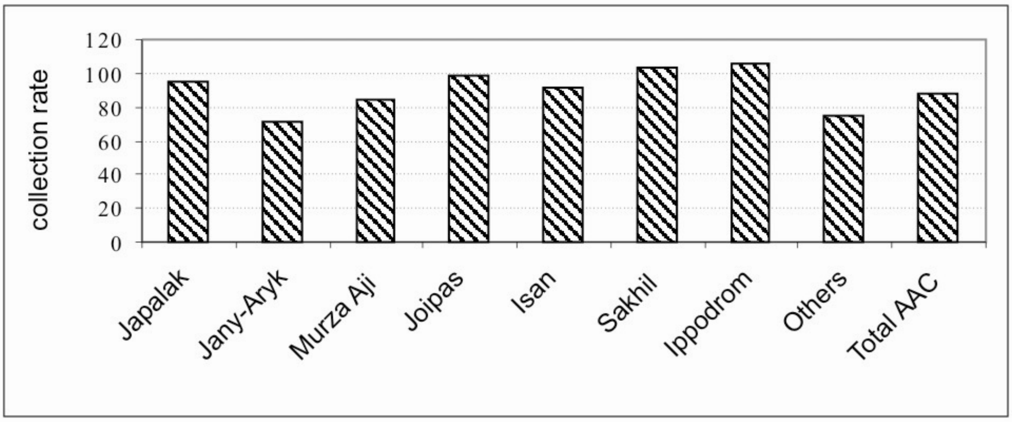


**Figure 5.39 A Fee Collection Rate in the AAC Administration and WUAs (the progressive total over the period of 2003 to 2007)**

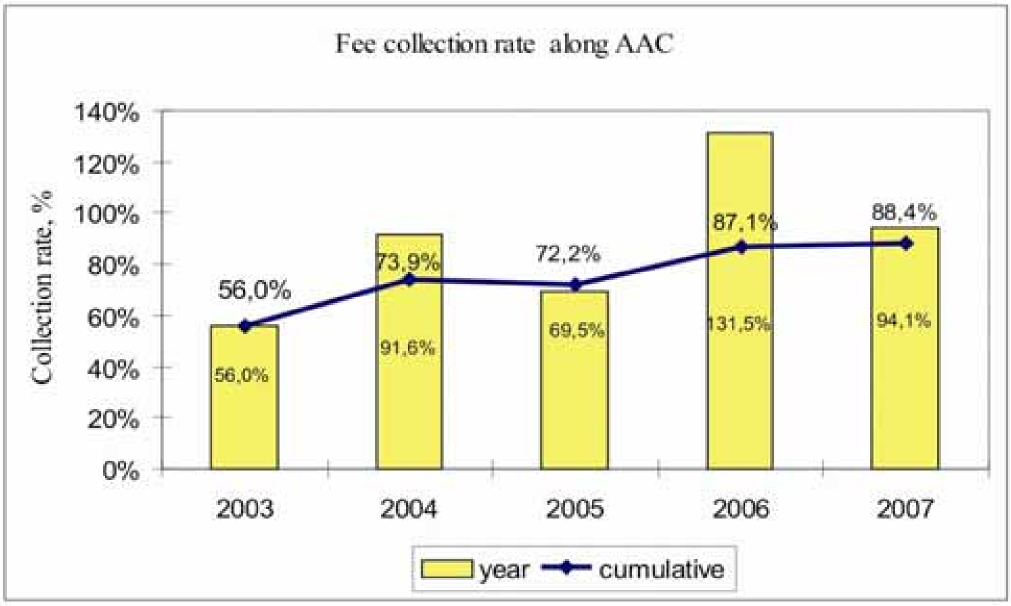


**Figure 5.40 A fee collection rate in the AAC Administration over years**

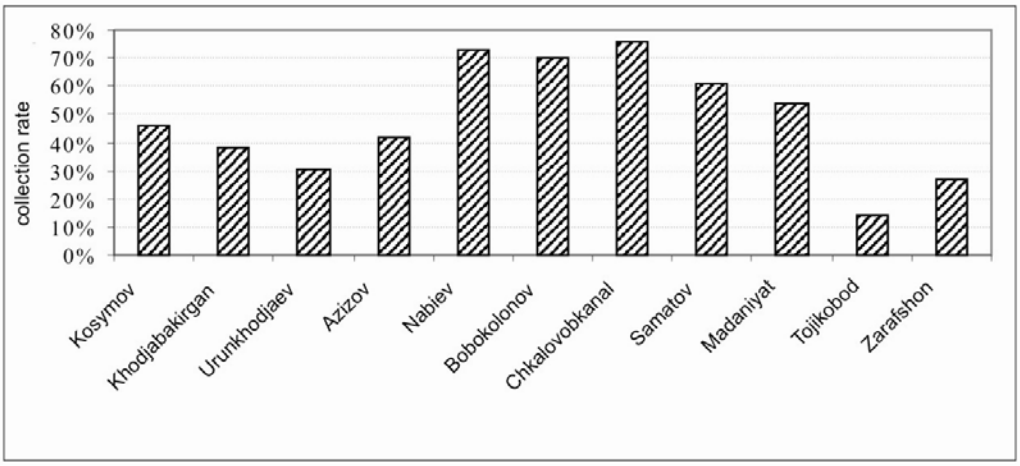


**Figure 5.41 A Fee Collection Rate in the KBC Administration and Water Users (the progressive total over the period of 2004 to 2007)**

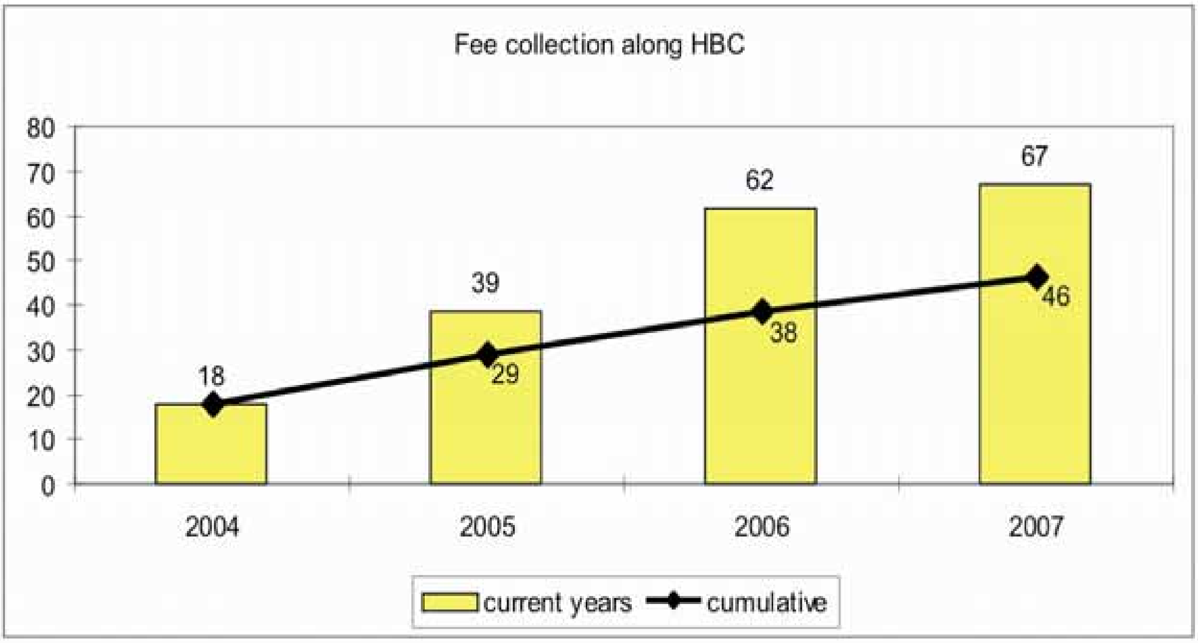


**Figure 5.42 A Fee Collection Rate in the KBC Administration over Years**

## The methodology of adjusting water tariffs

**Table 5.42 Tariffs for water services (per 1000 $m^3$ )[42]**

| Country | Tariff | | Exchange rate |
|---|---|---|---|
| | National currency | US$ | |
| Kyrgyzstan, Som | | | |
| Growing season | 30[43] | 0.82 | 36.4 |
| Off-vegetation period | 10 | 0.27 | 36.4 |
| Tajikistan, Somoni[44] | | | |
| Water supply by gravity | 7.8 | 2.27 | 3.43 |
| Pumped water supply[45] | 12.5 | 3.64 | |

[42] As of April 2008
[43] Tariff - 3 tiyin per 1m3 (plus 1 tiyin as the VAT) does not cover operational costs of the AAC Administration. In specialists' opinion, a tariff should be increased twice
[44] Tariffs as of 10.06.2007 without VAT at the rate of 20%. Water management organizations were not included into the list of organizations that were exempted from VAT. In principle, the matter of the VAT correctness regarding water services should be discussed.
[45] In Israel, tariffs were also differentiated depending on types of water supply (by gravity or pumped). However, that what is acceptable for the country with developed market economy may be unacceptable for Central Asian countries

**Analysis shows that tariffs in Central Asian countries differ by:**

1. a rate (the highest tariffs in Tajikistan)[46];
2. seasons (a growing season and off-vegetation period):
   i. The differentiated approach under which tariffs in the off-vegetation period three times lower than during the growing season was employed in Kyrgyzstan;
   ii. The single tariff that does not depend on seasons was established in Tajikistan (local specialists consider that the differentiated approach is more rational since it encourages water users to conduct water applications for land preparation during the off-vegetation period);
3. type of water supply:
   i. by gravity;
   ii. pumped;
4. procedures for developing and approval of tariffs. Tariffs are approved by:
   i. the Parliament (the Jogorku Kenesh) in Kyrgyzstan;
   ii. the Government (the Ministry of Economy) in Tajikistan.

