Water Use Aimed at Enhancing Land and Water Productivity

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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.

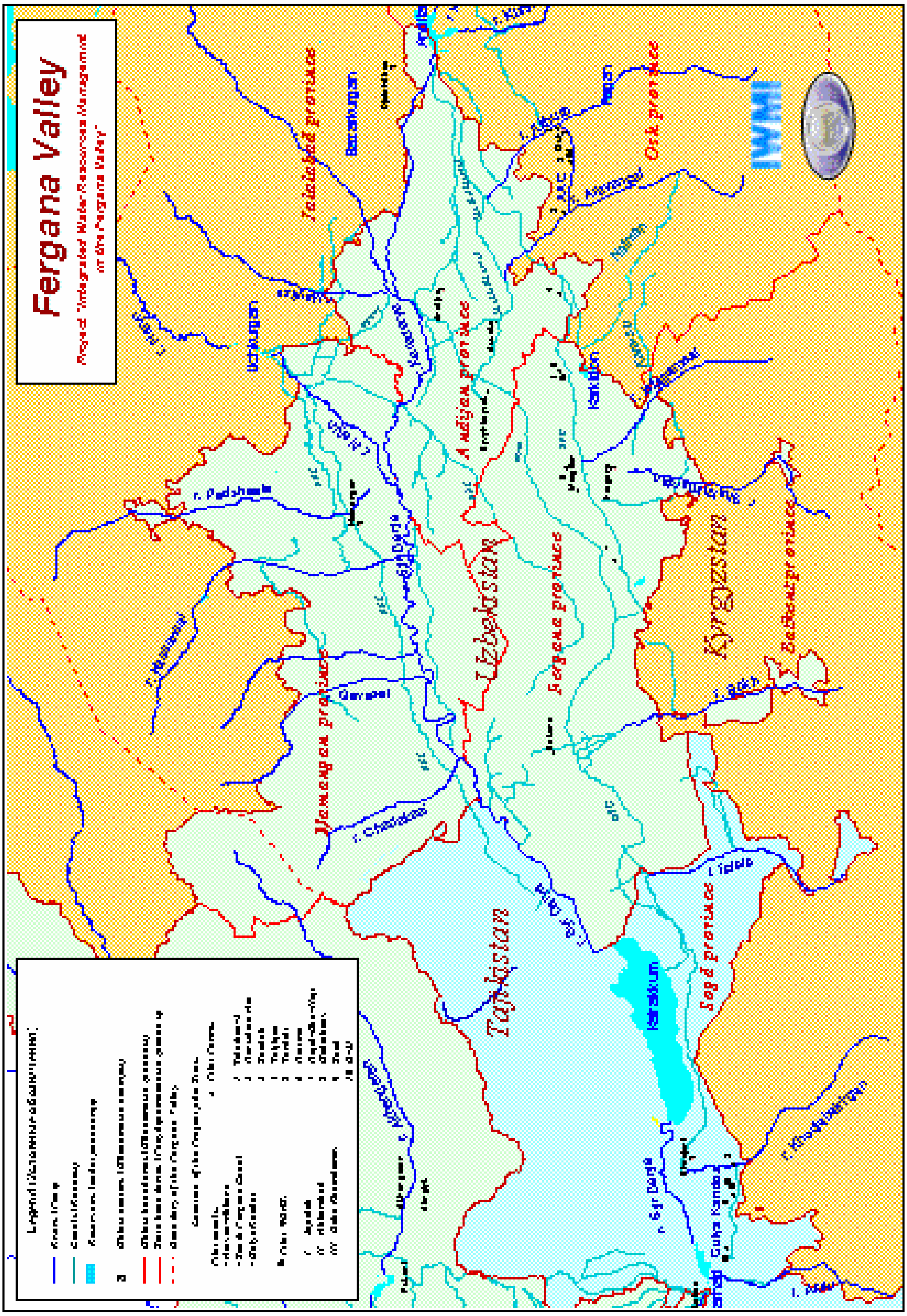

Figure 5. 27 The Fergana Valley: the Pilot IWRM-Fergana Project's Area

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[1] uplands	500 to 800 m	Thick topsoil of loam and sandy loam	GWT>5 m
PF «Nursultan-Ali»	Adyry[1] uplands	500 to 800 m	Stony loam underlain by pebble	GWT>5 m
PF «Toloykon»	Adyry[1] uplands	500 to 800 m	Stony sandy loam underlain by pebble	GWT>5 m
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»	Inter-adyry depressions	400 to 500 m	Topsoil of sandy loam of 0.5 to 0.7 m underlain by pebble	GWT>5 m

[1] Low foothills bordering the Fergana depression

DF «Samatov»			Topsoil of sandy loam of 0.5 to 0.7 m underlain by pebble	

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[2] 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).

