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

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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

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

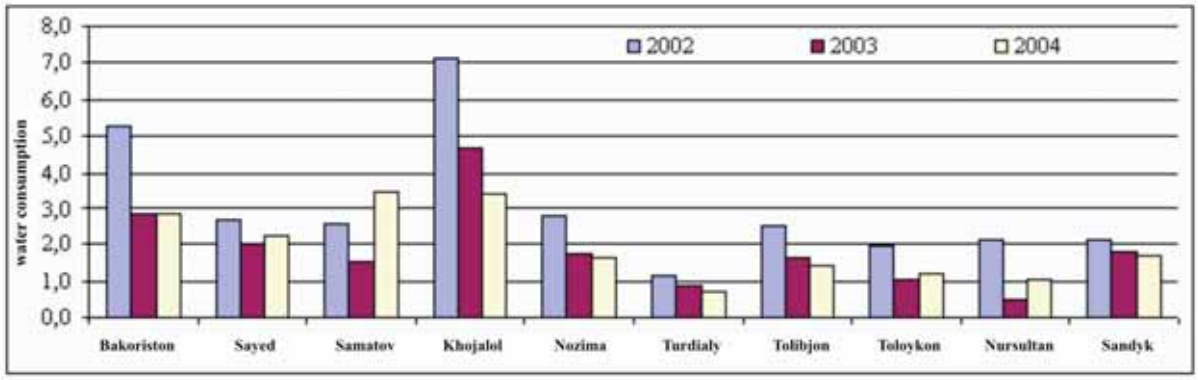

Figure 5. 32 Irrigation Water Consumption for Crop Growing at Project Demonstration Sites

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.

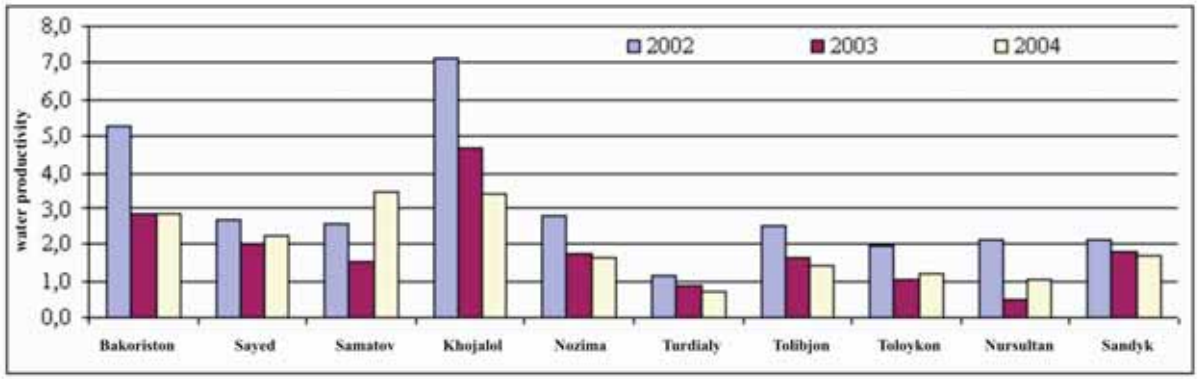

Figure 5.33 Irrigation Water Productivity

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

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 ($/ra)	158.5	307.8	467.8	165.2	1166.9	880.9	127.5	635.6	828.1

Indicator	Country								
	Uzbekistan			Kyrgyzstan			Tajikistan		
	2002	2003	2004	2002	2003	2004	2002	2003	2004
Irrigation water productivity ($/ths.m^3)	49.9	137.5	189.3	70.9	263.1	197.5	47.8	164.5	175.7

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

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.