The existing normative tariffs, as shown above, do not take into account the market principles and, as a rule, do not stimulate the growth rates of fee collection for water services. Hence, the water suppliers, for example, the Canal Administration suffer from shortage of water and water saving; and, at the same time, it is not advantageous for water users to pay for water services in timely manner and, all the more, to make prepayment.

Therefore, the following approach of adjusting tariffs for water services was proposed.[47]

**In general, the formula for computing a tariff can be presented as follows:**

$$T_r = T_p * K \,. \tag{5.5}$$

*where*

$T_r$ = the calculated tariff for water services (hereinafter referred to as “tariff”)

$T_p$ = normative (base) tariff

$K$ = overall adjustment factor

$$K = \frac{K_f}{K_l * K_s * K_t}\,. \tag{5.6}$$

*where*

$K_f$ = factor of water users’ water availability relative to limited water supply (hereinafter referred to as “limit”)

$K_l$ = limit factor

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[46] According to the world practice, the realistic level of water charges is about US$ 30 to 60/ha.

[47] It is necessary to stress that the rates of normative tariffs for water services under computing of which the profitability of water users and their readiness to pay should be considered are not discussed in this publication.

$K_s$ = factor of collecting fees for water services (hereinafter referred to as "fee collection rate factor)

$K_t$ = factor of timely charges for water services (hereinafter referred to as "a timeliness factor")

***1. Computing the limit factor (to take into account water availability of current year)***

$$K_l = \frac{W_l}{W_p}. \tag{5.7}$$

*where*

$W_l$ = limit of water use[48] for the current season

$W_p$ = planned water supply to water users for the current season

***2. Computing the factor of water availability (to take into account actual water supply)[49]***

If to follow the proportionality principle (actual water supplies during ten-day periods are proportional to the limit water supplies):

$$K_f = \frac{W_f}{W_l}. \tag{5.8}$$

If the proportionality principle was not observed (understated or overstated water use relative to limits take place):

$$K_f = \frac{\sum_{d=1}^{m}\left(K_d^f * W_{fd}\right)}{W_f}. \tag{5.9}$$

*where*

$K_d^f =$ actual water availability relative to the limit in d-ten-day period

$$K_d^f = \frac{W_{fd}}{W_{ld}}. \tag{5.10}$$

*where*

**d** = index of a ten-day period

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48 Limits of water supply for the growing season for irrigation systems, provinces etc. are formally established only in Uzbekistan since limited water use are employed here. In dry years, limits are also established in other countries. The term "limit" is traditionally used, although it is more correct to use the term "quota" that means the right for water.

49 Actual water supply should be taken into account under establishing tariffs for water services, for example in Israel where the cost of 1 m3 equals to $0.60 if actual water supply is less than planned volumes by 50% then tariff equals $0.14 (less by 77%) and if actual water supply is higher by 50% then tariff equals $0.30 (i.e. less by 50%).

m = number of ten-day periods over the period under consideration (in the case of the growing season **m** = 18)

$W_{fd}$ = actual water supplies during a ten-day period

$W_{ld}$ = limited ten-day period water supplies

### *3. Computing the fee collection rate factor*

$$K_s = \frac{P_f}{P_p}. \qquad (5.11)$$

*where*

$K_s$ = the fee collection rate factor

$P_p$, $P_f$, = planned and actual amounts of collected fees for water services over the design period

$$P_p = T_p * W_f \qquad (5.12)$$

### *4. Computing the timeliness factor*

$$K_t = \frac{100 + F * R}{100}. \qquad (5.13)$$

*where*

*F* = a difference between the established and actual date of the payment for water services. For example, a date within the first ten-day period after ending the settlement month, i.e. from 1st to 10$^{th}$ day of each month can be considered as an established date.

**For example:**

- If a payment was made within established terms then *F*=0; and the tariff for the period under consideration (month) is not adjusted and equals to the normative tariff. If a payment for services granted in May was done before the established term, for example, on 25 May (prepayment) then *F*=+5 days (with the sign "+")
- If a payment for services granted in May was done after the established term, for example, on 15 June then *F* =-5 days (with the sign "-")

*R* = coefficient of adjusting daily tariff (in %) that depends on an actual date of payment (prepayment or delayed payment). Its value can be reasonably established taking into account the real situation, for example, from 0.5% to 1.5%.

## Examples of computations

*Example 1*

***Let us assume the following:***

- $K_s$=$K_t$=1, i.e. water users pay for water services in full and timely;
- planned water supply ($W_p$) by a supplier to water users during the growing season amounts to 20 mln. $m^3$;
- different options of limited water supply (even such unlikely but possible option in principle when the limited water supplies are greater than the planned ones) are simulated;
- the principle of proportional readjustment of actual water supply over a ten-day period against limited water supply is observed.

Computing of tariffs is given in Figure 5.43 and Table 5.42. It is obvious that:

a) if $W_f = W_l = W_p$ then the calculated tariff equals to the normative one.

b) if $W_f = W_p$ and variable $W_l$ :

- with decreasing $W_l$ against $W_p$, the calculated tariff increases against the normative one, and vice versa when $W_l$ exceeds $W_p$, the calculated tariff becomes lower than the normative one. Thus:
- The less amount of water resources (dry year) the higher tariffs; this approach corresponds to the market principles, and at that water suppliers do not suffer from water resources deficit, but water users need to employ water-saving measures: reducing the cropped areas; decreasing the land use intensity, exclusion of water-loving crops from the crop pattern (rice, onion etc.), use of shorter furrows, increase in the number of irrigators, introduction of new technologies etc.
- The greater amount of water resources, the lower tariffs; at that water suppliers do not have unearned profit due to the abundance of water, and water users have the opportunity to apply additional kinds of irrigation (water applications for soil leaching, water application for land preparation, irrigations to trigger germination), to increase a share of water-loving crops and the land use intensity etc.

c) If $W_l = W_p$ and variable $W_f$:

- With decreasing $W_f$ against $W_p$, the calculated tariff decreases against the normative one, and vice versa when $W_f$ exceeds $W_p$, the calculated tariff becomes higher than the normative one. Thus, it becomes more profitable for water users to save water[50].

*Example 2*

**Figure 5.43 and Table 5.42 present two options of actual intra-seasonal water distribution (by ten-day periods) relative to the limited water supply:**

- proportional water supply;
- disproportionate water supply.

[50] Of course, the participants of the process of water distribution and other stakeholders can accept some reasonable and mutually acceptable limitations after their discussion

The table shows that in the case of the same value of seasonal water supply (16,000.000 m3) under the first (proportional) option of actual water supply during the growing season $K_{f1}$=0.9 and under the second option, when water abstraction less or greater the limited volumes of water supply, $K_{f2}$=1.24 i.e. under other things being equal, the tariff has increased by 34% due to the nonuniformity of water distribution per ten-day periods (due to water abstraction in the excess of limits).[51] At that, lesser water abstractions result in lowering the factor's value[52], and water abstraction in the excess of limits in rising of the factor's value. Since a share of water abstraction in the excess of limits (relative and absolute values) was higher, rising of the factor's value leading to the growth of tariff rate takes place.

As a whole, after taking into account both coefficients the adjustment factors make up 1.0 и 1.38 respectively.

**Table. 5. 42**
**Computing the Tariff Adjustment Factors for Water Services Taking into Consideration Limited and Actual Water Supplies**

| $W_f$, mln. $m^3$ | $W_l$, mln. $m^3$ | | | | | |
|---|---|---|---|---|---|---|
| | 14 | 16 | 18 | 20 | 22 | 24 |
| 14 | 1.43 | 1.10 | 0.87 | 0.70 | 0.57 | 0.50 |
| 16 | 1.63 | 1.27 | 1.00 | 0.80 | 0.67 | 0.57 |
| 18 | 1.83 | 1.40 | 1.10 | 0.90 | 0.73 | 0.63 |
| 20 | 2.03 | 1.57 | 1.23 | 1.00 | 0.83 | 0.70 |
| 22 | 2.23 | 1.73 | 1.37 | 1.10 | 0.90 | 0.77 |
| 24 | 2.43 | 1.87 | 1.47 | 1.20 | 1.00 | 0.83 |

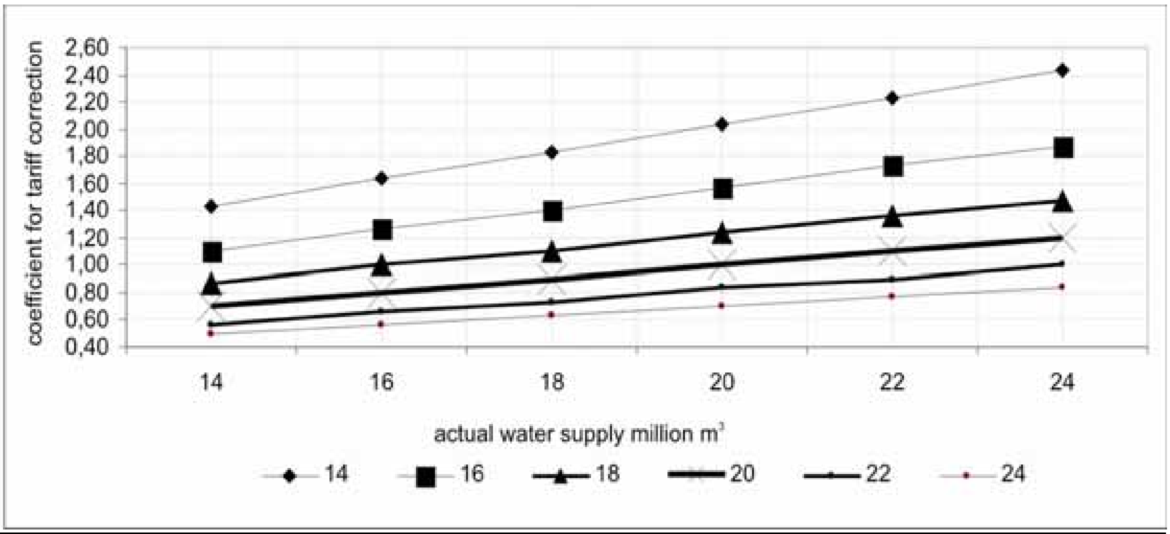


**Figure 5.43 Chart for Computing the Adjustment Factors Taking into Account Limited and Actual Water Supplies**

[51] Penalties for water abstractions in the excess of limited water supply (stoppage of water deliver or penalties) are envisaged, but these measures, as a rule, are not effective.

