

13. TRENDS IN WATER PRODUCTIVITY ON MAIN CROPS

13.1 Actual Productivity of Irrigation Water in Field

For evaluation of irrigation application efficiency along with some other indices so called irrigation efficiency coefficient is used (derived by S.A. Delinikaitis). This coefficient reflects volume of irrigation water used for production of additional one ton of yield (received due to irrigation) and can be expressed by the following equation:

$$K_{ir} = W/(Y_{ir} - Y_d) \quad (13.1)$$

where:

W - specific volume of water used for irrigation of crop (tcm/ha);

Y_{ir} - yield under irrigation (t/ha);

Y_d - yield of the same crop without irrigation (rain fed) (t/ha).

Coefficient of irrigation productivity (**P_{ir-crop}**) has the same meaning, but expressed by different equation.

$$P_{ir-crop} = (Y_{ir} - Y_d) / Mo \quad (13.2)$$

This coefficient is the index of volume of production, produced per unit of water applied. Certainly, more comprehensive understanding of water use productivity can be provided by all indices of the above equation expressed in monetary term, because in this case only it will be possible to compare water productivity for different crops, taking into account difference in water prices in CAR. At the same time, such approach allows to evaluate in the first approximation the main trends in water resources use on on-farm level.

Efficiency of irrigation water use per unit of agricultural production (tcm/t) for main crops on sample fields in all region is shown in Table 13.1.

Total volume of water used for irrigation at field intake includes pre-irrigation and leaching. For comparability of evaluations data for two agricultural years, 1997 and 1998, were used, because in 1996 field monitoring was started at 1 April 1996 and volume of water used during dormant period (01.10.95-31.03.96) was not recorded.

13.2 Cotton

Evaluation was made on the basis of data for 117 cotton fields in 1998 (in 1997 there were 95 cotton fields). On average by 117 cotton fields in 1998 gross water supply to field intake was 6.15 tcm/ha as compared with 7.07 tcm/ha in 1997. The reduction was almost 1 tcm/ha. There was some reduction of water use per unit of production from 2.97 tcm/t in 1997 to 2.72 tcm/t in 1998.