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			

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

		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-	Sandy loam	0.5- 0.7	pebbles	**II - the zone of steep**	B - high permeability

ona-Khoji"				**slopes**	
				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
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").

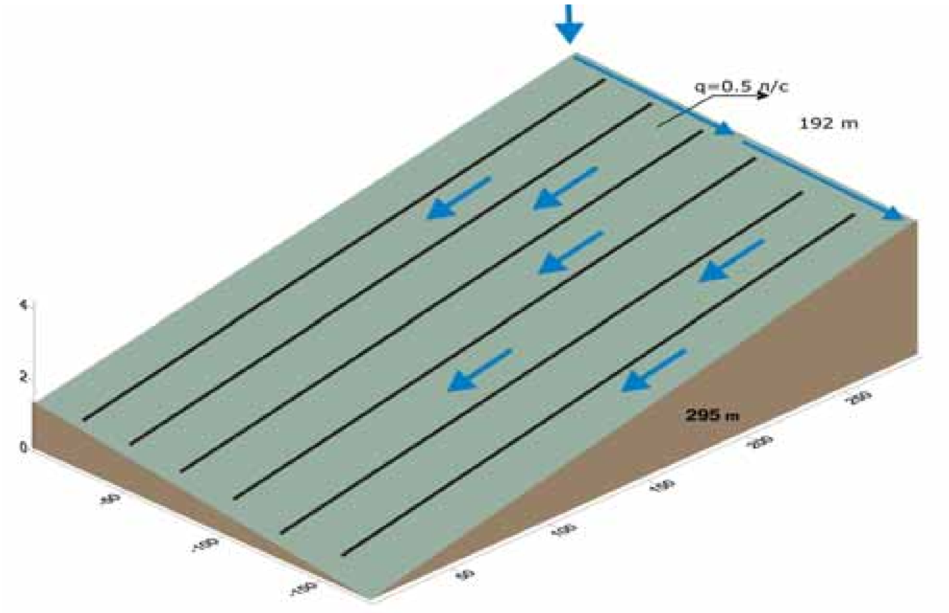

Figure 5.28 Parameters of the Furrow Irrigation System in PF "Khojalkhon-ona-Khoji" (2002)

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.

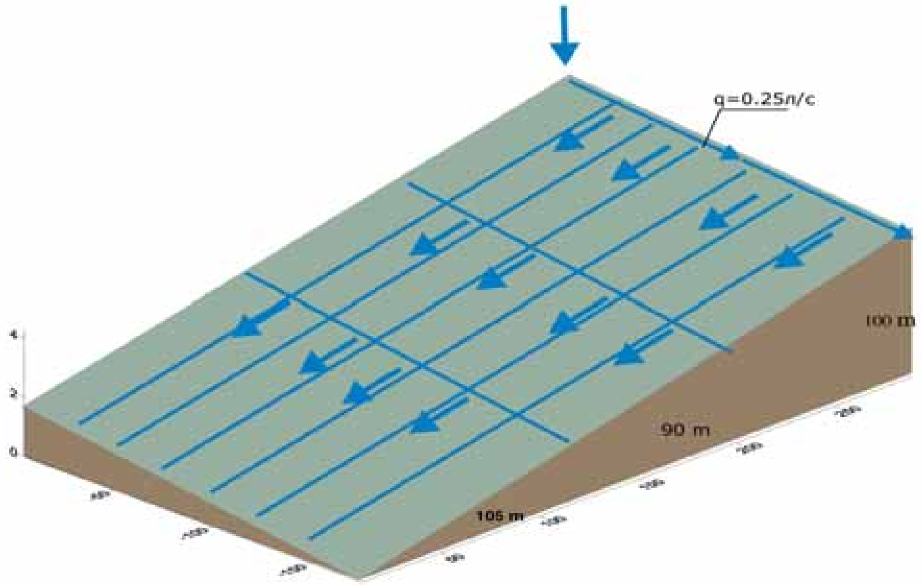

Figure 5. 29 Parameters of the Furrow Irrigation System Recommended for PF "Khojalkhon-ona-Khoji" (2003)

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)