[52] Lesser water abstractions can be caused: i) at will of water users (in our example just this case is considered); ii) due to force majeure circumstances; and iii) through a water supplier's fault. The agreement between water suppliers and water users foresee such circumstances, but it is difficult to recall the case when water supplier was punished because water supplier always can allege force majeure circumstances. In addition, it is possible that under using our method, lowering the tariff due to lesser water abstractions through a water supplier's fault can be insufficient to cover damage.

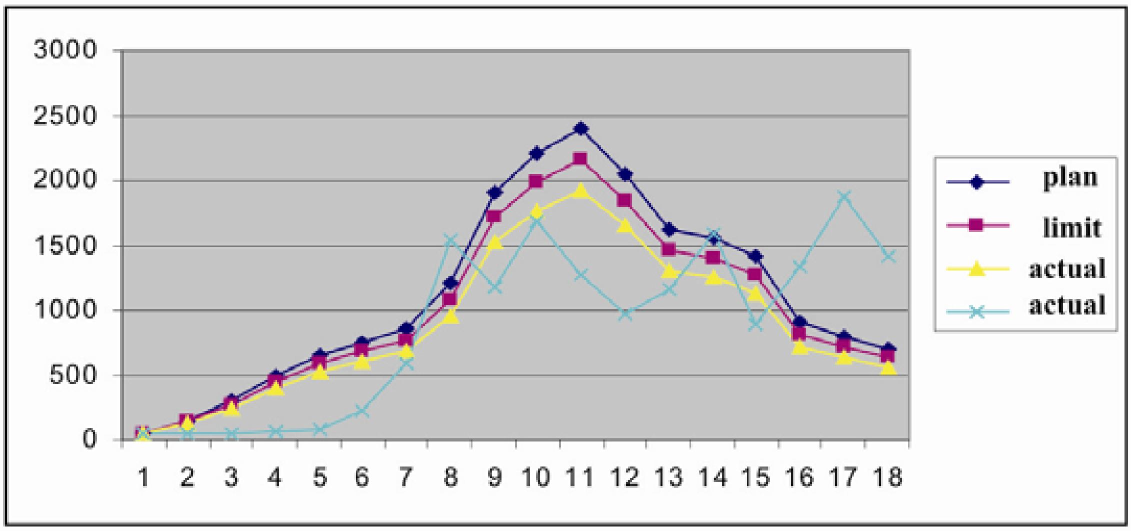


**Figure 5.44 Water Supplies per Ten-Day Periods**

**Table 5.43.**

**Computing the Water Tariff Adjustment Factors under Nonuniformity of Water Distribution per Ten-Day Periods**

| Indicator | Unit | Growing season |
|---|---|---|
| $W_p$ | 000' $m^3$ | 20,000 |
| $W_l$ | 000' $m^3$ | 18,000 |
| $K_l$ | | 0.90 |
| $W_{f1}$ | 000' $m^3$ | 16,000 |
| $K_{f1}$ | | 0.90 |
| $K_1$ | | 1.00 |
| $W_{f2}$ | 000' $m^3$ | 16,000 |
| $K_{f2}$ | | 1.24 |
| $K_2$ | | 1.38 |

***Example 3***

**Let us assume that:**

1. $W_f = W_l = W_p$, i.e. $K_f = K_l = 1$ and there are not any problems related to water distribution.
2. $R$ = 1%.

Computing of adjustment factors, taking into account a fee collection rate and its timeliness, is given in Table 5.44.

The method of adjusting tariffs can be applied on the monthly or seasonal basis. It is obvious that the seasonal approach, under which mutual settlements with water users taking into account above factors are made in the end of the growing season, is more acceptable during the initial period. Under these circumstances, if a water provider is found as a debtor then a water provider's debt is considered as the prepayment of a water user for the next growing season.

**This approach can be employed at different levels of water sharing:**

- at the main canal's level: relations of the Canal Administration and WUAs;
- at the WUA's level: relations of a WUA and farmers.

In principle, other economic incentives for rising of the level of fee collection rate and water savings are also possible. Only some of them were suggested for their discussion. It is talked of wide discussing not only among scientists but also among water professionals and water users. In the case of positive perception of this approach and after its improvement according to comments, its introduction at the WUA's level can be faster than at the main canal level since, in principle, a WUA can settle this matter at the general meeting of water users. At the main canal's level, it is necessary to arrange the discussion firstly at the CWUC's sessions and then at the enlarged sessions of the CWC with participating of all stakeholders and decision makers.

**Table 5. 44**

**Computing the Adjustment Factors Taking into Account the Fee Collection Rate and Its Timeliness**

| Indicators | Unit | Design month | | | | | | Total |
|---|---|---|---|---|---|---|---|---|
| | | April | May | June | July | August | September | |
| Initial information | | | | | | | | |
| $W_p$ | 000 $m^3$ | 1,750 | 2,750 | 3,950 | 5,000 | 4,250 | 2,300 | 20,000 |
| $W_f$ | 000 $m^3$ | 1,750 | 2,750 | 3,950 | 5,000 | 4,250 | 2,300 | 20,000 |
| $R$ | % | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Design information | | | | | | | | |
| $P_p$ | US$ | 3,973 | 6,243 | 8,967 | 11,350 | 9,648 | 5,221 | 45,400 |
| $P_{f1}$ | US$ | 3,973 | 6,243 | 8,967 | 11,350 | 9,648 | 5,221 | 45,400 |
| $P_{f2}$ | US$ | 1,230 | 5,000 | 5,750 | 8,700 | 7,700 | 3,400 | 31,780 |
| $P_{f3}$ | US$ | 1,230 | 5,000 | 5,750 | 8,700 | 7,700 | 3,400 | 31,780 |
| $P_{f4}$ | US$ | 5,164 | 8,115 | 11,656 | 14,755 | 12,542 | 6,787 | 59,020 |
| $K_{s1}$ | | | | | | | | 1.00 |

| Indicators | Unit | Design month | | | | | | Total |
|---|---|---|---|---|---|---|---|---|
| | | April | May | June | July | August | September | |
| $K_{s2}$ | | | | | | | | 0.70 |
| $K_{s3}$ | | | | | | | | 0.70 |
| $K_{s4}$ | | | | | | | | 1.30 |
| $D_1$ | | 25 May | 25 June | 25 July | 25 August | 25 September | 25 October | |
| $D_2$ | | 01 May | 01 June | 01 July | 01 August | 01 September | 01 October | |
| $D_3$ | | 25 May | 25 June | 25 July | 25 August | 25 September | 25 October | |
| $D_4$ | | 15April | 15 May | 15 June | 15 July | 15 August | 15 September | |
| $F_1$ | day | -15 | -15 | -15 | -15 | -15 | -15 | |
| $F_2$ | | 0 | 0 | 0 | 0 | 0 | 0 | |
| $F_3$ | | -15 | -15 | -15 | -15 | -15 | -15 | |
| $F_4$ | | 15 | 15 | 15 | 15 | 15 | 15 | |
| $K_{t1}$ | | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 |
| $K_{t2}$ | | 1 | 1 | 1 | 1 | 1 | 1 | 1.00 |
| $K_{t3}$ | | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 |
| $K_{t4}$ | | 1.15 | 1.15 | 1.15 | 1.15 | 1.15 | 1.15 | 1.15 |
| $K_1$ | | | | | | | | 0.85 |
| $K_2$ | | | | | | | | 1.43 |
| $K_3$ | | | | | | | | 1.21 |
| $K_4$ | | | | | | | | 0.88 |

*Note*: D – a date of payment for water services in the calculated period – a month

**Proposals for putting into practice**

1. For mitigating the water crisis in Central Asia it is necessary to learn to manage water demand in the efficient manner;
2. According to the world practice, the most effective way to manage water demand is the method of economic incentives for water saving;
3. Economic incentives for water saving can be provided through transition towards water charging and improving the tariff policy;

4. Approaches to the adjustment of normative (basic) tariffs that are established by the government (at the main canal's level) or by the WUA general meeting are described in this publication with the purpose of initiating their discussion;
5. Under applying this approach, water suppliers and water users would have the economic incentives for water conservation and efficient use of water resources;
6. Water suppliers and water users should select the mutually acceptable approach and assume some rational and mutually acceptable limitations;
7. This approach to settling financial relations between water suppliers and water users can be used both at the main canal's level and the WUA's level;
8. The consensus is quite possible since the approach has attractive incentives both for water suppliers and water users;
9. This approach should derive encouragement from decision makers since it is directed at water conservation; and
10. This approach shouldn't be foisted on participants of the process of water allocation; on the contrary, it is very important to organize its discussion and improvement, taking into consideration their comments and wishes.