Table 13.1. Use of Irrigation Water on Main Crops

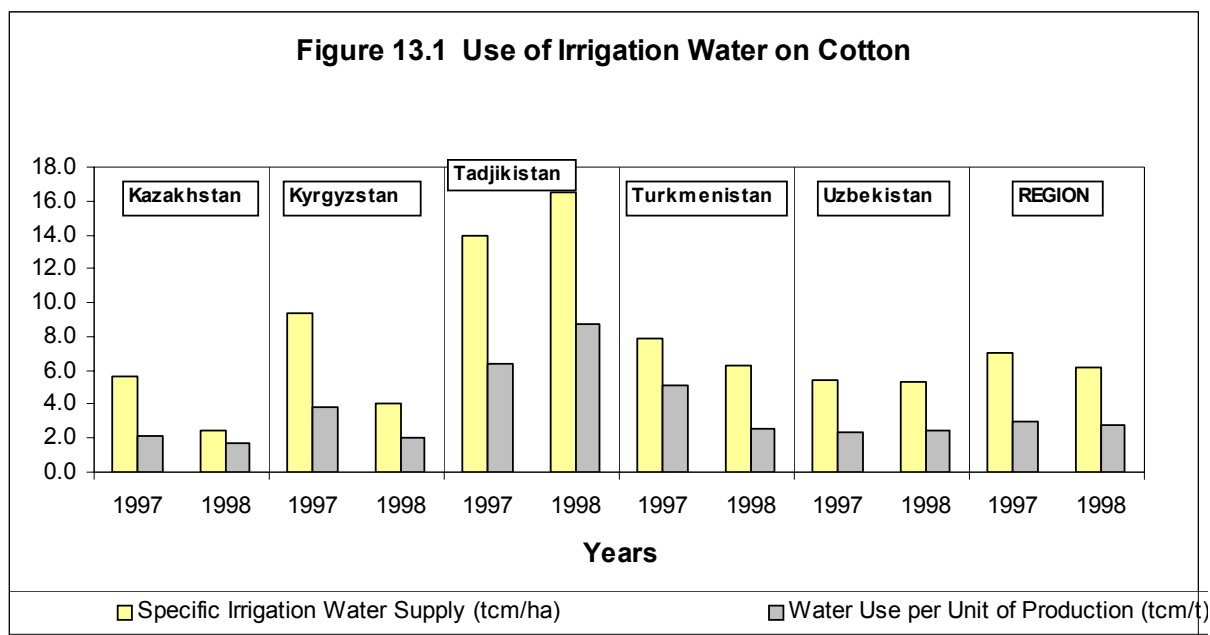
Cotton	Kazakhstan		Kyrgyzstan		Tadjikistan		Turkmenistan		Uzbekistan		Average	
	1997	1998	1997	1998	1997	1998	1997	1998	1997	1998	1997	1998
Number of sample fields	13	16	13	10	10	13	9	10	50	68	95	117
Specific water irrigation water supply (tcm/ha)	5.62	2.41	9.36	4.07	13.96	16.47	7.85	6.24	5.48	5.34	7.07	6.15
Yield (t/ha)	2.58	1.41	2.42	1.86	1.77	2.06	2.71	2.47	2.38	2.53	2.38	2.26
Productivity of irrigation water (t/tcm)	0.46	0.58	0.26	0.46	0.13	0.13	0.35	0.40	0.43	0.47	0.34	0.37
Use of water per unit of crop production (tcm/t)	2.18	1.71	3.87	2.04	6.38	8.77	5.15	2.53	2.30	2.41	2.97	2.72
Return per unit of water used (\$/tcm)	181.8	141.4	81.5	45.1	35.9	30.3	72.0	57.8	38.0	47.6	67.0	59.1
Wheat	1997	1998	1997	1998	1997	1998	1997	1998	1997	1998	1997	1998
Number of sample fields	2		8	7	3		8	7	24	24	45	38
Specific water irrigation water supply (tcm/ha)	1.04		5.58	2.15	6.97		8.05	6.06	3.57	3.88	4.76	3.97
Yield (t/ha)	1.85		3.16	2.91	2.88		1.67	1.40	2.60	2.57	2.52	2.42
Productivity of irrigation water (t/tcm)	1.78		0.57	1.35	0.41		0.21	0.23	0.73	0.66	0.53	0.61
Use of water per unit of crop production (tcm/t)	0.56		1.77	0.74	2.42		4.82	4.33	1.37	1.51	1.89	1.64
Return per unit of water used (\$/tcm)	61.8		61.7	45.1	10.6		-4.3	-4.9	-18.4	-0.2	2.5	7.5
Lucerne	1997	1998	1997	1998	1997	1998	1997	1998	1997	1998	1997	1998
Number of sample fields	4		4	4	1	1	3	1	8	8	20	14
Specific water irrigation water supply (tcm/ha)	1.14		7.22	3.99	13.44	13.28	3.64	6.81	4.06	5.35	4.51	5.65
Yield (t/ha)	1.81		22.04	27.49	25.42	25.42	16.18	26.47	35.27	24.22	22.58	25.40
Productivity of irrigation water (t/tcm)	1.59		3.05	6.89	1.89	1.91	4.45	3.89	8.69	4.53	5.01	4.50
Use of water per unit of crop production (tcm/t)	0.63		0.33	0.15	0.53	0.52	0.22	0.26	0.12	0.22	0.20	0.22
Return per unit of water used (\$/tcm)	31.8		21.7	72.4	-11.0	-13.4	-33.8	-1.3	-57.0	-12.0	-17.7	14.7
Rice	1997	1998	1997	1998	1997	1998	1997	1998	1997	1998	1997	1998
Number of sample fields	14	11							8	9	22	20
Specific water irrigation water supply (tcm/ha)	18.88	31.74							20.65	26.04	19.52	29.17
Yield (t/ha)	3.37	3.12							3.83	4.40	3.55	3.70
Productivity of irrigation water (t/tcm)	0.18	0.10							0.19	0.17	0.18	0.13
Use of water per unit of crop production (tcm/t)	5.60	10.17							5.39	5.92	5.50	7.88
Return per unit of water used (\$/tcm)	11.3	14.1							24.5	19.8	16.1	16.7

In 1998 productivity of water use (in physical term) also was increased up to 0.37 t/tcm as against 0.34 t/tcm in 1997. But at the same time return per unit of water used was dropped from 67 \$/tcm in 1997 to 59.1 \$/tcm in 1998 due to reduction of yield (from 2.38 t/ha in 1997 to 2.26 t/ha in 1998) and increase of production costs.

Comparison of data by between republics of the region shows more chequered picture. Cotton fields received less irrigation water practically in all republics (except Tadjikistan) in 1998 as against 1997:

- in Kazakhstan it was 2.41 tcm/ha as against 5.62 tcm/ha in 1997;
- in Kyrgyzstan it was 4.07 tcm/ha as against 9.36 tcm/ha in 1997;
- in Turkmenistan it was 6.24 tcm/ha as against 7.85 tcm/ha in 1997;
- in Uzbekistan it was 5.34 tcm/ha as against 5.48 tcm/ha in 1997.