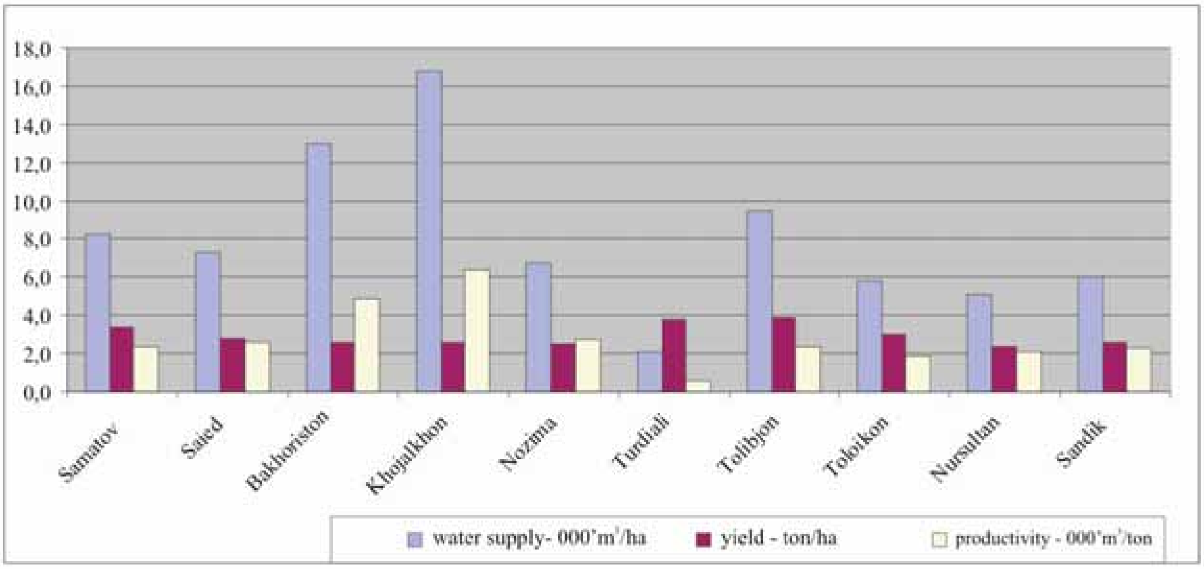

Figure 5.30 Assessment of the Actual Irrigation Water Productivity

Note: where Nf – an actual irrigation rate; РУ- 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 m3/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.

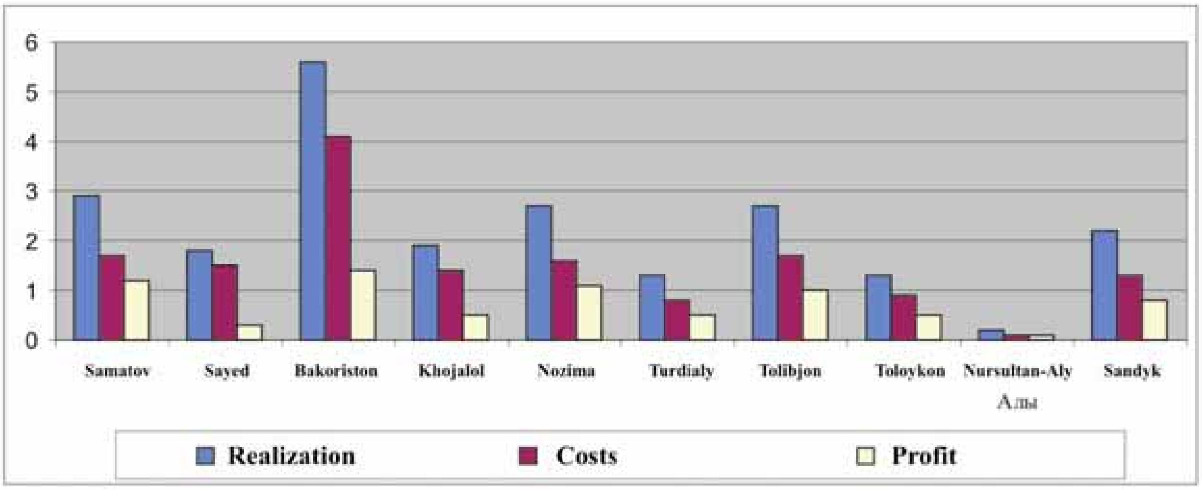

Figure 5.31 Economic Assessment of Agricultural Production

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.