## 5.9. Capacity Building and Training are Key Tools for Implementing IWRM

**(P.D. Umarov)**

The capacity-building program complies with the fundamental provisions of the Regional Water Resources Management Strategy in the Aral Sea Basin [9] and IWRM. It encompasses the ICWC training system, along with strengthening the network of regional organizations and their subdivisions, establishment of regional and national information systems and communication facilities, SCADA, and developing the legal base for joint management of transboundary water resources.

Collection of information on modern world trends on development and improvement of the water sector practices and dissemination of this knowledge by conducting 'get-to-know' seminars, where the IWRM experience gained in countries such as Canada, France and Israel have preceded the popularization of IWRM in the region. The SANIIRI[53] experience, gained in the 1970s and 1980s by conducting regular scientific, practical and advanced training for water professionals from developing countries and providing technical assistance, within the framework program developed by the UN Economic Commissions for Africa, Asia and the Pacific, Latin America and Caribbean Basin etc., was very useful for this activities. At that time, the Regional Branch of All-Union Institute for Advanced Training of Water Professionals (for specialists from Central Asian countries, Kazakhstan and the Caucasus) was also established under the umbrella of the SANIIRI.

Reviewing the experience accumulated in our national water sector and comparing it with modern achievements of our foreign colleagues, one can state the fact that our science and practice undoubtedly were at sufficiently high level, although there were some shortcomings, for example, insufficient consideration of nature needs and the potentials of participatory approach in water resources management. Still, after the disintegration of the USSR and rupture of former links, with economic hardships faced in the course of transition towards the market economy, and lowered scientific and technical potential in the water sector in all Central Asian countries, the SANIIRI (already in the status of the SIC ICWC) continues the development of human resources. The young specialists familiar with modern methods of informatics, management, economy and legislation are being trained. At the same time, maintaining and developing relations with the International Commission on Irrigation and Drainage (ICID), UN Economic Commissions, UNESCO, FAO, CIDA, USAID, Mashav, NATO and other international agencies, the SIC ICWC has initiated the exchange of information and knowledge, including the organization of regional seminars in Tashkent and abroad.

[53] SANIIRI is the research institute under the Ministry of Water Resources of the USSR that serviced the irrigation and drainage subsectors.

This combination of the regional experience with international scientific and technical co-operation has promoted, to a considerable degree, the formation of the ICWC and development of the Aral Sea Basin Programs, GEF and Tasic projects. The Terms of References for these projects included the component of training and study tours for sectoral leaders to develop their own understanding of the needs of reforming the water resources management system along with the IWRM approach. Through these activities, public awareness on forthcoming water crisis, the necessary political support for the urgent necessity of introducing IWRM and transforming it into the state policy are being achieved.

The ICWC with its executive bodies (SIC ICWC, BWOs "Amu Darya" and "Syr Darya," and the Secretariat) has developed relations with international water communities. As a result, in 1996, the World Bank supported development of "*The Basic Provisions for the Development of the Regional Water Management Strategy in the Aral Sea Basin". In this document,* and for the first time, the need of implementing IWRM and as one of the key components of it, the 'program of capacity building for joint transboundary water resources management and development', has been developed and then approved at the governmental level.

In parallel with above, due to realization of the needs in regular advanced training courses for water professionals, a decision was made at the 21st ICWC Session (24.10.1998) to establish Training Center with the financial support from the Canadian International Development Agency (CIDA). Thus, since 2000 the five-year project: "The Water Resources Management Training Project in the Aral Sea Basin" was launched in the partnership with the McGill University and Mount Royal College (Canada). The ICWC Training Center has started its activities by the kick-off seminar with the participation of senior officers of the ICWC and its executive bodies in compliance with the approved plan of advanced training courses for senior water professionals. The training policy aimed at achieving the awareness of IWRM backgrounds by the senior policy makers, leaders of governmental and non-governmental organizations and other stakeholders involved in implementing the pilot projects at each level of the water management hierarchy was specified in the course of this seminar. During the initial stage, senior officers of appropriate ministries and departments, then managers of regional and basin water management bodies, and finally specialists of water agencies were step-by-step involved into the training process.


**Photo: Management of the SIC ICWC and ICWC Training Center together with the GWP Chair Mrs. Margaret Catley-Carlson**

The basic training strategy is the popularization of IWRM concepts and embedding them in the national action plans of reforming the national water sectors. Active participation of the leaders of national water sectors - ICWC members in the training courses has provided all-round support to social mobilization of water users and all stakeholders and the preparation of national IWRM action plans with the their follow-up approval by national governments. Such a training strategy was also aimed at raising the public awareness of the need in seeking inexpensive solutions and non-governmental funds for improving the water sector through developing new forms of institutions and public participation. All these actions have facilitated the advancement of IWRM and its recognition in national legal and normative documents.

A principle feature of these training activities were to ground the research findings of joint inter-state programs and various regional projects such as “IWRM-Fergana”, “IWRM Strategic Planning”, “Transition to IWRM in Lower Reaches of the Amu Darya and Syr Darya Rivers”, “Drainage Problems in Central Asia”, “Water & Education” “TWINBASIN”, “Central Asia Regional Water Information Base (CAREWIB)” etc. These research findings were used as case studies in lectures and presentations in the training courses. Regular upgrading the presentations, diversifying the seminars’ topics and improving training methods including the elements of situation modeling was also facilitated the co-operation with colleagues from the leading international universities and institutions, including the McGill University and Mount Royal College (Canada), IHE-UNESCO and ILRI (The Netherlands), Bonn University and Stuttgart University (Germany) etc. With the appointment of its Director, the regular information exchange between the membership of SIC ICWC and such international organizations as the ICID, WWC, INBO, IWRA, and GWP was established thanks to the support of such donor organizations as the CIDA, WB, SDC, ADB, USAID and as well as others who promotes solving these tasks. Mentioning the fact that establishment of the Regional Technical Advisory Committee of the GWP CACENA was also initiated by the director of the SIC ICWC and the kick-off seminar with participation of representatives of the GWP Secretariat was also held in the ICWC Training Center, is quite appropriate here.

Another feature of our training is the improvement of its efficiency due to decentralization through establishing the branches of the ICWC Training Center and covering greater number of water professionals. In Osh, for training specialists from the Fergana Valley’s provinces within boundaries of Kyrgyzstan, Tajikistan and Uzbekistan (with the support from SDC); in Urgench for training specialists representing provinces in the Amu Darya Lower Reach within boundaries of Turkmenistan, Uzbekistan and Karakalpakstan (with the support from CIDA); in Alma-Ata (with USAID support ) and in Bishkek (with ADB support). It is also planned to establish the similar branches in Dushanbe (for training specialists representing South Tajikistan and Syrkhandarya and Kashkadarya provinces of Uzbekistan) and in Kyzyl-Orda (for training specialists representing South Kazakhstan and North Uzbekistan).

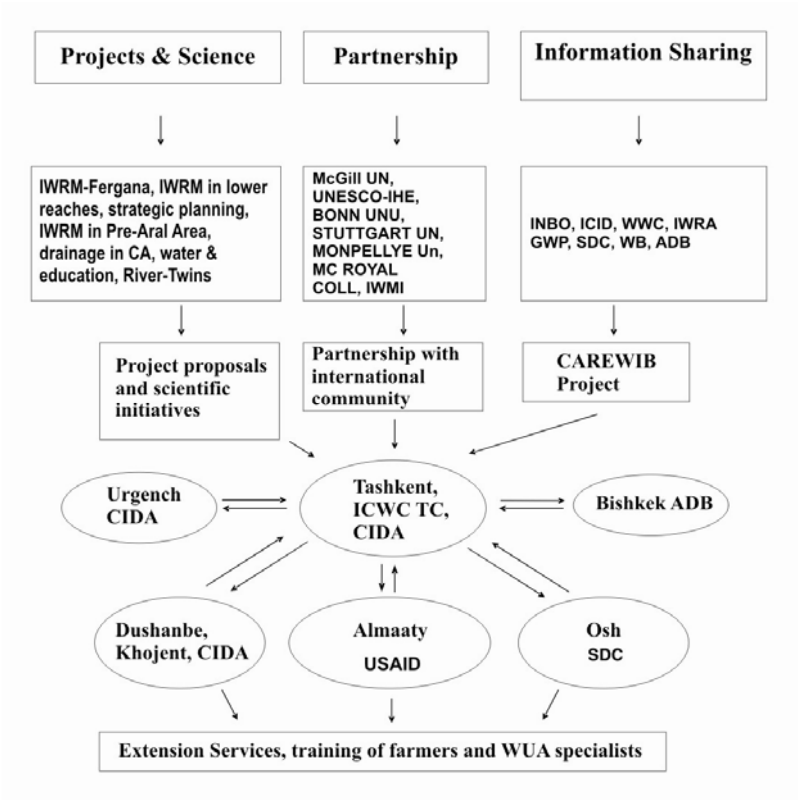


**Figure 5. 45 Dissemination of Water-Related Knowledge and Information**

Apart from the Osh Branch of ICWC Training Center, where seminars for training the specialists from Canal Administrations, provincial and district water management organizations and WUAs are held, the local training centers in Fergana, Andijan, and Khodjent were established in the frame of the IWRM-Fergana Project. In addition, the pilot training center on the basis of the pilot WUA "Akbarabad" was established in Kuva District of Fergana Province for training farmers and representatives of WUAs, community-based governments and village committees. Results of local training activities show that in order to improve the water use practice and water productivity the dissemination of positive experiences should be organized through the extension services. Therefore, further development of training activities requires the establishment of the special training points located directly on demonstration fields. In the framework of consultancy assistance, the trainers trained at higher levels of the training pyramid will be able to use these demo fields to train farmers to use up-to-date methods of water measurement and accounting, water applications and other technologies related to raising of water and land productivity.