In Tadjikistan water supply is increased and it was 16.47 tcm/ha as against 13.96tcm/ha in 1997.



Taking into account contribution from effective rainfall and high groundwater table water availability for the majority of cotton fields was close to crop water requirements in Kazakhstan, Turkmenistan and Uzbekistan. But it seems that share of water actually used by crop was rather small due to nonconcurrency between actual date of water supply and date of actual demand of water for crop. In WUFMAS 1997 Report balance between water supply and water use by crop on the level of field is analyzed in more detail.

Use of water per unit of production was reduced in accordance with reduction of specific water supply with the exception of Tadjikistan, where water use per unit of production was higher, 8.77tcm/t as against 6.38 tcm/t in 1997. In Turkmenistan and Uzbekistan water use per unit of production is on the same level, but higher than it is in Turkmenistan and Kyrgyzstan. However, along with these relatively good indices of efficiency of water use in 1998, there is an evidence of yield reduction. It is especially sharp in Kazakhstan (from 2.58 t/ha in 1997 to 1.41 t/ha in 1998) and in Kyrgyzstan (from 2.42 t/ha in 1997 to 1.86 t/ha in 1998).

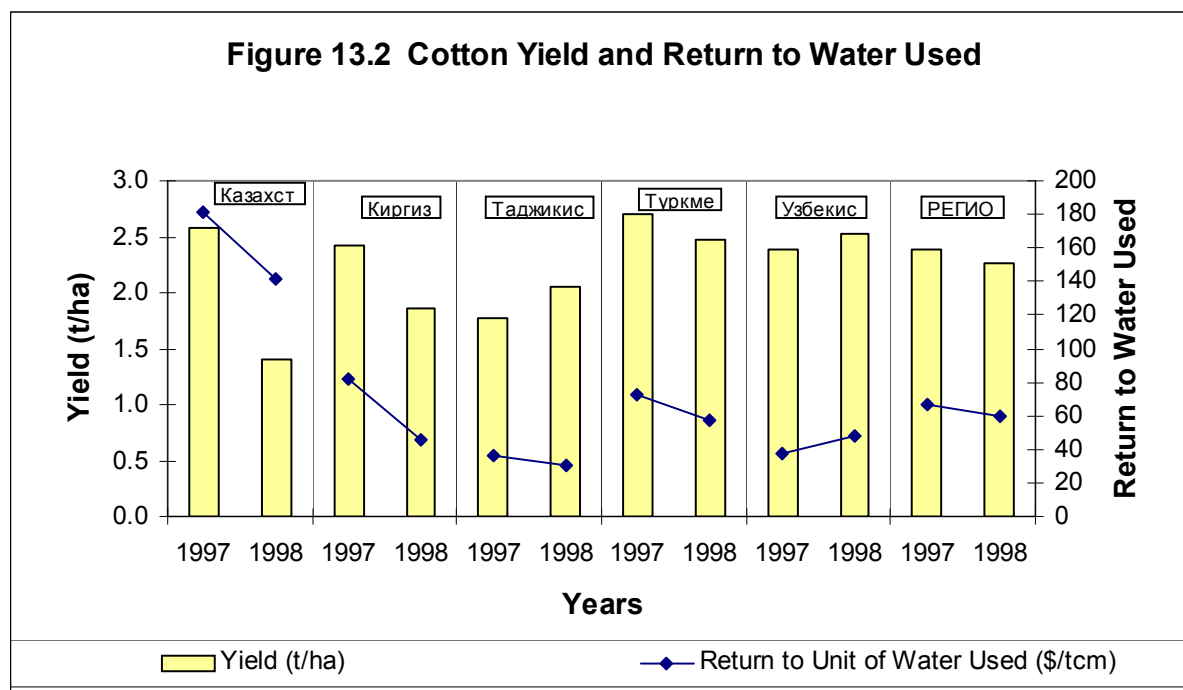
Some yield increase was recorded in Tadjikistan (from 1.77 t/ha in 1997 to 2.06 t/ha in 1998) and in Uzbekistan (from 2.03 t/ha in 1997 to 2.41 t/ha in 1998).

Return per unit of water used was reduced as against 1997 practically in all republics except Uzbekistan:

- in Kazakhstan it was short by 40.4 \$/tcm;
- in Kyrgyzstan it was short by 36.4 \$/tcm;
- in Turkmenistan it was short by 14.2 \$/tcm;
- in Tadjikistan it was short by 5.6 \$/tcm.