***Interaction of the ICWC Training Center and its branches is organized in the following way:***

- Workshops for specialists of higher and middle levels and preparation of programs, workbooks and learning aids for the branches are conducted in the ICWC Training Center in Tashkent;
- Training of lower level's personnel of water management organizations is conducted in ICWC Training Center's branches by trainers who participated in preparation of programs of training courses and learning aids, using the network of project demonstration sites, database and the integrated information system of the ICWC Training Center.

Another important feature of activities of the Training Centre is the thematic seminars, involving representatives of related sectors. Topics of the training seminars are the followings:

**Photo: Professor Ch. Madromoto (McGill University) Opens the Regular Seminar Session at the ICWC Training Center**

- integrated water resources management;
- co-operation in transboundary river basins;

- water legislation and policy; and
- improving irrigated farming.

The specialists from ministries and departments of nature protection, energy and representatives of NGOs along with the water professionals from Central Asian countries attended the first two seminars. The representatives of Ministries of Foreign Affairs and Ministries of Justice from each country, who are engaged in the preparation of inter-state agreements and national legislation in the field of water economy and nature protection were invited to attend at the seminars on water legislation and policy that were held with participation of experts from the Great Britain (the Dundee University) and Israel (the Israel Center of Negotiations and Arbitration).

The training system in the ICWC Training Center, envisages the organization of monthly 7-day seminars for training 20 to 30 persons, in the equal proportion representing five countries. , And in between these seminars, additional trainings are conducted in the branches. Those are held by lectures (specialists from local water management organizations who were specially trained by the lead trainers from the ICWC Main Training Center) for similar numbers of participants.

The accepted interactive form of training based on up front dissemination of the tutorials and additional training documents, and organizing dialogues and discussions on current problems and tasks faced by the water sector under the leadership of experienced moderators (often the ICWC members), facilitates fellow feeling, openness and trust. Essentially, each regional training seminar turns into a "round table" for representatives of different countries and economic sectors where the "brainstorming[54]" encouraged by moderators and an appropriate topic of lecture promotes reaching the consensus in the region at the cross-sectoral and inter-state level. At the same time, the minutes with collective recommendations are drawn up at the end of each seminar is sent to all ICWC members for further dissemination and taking the measures for upgrading and improving the existing systems.


**Photo: Participants of the Seminar Held at the ICWC Training Center**

Establishment of an enabling environment for friendly contacts between specialists from different countries and economic sectors engaged in solving water problems during joint exercises and leisure-time is an additional achievement of such regional trainings. This is especially important because today's participants

[54] intensive discussion to solve problems or generate ideas

of training courses are young people who in the nearest future can be leaders of local or republican authorities, large production associations and even economic sectors i.e. the policy makers.

Up to now, more than 2690 specialists have learnt such topics as IWRM principles and experience, water legislation, best irrigated farming practice, participatory approach, gender aspects of IWRM and others in the ICWC Training Center.

**Table 5.45 Training of Water Professionals: Number and Distribution over Countries**

| Country / Year | Kazakhstan | Kyrgyzstan | Tajikistan | Turkmenistan | Uzbekistan | Other countries | Total |
|---|---|---|---|---|---|---|---|
| 2000 | 9 | 11 | 11 | 6 | 12 | - | 49 |
| 2001 | 63 | 45 | 55 | 27 | 99 | 7 | 296 |
| 2002 | 76 | 71 | 60 | 28 | 104 | 5 | 344 |
| 2003 | 41 | 89 | 64 | 30 | 159 | 1 | 384 |
| 2004 | 73 | 85 | 74 | 38 | 227 | 1 | 498 |
| 2005 | 49 | 90 | 76 | 39 | 192 | 9 | 455 |
| 2006 | 70 | 85 | 84 | 28 | 386 | 15 | 668 |
| **Total** | **381** | **476** | **424** | **196** | **1179** | **38** | **2694** |

The ICWC training Center has established the special database with current information on each former participant of training courses to support feedback with them. This database is annually updated, taking into account all changes in their professional status and some of them are invited for jobs in our branches. Thus, specialists who were trained in the ICWC Training Center in Tashkent can train the lower level personnel of water management organizations, WUA and farmers using the program modules, methodological manuals and visual aids developed in the ICWC Training Center. At that, the efficient multi-step system, under which each trainee hands over his knowledge to his peers and lower levels (the domino principle), is established.

Information on the ICWC Training Center's activities and also its recent and planned seminars is available on the website. For qualitative evaluating efficiency of these seminars', let us review, for example, the advanced course on integrated water resources management attended by the overwhelming majority of trainees representing water professionals of top and middle levels of the water management hierarchy as well as water users and their associations. Raising their awareness on the significance and necessity of the water sector reforms through introduction of advanced principles of water resources management, prepared the enabling environment not only for implementing the IWRM-Fergana Project but also for the project of water resources management in the transboundary Chu-Talas basin, based on the participatory approach taking into account the interests of all stakeholders.

All these activities, in turn, have resulted, on the one hand, in widening the circle of like-minded persons and disseminating IWRM ideas as the single way for our planet to survive in the future and, on the other hand, in strengthening the partnership of water professionals for solving water problems. At present, the opportunities for introducing IWRM in the river lower reaches of the Amu Darya and Syr Darya, as well as in the Zerafshan River Basin are being reviewed according to the same principles.

Raising the awareness level in respect of IWRM and involving water management organizations' personnel and water users in appropriate pilot projects have been promoted step-by-step. This has resulted in inclusion of these ideas into important legal documents, such as Water Codes of Kazakhstan, Kyrgyzstan and Tajikistan, the Law "On Water Users Associations" (Kazakhstan), the Decree signed by the President of the Republic of Uzbekistan "On Major Directions of Reforming the Agricultural Sector" and the Resolution of the Cabinet of Ministers "On Improving Governance of the Water Sector" (Uzbekistan).

Similar positive results were achieved in the cooperation related to joint management of transboundary water resources and developing water legislation and policy due to the advanced seminars with participation all stakeholders involved in activities of cross-sectoral conciliation commissions engaged in the preparation of inter-state agreements. The experience of seminars and their collective minutes undoubtedly confirm that countries located in the Aral Sea basin can successfully and efficiently solve the problems of water availability for irrigation and hydropower generation only based on effective mutually beneficial collaboration. Such co-operation should base on the principles of hydro-solidarity, mutual respect, consideration of all stakeholders' interests, minimizing harm for the irrigation practice, hydropower generation, and the environment and using the existing potential under transition towards the market economy.

It is obvious that before, the separatist tendencies that impeded activities related to realization of agreements on information exchange and strengthening the regional executive agencies that were earlier signed by the ICWC members have dominated in inter-state water relations. Now, understanding of the need in consolidation based on the collaboration and readiness to revive activities of conciliation commissions is rising due to widening the circle of like-minded persons in appropriate ministries and institutions in each riparian country.

There are similar positive shifts related to the advanced courses on improving the irrigated farming practices. Those are creating the awareness that under water resources scarcity, the only solution to mitigate contradictions between supply and demand of water is demand management, based on the introduction of water-saving technologies. As a result, the awareness of opportunities for achieving potential water productivity, enable to increase agricultural output twice with reduced water consumption by 10%, is rising. This, in turn, stimulated the governments to allocate investments for establishing the network of demonstration sites that play a role of the extension services for farmers, WUAs and water management organizations and demonstration of latest methods of water conservation. In the course of the advanced training on water-saving technologies and raising water and land productivity, the need of involving women in solving these socially-significant tasks and developing the special program "Water, Gender Aspects and Agriculture Production Improvement" was revealed.

Series of seminars, with invited representatives of NGOs and mass media, was conducted to raise the public awareness. Trainees of these advanced courses, studied the current problems of the water sector and nature protection, including the peculiarities of reforming and democratization of the governance of water sector. Popularization of the importance of participatory approaches under the introduction of IWRM and water conservation practices is the only way of survival under the growing water resources scarcity is the important message conveyed through these training activities.

A series of seminars under the framework of 'Water & Education Project' that is supported by the OSCE and the Ministry of Education of the Republic of Uzbekistan was conducted to form the vision of the future generation of water consumers that should be oriented on care of water resources. IWRM basics are explained to school teachers at these seminars, in order to facilitate the integration of IWRM principles into school curricula.

The regularity is a key factor in the establishment of an efficient training system. It is important not only due to permanent personnel turnover at all levels of water management hierarchy but also due to update of knowledge and methods tested at pilot systems that should be disseminated among water users. Advanced courses on IWRM, therefore, for Heads of departments and divisions of the MAWR (committees, departments, central administration) should be held on a regular basis (no less than twice a year: prior to and after the growing season) in Tashkent, Urgench, Alma-Ata and Bishkek. In addition, the similar advanced courses need to be organized for chiefs of provincial water authorities and BISA, their deputies and heads of water use departments, representatives of local governments and WUAs' specialists no less than twice a year in each province of Central Asian countries. These advanced courses should cover the following topics:

- institutional and legal aspects of improving the system of establishing WUAs, Canal Water Users Unions, and Water Users Groups;
- improvement of the water measurement and accounting systems at the level of WUA, WUG and CWUC; and
- Rehabilitation of irrigation and drainage systems and ameliorative measures on the fields.

Advanced courses for water professionals and capacity-building efforts in the water sector need to be developed along with upgrading the information system, introduction of the SCADA and creating the legal base for joint management of transboundary water resources. This was initiated in 1996, when the regional information system “WARMIS” and the database[55] on land and water resources with GIS component were established in the frame of the WARMAP Project[56] (the EU Tacis Program). This system is regularly updated and improved, with filling information along the following blocks: economy, surface water resources, groundwater, land resources, climatic data, industry, administrative-territorial system, the ecological aspects of the Aral Sea and Pre-Aral area. At present, this activities is in progress with financial support from the SDC in the framework of the project “Central Asian Regional Water & Environment Information Base (CAREWIB)”. The project has created a web-portal for water and environmental issues in Central Asia (“CA Water-Info”) and the regional information system including the knowledge database. This database with a GIS component, information block of Hydro-Meteorological Services with data on river flow rates, BWO block with data on sharing water resources in river basins, and analytic block with a set of modules and models for assessing current water availability and forecasting annual and mean annual water availability. The project is aimed at capacity building of water management organizations through their involvement in the relevant network operations. They are actively interacting at the regional, basin and national levels through establishment of national information systems linked to regional, basin and national databases. At the same time, in order to maintain the sustainable operation of the CAREWIB, the advanced courses are conducted for the specialists, who services the national information systems. They flow through the introductory course on the unified methodological base of building-up the information system. At the end receive the software and existing data on their countries and provinces, as well as the follow-up transfer of data for the purpose of supporting and developing the national databases. In return, provide regular information exchange and filling the regional database with appropriate data. Coordinated actions of specialists at all levels of the water management hierarchy and free access to information for all stakeholders will undoubtedly facilitate capacity building of the water sector and successful introduction of IWRM in the region.

The establishment of systems of control and data acquisition (SCADA) at water intakes of inter-state importance, was initiated on waterworks serviced by BWO “Syr Darya” with the financial support of the USAID, and now is implemented on pilot main canals of the IWRM-Fergana project and funded by the SDC. This system equipped with electronic means of accessing, storing, and transferring information allows preventing not only uncontrolled water diversions from the river but also raising the accuracy of water supply (up to 2% instead of 10% in the past) and reduces unproductive water losses. In addition, the integrated complex of automated transmition of technological information ensures free access to information by all stakeholders. The daily updated actual data on flow rates and water levels at all waterworks serves as a confidence-building measure in the process of joint water resources management. The special training seminars are held in the ICWC Training Center, its branches and directly at waterworks equipped with the SCADA systems for specialists responsible for operation of these systems to improve their professional skills. The introduction of SCADA system on waterworks serviced by BWO “Amu Darya” is planned in the nearest future with the support of ADB.

Developing the legal base for joint management of transboundary water resources was also initiated under the framework of the WARMAP project that enabled the preparation of drafts of four agreements regulating the institutional set-up, information exchange, water use and nature protection. Authorized national working groups consisting of representatives from different economic sectors were established and they work on continuing basis provids the continuity to this activities of improving legal base of regional cooperation. In parallel, activities on improving the national water legislations, by means of including the

[55] The WARMIS Database is a relational database, consisting of tables with text data. The database contains information on water and land resources and their use, climate, economic indicators, and water quality.
[56] Water Resources Management and Agricultural Production Project

provisions that regulate the introduction of IWRM as a key tool to raise water productivity at all levels of water use was initiated. At present, this activities is supported by the ADB and implemented through the project: «Improvement of Shared Water Resources Management in Central Asia» (ADB RETA 6163) that is aimed at developing the program of legal and institutional measures for capacity building of inter-state water co-operation in the Aral Sea basin. As a result of this activities the drafts of agreements were developed and then discussed at regional workshops, covering the following aspects: i) information exchange; ii) strengthening the ICWC status; iii) joint use of water and hydropower resources of the Syr Darya River; and some separate regulations and rules of river basins management.

Inclusion of the findings of all abovementioned projects into workbooks of the ICWC Training Center creates the closed cycle of continuous self-improving the established training system and the continuity of capacity building process.

In the process of capacity building it is necessary to extend the subject area and to involve specialists from related economic sectors such as hydropower generation, drinking water supply, nature protection, hydro-meteorological services into activities related to improving water governance and ensuring rational use of water resources. At the same time, it is necessary to organize the special seminars aimed at preparing the base for public participation in IWRM and establishment of network of NGOs interacting with the water authorities in each Central Asian countries. There is a need to conduct training courses on management of water and environment projects, including such aspects as preparing for economic reforms, improving agricultural production, developing fishery in irrigation systems. In addition, the scope of activities should be extended to works related to the training programs of international development agencies and financing institutions.

Thus, the established system for capacity building of the water sector assists water professionals to study the world experience, to project the path “from the vision towards the action”, to screen priorities, to reach the new quality levels using the state-of-the-art systems of computerization and informatics, as well as internet resources. Along with raising the level of professional knowledge and acquaintance with state-of-the-art technology in the field of water and land resources management, irrigation and drainage and environmental protection, the established system of training facilitates, the strengthening of cooperation between riparian countries and development of the common approaches at the level of technical experts and policy makers. Hence, the ICWC Training Center, being the champion of state-of-the-art technology in the field of water and land resources management, also becomes the platform for strengthening the regional cooperation in practical implementing IWRM at the level of irrigation systems and river basins in coordination with national priorities, balancing national needs with regional limitations.

## 5.10. Gender Aspects of IWRM

**(G.V. Stulina, D.R. Ziganshina, Sh.Sh. Mukhamedjanov)**

Water is an economic, social and ecological good granted for the welfare of all the people without any exception. Considering the IWRM systems, the UNDP links water with four key areas of activities: i) struggle against poverty; ii) life support; iii) environmental protection; and iv) gender equality. A community consists of individuals and groups with different rights, welfare, power and abilities to express their needs and rights; and this fact should be taken into consideration while managing water resources.

As a rule, the extent of participation, interests, priorities and responsibilities of women and men are different in the governance of water resources. There are also gender differences in access to water resources and in water rights. Gender inequalities of women and men are evident in terms of knowledge and various experiences in such areas as water services, water policy and water availability. Any initiative in the water resources management sphere needs to be assessed concerning its impacts on women and men in order to understand clearly all the effects and to avoid negative consequences. Mainstreaming gender in IWRM strategies and plans has three key entry points [2]:

1. While developing new initiatives and programs, it is necessary to carry out a good gender analysis to specify the differences in their perceptions by women and men. Ideally, both women and men should be involved in carrying out the gender analysis;

2. Based on findings of this analysis, all initiatives have to take into account perspectives, needs, and interests of both men and women; and to promote a more active role of women to reduce the level of gender inequality, if possible;
3. It is necessary to use participatory approaches, facilitating the equal participation of women and men in water resources management, especially at the level of decision-making.

### *Key provisions of the gender theory*

The gender theory has originated from social sciences more than thirty years ago and, by now, spread all over the world. One of its fundamental provisions is differentiation in applying such terms as "sex" and "gender". In social sciences, the term "sex" refers to the biological -anatomic structure of a human being. At the same time, the term "gender" is used to specify differences between male and female social roles and their emotional characteristics that society prescribes to people according to their sexual distinctions. A hierarchical structure that considers a male as the dominating factor and a female as the subordinated factor underlies gender differentiations. As a result, both men and women are "victims" of the traditional system of social norms and stereotypes. It is necessary to remind that gender relations may be quite different in various cultures; and as our survey has revealed, relations between women and men in countries under consideration are drastically different. It follows from this that gender is the cultural, social, and historical concept, and at the same time, gender relations are inter-changeable in time. This is not a rigid framework into which willy-nilly we have to squeeze ourselves in, obeying its rules; however, this is the system, which needs to be changed, if it has become out-of-date and does not meet demands of the times. The gender theory and methodology provide to scientists new analytical tools for investigating society and enables them to discover social and cultural mechanisms that form gender disparity in traditional society. However, the fundamental values necessary for development of countries and their residents independently of gender differentiation encompass the following concepts:

***Freedom:*** Men and women have equal rights to prosperous life and parenting of children without fearing famine, violence, oppression, and inequity. The democracies, based on people's will, ensure these rights in the best way.

***Equalit:.*** No human being in the country has to be deprived of the opportunity to use advantages of democratic development. Men and women should be provided with equal rights and opportunities.

***Tolerance:*** Given all, there are many religions, cultures, and languages, which people have to respect by each other. One should not fear or suppress differences between people; vice versa, it is necessary to keep them for future generations.

***Respect to nature***: Prudence should be displayed in all aspects including the attitude towards natural resources (water and land). Only in this manner, we can preserve and hand over immense wealth granted by nature to our descendants. Out-of-date and inefficient production and uses should be eliminated in the interests of our descendants.

***Responsibility:*** Responsibility for managing economic and social development in countries.

### *Gender analysis carried out in the water sector in Central Asia and the Caucasus*

In 2005, with the assistance of GWP CACENA, the researchers from Kazakhstan, Tajikistan, Turkmenistan, Kyrgyzstan, Armenia, Azerbaijan, Georgia, and Uzbekistan took part in a study monitoring gender equality aspects in countries of Central Asia and Caucasus [2]. The researchers were authorised to select specific regions within their countries, which would ensure the representative sample of all types of household management (in private farms, agricultural cooperatives (shirkats), family (dekhkan) farms etc.). The gender survey was conducted in the form of filling the questionnaires by interviewers based on answers of owners and members of rural households.

Data of questionnaires were entered into the database and then analyzed. With results of these analysis, reports that reflected the current situation with respect to gender relations were prepared for each country.

The population in the regions under consideration, to a greater or lesser extent, is aware of real problems faced by women rather than the gender theory. Men's views on these problems differ from those of women. In other words, the question how "an oriental man" treats gender problems and whether he is ready to be at the one social level together with a woman remains traditionally topical. Traditionally, many explain the difference in social status of men and women and disparity in their rights through biological reasons. However, the analysis of historical, ethnographic, and cultural facts reveals that major causes of antithesis of women and men are social ones, i.e. norms of behavior established (designed) by society. Therefore, these social and cultural norms are in the focus of our studies, which were conducted in rural areas, where mentioned traditions are the most conservative. We attempted to review whether society deals with men and women in different ways, and why they have unequal opportunities for self-realization in public and personal spheres despite the fact that the equality is legally recognized in all legal documents adopted by the states. However, religious principles, centuries-old traditions, and way of life in countries under consideration, primarily presume the gender disparity with respect to the female population in these countries. Georgia is the only exclusion to the general rule, where the attitude toward women always differed from generally accepted norms in the oriental countries.

Mentioned problems are aggravated by economic hardships that limit the financial stability of men and women, and, in addition, restricts women's access to control their own livelihoods. However, there is no doubt that poverty affects men and women in different ways. The quality, composition, and quantity of food consumption as well as access to good education and qualitative medical services may be indicators that reflect the poverty rate. People who legally have various rights, do not have any opportunity to use them without economic support. The high unemployment in countries under consideration, including the latent unemployment caused by domestic circumstances, has baneful consequences for women. Women make up about two-thirds of the total number of unemployed and those who are working are basically engaged in unpaid or low-paying occupations. Underemployment remains the critical and real indicator of poverty in the countries. Women are the especially vulnerable group since they are engaged in low-paying and temporary works. Gender challenges in the field of labor and employment also can depend on the current legislation on women's social security, which very often limits entrepreneurs' who wish to hire women. Conditions of employed women are also problematic since they are being engaged in the economic sectors, where traditionally wages are low: public health and education. Even greater problems exist in the agricultural and informal sectors where labor of women is practically not protected by the state in the form of social guarantees, and therefore there is high likelihood for violation of human rights and for wrongful exploitation of women labor.

Gender disparity in the field of employment is observed at all hierarchical levels. Existing gender disparity restricts access of women to specific economic sectors and their professional promotions. The likelihood to find a proper job is very low; usually this is low-paid, low-skill, and seasonal work. Currently, the number of women seeking jobs at informal labor market is considerably increased in the region.

It is necessary to note that women actively participate in agricultural production. Rural women are mainly engaged in producing agricultural outputs for provision of their own families and for sale. Therefore, they are concerned with problems of marketing for their agricultural products, of its hauling, and prices. Banks unwillingly grant credits on the security of property preferring to deal with entrepreneurs that already have profitable farms, and these are usually men.

Rural women have less time for marketing activities, less access to agricultural knowledge, and less professional skills in order to establish their own businesses. Reforms of the rural sector, privatization of agricultural enterprises, and establishing private farms are implemented without due participation of women because of their low representation in local governments and the lack of funds and skills for rural entrepreneurial activities. Taking into account these aspects, we would like to recommend developing programs on financing and training, which are targeted at women-farmers, or women, who wants to become entrepreneurs.

The curriculum on gender issues is valuable for students and teachers at colleges of social sciences and secondary schools, because it covers both discussion and analysis of problems, which affect each of us: a person and his relations with the world, freedom and its limitations, differences between people and the need for observing equal rights (despite differences), marriage, the family, relations between spouses and children, traditional and democratic values, and many other things. In other words, the gender curriculum should be aimed at: (i) development of social responsibility of each person; (ii) forming of the system of humanitarian values and sense of equity; and (iii) protection of human rights. The idea of equal secondary education for girls and boys is supported by less than 40 percent of women; at the same time, 60.7 percent of women speak in support of different curriculums depending on gender. Most male and female respondents consider that such subjects as mathematics, physics, technical and legal knowledge, and sports are more important for boys, at the same time, such subjects as housekeeping, history, literature, ethics, psychology of the family life, and sexual education are more important for girls. Based on traditional stereotypes with respect to roles of women and men, the adults themselves who suffer from gender disparity unknowingly bring up their children in the same spirit. Schools often follows this path. It is necessary to stop this process and to propose people a new democratic outlook.

Therefore, the need in changing consciousness of men and women is extremely topical today. None of the respondents pointed gender equity as a social value. However, any social changes are starting with shift in consciousness.

The analysis [2] has shown that certain discrimination of rural women that becomes apparent, in principal economic dependence from their husbands and other members of the family, takes place practically in all Central Asian countries. As was mentioned, only 7.6 percent of women in countries of Transcaucasia and 3.2 percent of women in Central Asian countries possess the right to manage the family budget independently. And, most women cannot spend money earned by themselves at their own discretion. A negligible amount of women has received access to land resources for establishing a farm as a proprietress. Discrimination of women is observed in the increase of unrequited labor on garden plots; in addition, the low level of utility services negatively affects women negatively by increasing their physical inputs. Mass involvement of women in agricultural works in farms of Tajikistan, Uzbekistan, and Turkmenistan is seasonal, and at the same time they carry out the most labor-intensive and low-paid works.

The survey revealed that a share of women having higher and special secondary education amounts to 14.8 percent of all women in Central Asian countries. However, most women are engaged in low-paid budget sectors, and therefore, according to data of the survey, the gender gap in input to the family budget makes up 55 percent in the CAR. Neglecting personal interests owing to fear of loosing the opportunity to work and earn money, women agree to be engaged in low-status and low-skill occupations without opportunities to upgrade their professional skills.

There are certain obstacles for developing business undertakings among women. An overwhelming number of women-entrepreneurs operate in the field of small retail trade without access to infrastructure, systems of credit and transport services. Therefore, they have to sell small lots (of goods), in general, (this is quite a labor-intensive occupation taking into account remoteness of markets) only to satisfy the momentary needs of their families. Both men and women treat positively to the development of female business, although men are more cautious in their assessments. Respondents mentioned the following causes that impede active involvement of women to private business (in descending order):

- lack of money to start-up businesses;
- bureaucratic barriers;
- lack of specialized knowledge and education;
- lack of professional skill for business management; and
- restricted access to education.

Dynamic revival of such traditions as early marriages and isolated life, and declined prestige of education has resulted in decreasing a share of female students in higher education institutions and colleges. In turn, this has resulted in low representation of rural women at the high-skill labor markets in the regions. It is necessary to note that basic concerns for children and aged people lie on “women’s shoulders”, and, in turn, increase workload on women and do not enable them to use existing opportunities for self-realization and self-perfection. This analysis has sufficiently supplemented the earlier studies related to evaluating the gender situation.

On the initiative of the project "Adaptation to Climatic Changes" that is jointly implemented by the SIC ICWC and McGill University (Canada), the study "Gender Aspects of Water Resources Management" was undertaken in pilot districts in Uzbekistan, Kyrgyzstan and Tajikistan to specify the vital problems in private farms in various areas including public health, education, culture, access to resources, employment, income-generating activities etc. Gender problems related to access to and management of water resources were analyzed. Gender inequalityin such areas as the rights on land use, access to water, control over resources, participation in governance of water resources in the agricultural sector, access to markets and commercial services is obviously observed in the water and agricultural sector. A substantial target of this study is also the collection of reliable information on basic issues of gender disparity.

On the initiative of the GWP CACENA and ICWC, in 2004, with the Business Women Association (the Kokand Branch, Uzbekistan) using PRA methods conducted a field survey and analyzed gender problems in the water and agricultural sector in the region (in Kuva District of Fergana Province). The general conclusion from this study is that problems of rural women, such as access to water, land, financial, and material resources and to education and culture, are topical and it may be considered that most of rural women are restricted in realizing their opportunities. Findings of our gender survey testify that revision to the social policy, in respect to rural women should be done. It is necessary to initiate a transition towards practical implementation of tasks aimed at decreasing the level of gender discrepancy.

This gender survey has shown that redistribution of gender roles in the family take place in the rural areas. Men are losing the status of "bread-winners"; at the same time, search for job forces many rural inhabitants to leave their households for other regions. All these factors considerably affect the social stability and result in imbalance within households and families. The status of rural women is aggravated by greater workload resulted from non-paid housekeeping labor and traditional possession of many children. A few major factors that strengthen the rural women's vulnerability were specified, and among them the following:

- "the time deficit" due to intensive and non-payable housekeeping labor that restricts considerably the women opportunities;
- the lack of proper conditions of life (running water, power cut, and irregular gas supply) that aggravates the problem of housekeeping;
- as long as women, in considerable less extent, occupy leading management positions in the agricultural sector, they have less organizational skill. At the same time, the gender survey has shown that women are more active in comparing with men in matters of introducing a new agricultural practice and principles of self-organization;
- the low level of representation of women in local governments predetermined the fact that rural women did not practically participate in privatization of enterprises;
- agricultural activities presumes the greater participation of women. At the same time, women are engaged in low-paying and low-skill works with the low level of labor efficiency;
- women have to spend more time on their garden plots to supply foodstuff to their families. Output produced in households due to the lack of machinery, insufficient funds, undeveloped market and sale system does not generate any income. It means that women are mostly busy in producing non-marketable agricultural products;
- traditional views on gender-based social roles negatively affect social and income-generation activities of women in the rural regions. Incidents of family violence with respect to women take place.
- increase in the workload on women that is related to up-bringing of their children due to decline in the social security and the number of nursary schools; along with children, disabled workers, war veterans and pensioners are major consumers of social services.
- the low level of access to education and in this connection the lack of professional skill do not promote women to be more active at the labor market; and

- limited opportunities for proper leisure and entertainment due to the lack or non-functioning rural cultural centers.

## Gender Aspects of the IWRM-Fergana Project

One of the IWRM tools is social mechanisms. This includes i) training of younger generation; ii) involving water users and other stakeholders in water resources management; iii) training water users and other stakeholders; iv) public participation; v) partnership of governmental and community-based organizations; vi) establishing good relations between stakeholders and WMOs; vii) use of traditions and public experience; viii) water ethics; ix) social mobilization; x) guarantees of water supply to the poor; and xi) public awareness. Each of above mentioned mechanisms should be reviewed from the gender aspects.

Gender analysis implemented under the IWRM-Fergana Project has shown that yet there is gender imbalances in water resources management (Table 5.45).

There were 2157 people participated in the trainings and seminars, out of which only 166 were women. Following was the gender distribution over the training components: i) water distribution on pilot canals – 520 men and 52 women; ii) WUAs' activities – 373 men and 17 women; iii) farm practice – 1047 men and 91 women. A percentage of women, who have attended the training seminars amounts to 7% on average. This percentage is ranging from 3% to 12% over the countries (Figure 5.46).

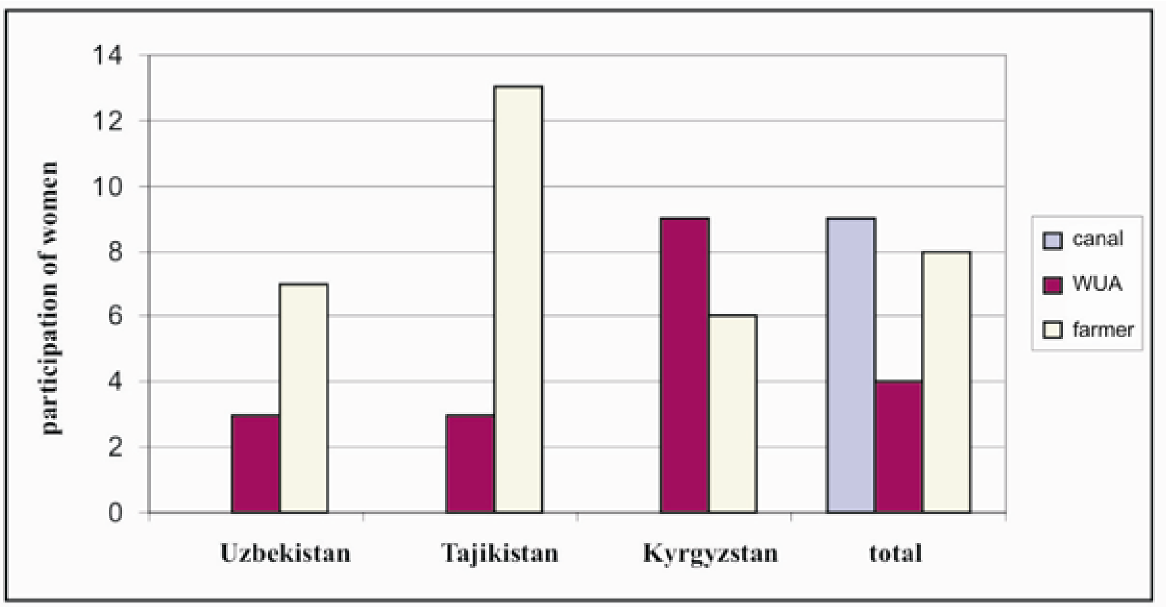


**Figure 5.46 Participation of Women in Training Activities of the IWRM-Fergana Project**

However, it is necessary to note that the level of women's business activities is rising in rural areas; and women-leaders are appearing. For example, Mrs. Masturkhon Sayfutdinova is the chair of the Canal Water Users Council that was established for the first time in Central Asia. Such leaders, having the considerable experiences in agriculture and governance, crush the social stereotypes of perception of women as housewives who do unskilled works in a field. Changing social conditions force many women to manage their farms without any assistance. In Uzbekistan, for instance, women head 17,000 out of 212,000 private farms. Their social activeness should be supported by raising their gender awareness and professional development.

In the Akhunbabaev District of Fergana Province in Uzbekistan, about 10% of the executive positions, such as Deputy Khakim of the District, chief editor of the daily newspaper, municipal chief engineers, chief bookkeepers, are women. Women make a considerable contribution into the family budget. Taking into account that income from smallholdings amounts to 19% of the total, this share of incomes can mainly be referred to as result of female labor.

In Jabbar-Rasulov District in Soghd Province, women are mainly responsible for the potable water supply since only 14% of households have running water in their courtyards. Other 86% of residents carry water using bicycles and handcarts or buckets. Out of these women provide 95%. It would be interesting to know what the right to distribute water in households belong to women (82.9%), at the same time, in private farms – only 9.7%! However, at present, due to considerable migration of men for labor (migrant workers), the number of women playing the role of irrigators and water managers has drastically increased.

### *Measures recommended providing gender equality in Center Asia*

The gender survey enabled us to make a conclusion that discrimination of rural women in access to water resources and water management negatively affect the general social status of women. To improve this situation it is necessary to implement a complex of measures, including the following actions:

1. Conduct training courses covering matters of water use and management for the groups consisting mainly of women. The curricula for these courses should include learning water-saving technique and methods of water management;
2. promoting establishment of water users' groups, at the same time, women who participated in the training courses should be initiators of establishing water users' groups (WUGs), and their major actors;
3. conducting the campaigns that popularize the ideas of establishing rural WUGs, practical application of water-saving technologies, installation of water-metering devices etc.;
4. supporting initiatives, which facilitate protection of water sources from pollution, their development and improving their sanitary conditions; and
5. Organizing workshops for exchanging experiences in the field of water use with invited water professionals and representatives of the regions where WUGs were already established and successfully operate.

It is necessary to promote formation of budgets seeking additional financial resources for social aid to rural residents. Rural women should be considered as a specific target group. At the same time, it is necessary to take into account diversity of social groups living in specific regions and conditions of their life, and closely cooperate with activists of non-governmental organizations created in the regions, whose activities address gender issues.

There is a need for Gender Study Centers, the purpose of which will be promotion of public awareness with respect to gender issues, dissemination of knowledge produced by social and humanitarian sciences regarding gender aspects, developing the gender curriculum for educational institutions, as well as implementing the gender educational programs and pilot projects.

At present, the website "Gender and Water" on the Internet portal "CAWATER" and the project "GWANET" (the Central Asian Gender and Water Network) that was initiated by the SIC ICWC and financed by the ADB, with the purpose of establishing informal network for disseminating knowledge, analyzing gender situation in the water sector and to forward problems and proposals to decision-makers can be considered as a substantial progress in raising awareness on this topic in Central Asia.

## Gender Balance

| Indicator | Country | | | | | | | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Uzbekistan | | | Tajikistan | | | Kyrgyzstan | | | | | |
| | **male** | **female** | **total** | **male** | **female** | **total** | **male** | **female** | **total** | **male** | **female** | **total** |
| Project personnel | 104 | 11 | 115 | 24 | 1 | 25 | 23 | 2 | 25 | 151 | 14 | 165 |
| Training participants: | | | | | | | | | | | | |
| Topic: CC activities | | | | | | | | | | 520 | 52 | 572 |
| Topic: WUA's activities | 231 | 8 | 239 | 69 | 2 | 71 | 73 | 7 | 80 | 373 | 17 | 390 |
| including: | 8 | - | 8 | 2 | - | 2 | 1 | - | 1 | 11 | - | 11 |
| *Council Chairman* | 54 | 1 | 55 | 3 | - | 3 | 7 | - | 7 | 64 | 1 | 65 |
| | - | 1 | 1 | - | - | - | 5 | - | 5 | 5 | 1 | 6 |
| *WUA director* | 106 | 1 | 107 | 32 | - | 32 | 29 | 1 | 30 | 167 | 2 | 169 |
| *WAG leader* | | | | | | | | | | | | |
| *WUA members* | 40 | 3 | 43 | 16 | 2 | 18 | 15 | 6 | 21 | 71 | 11 | 82 |
| | 586 | 40 | 626 | 235 | 37 | 272 | 226 | 14 | 240 | 1047 | 91 | 1138 |
| *WMO* | 30 | 4 | 34 | 10 | 1 | 11 | 11 | 1 | 12 | 51 | 6 | 57 |
| Topic: Activities at the farmers' level | | | | | | | | | | | | |
| TC of the SIC | | | | | | | | | | | | |
| Board composition of the CWUC | 6 | 1 | 7 | 5 | 0 | 5 | 7 | 0 | 7 | 18 | 1 | 19 |
| Composition of branches' boards | 62 | 2 | 64 | | | | | | | | | |

## The IWRM-Fergana Phase-III Project: Component «Pilot Canals»

### *I. Composition of Project Team*

| No | Specialists | Number of members | Incl.: women |
|---|---|---|---|
| 1 | Regional group | **13** | **2** |
| 2 | Local groups (total):<br>including:<br>- in SFC command area<br>- in AAC command area<br>- in KBC command area | **34**<br><br>19<br>8<br>7 | **4**<br><br>2<br>1<br>1 |
| | **Total:** | **47** | **6** |

### *II. Composition of Training Seminars' participants*[57]

| No | Year | Number of participants | Incl.: women |
|---|---|---|---|
| 1 | 2005 | 53 | 4 |
| 2 | 2006 | 264 | 31 |
| 3 | 2007 | 255 | 17 |
| | **Total:** | **572** | **52** |

### *III. Composition of Boards of the Canal Water Users Unions*

| No | Pilot Canal | Number of members | Incl.: women |
|---|---|---|---|
| 1 | SFC | 7 | 1 |
| 2 | AAC | 7 | |
| 3 | KBC | 5 | |
| | **Total:** | **19** | **1** |

[57] Since May 1, 2005 until September 15, 2007

### *IV. Composition of Branches' Boards of the SFC Water Users Union*

| No | Hydro-operational site | Number of members | Including: women |
|---|---|---|---|
| 1 | K-1 | 5 | |
| 2 | Aravan | 7 | |
| 3 | Khamza | 7 | |
| 4 | Besholish | 9 | |
| 5 | Margilan | 5 | |
| 6 | Fayzabad | 7 | 1 |
| 7 | Palvantash | 5 | |
| 8 | KFC | 7 | |
| 9 | Akbarabad | 7 | 1 |
| 10 | Shalhrikansay | 5 | |
| | **Total:** | **64** | **2** |