In Uzbekistan return per unit of water used was increased by 7.9 \$/tcm in 1998 as against 1997.

In 1998 the highest return per unit of water used 141.4 \$/tcm was recorder in Kazakhstan. Such high return was achieved from cotton fields of private farms, because low scale farming allows eliminating a lot of expenses, unavoidable in large state farms.



13.3 Winter Wheat

Evaluation was made on the basis of data for 38 winter wheat fields in 1998 (in 1997 there were 45 winter wheat fields). On average by all winter wheat fields in 1998 gross water supply to field intake was 3.97 tcm/ha as compared with 4.76 tcm/ha in 1997. There was some reduction of water use per unit of production from 1.89 tcm/t in 1997 to 1.64 tcm/t in 1998.

In 1998 productivity of water use (in physical term) was increased up to 0.61 t/tcm as against 0.53 t/tcm in 1997. Return per unit of water used was also increased from 2.5 \$/tcm in 1997 to 7.5 \$/tcm in 1998.

In Kyrgyzstan specific water supply to winter wheat was almost halved, 2.15 tcm/ha as against 5.58 tcm/ha in 1997. In Turkmenistan water supply to winter wheat was short by 2 tcm/ha (6.06 tcm/ha as against 8.05 tcm/ha in 1997).

In Uzbekistan specific water supply was slightly higher in 1998 (3.88 tcm/ha as against 3.57 tcm/ha in 1997).

Along with reduction of specific water supply, use of water per unit of production was also reduced in Kyrgyzstan and Turkmenistan:

- in Kyrgyzstan it was 0.74 tcm/t as against 1.77 tcm/t in 1997;
- in Turkmenistan it was 4.33 tcm/t as against 4.88 tcm/t in 1997.

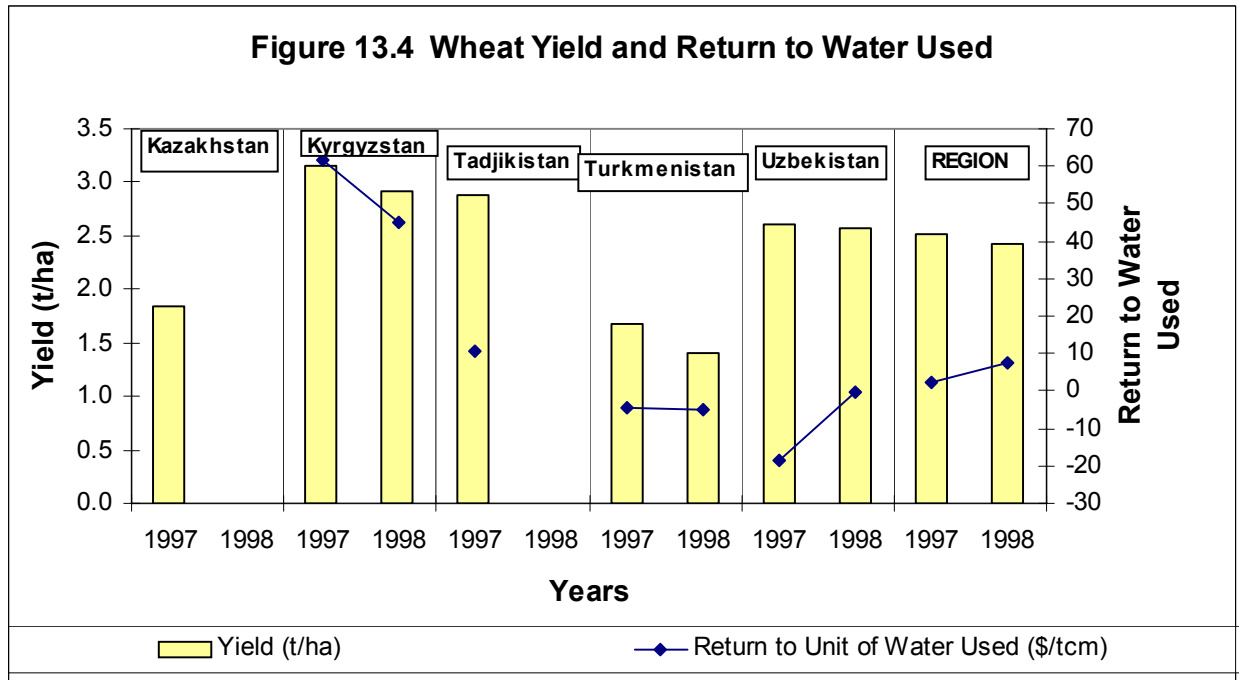
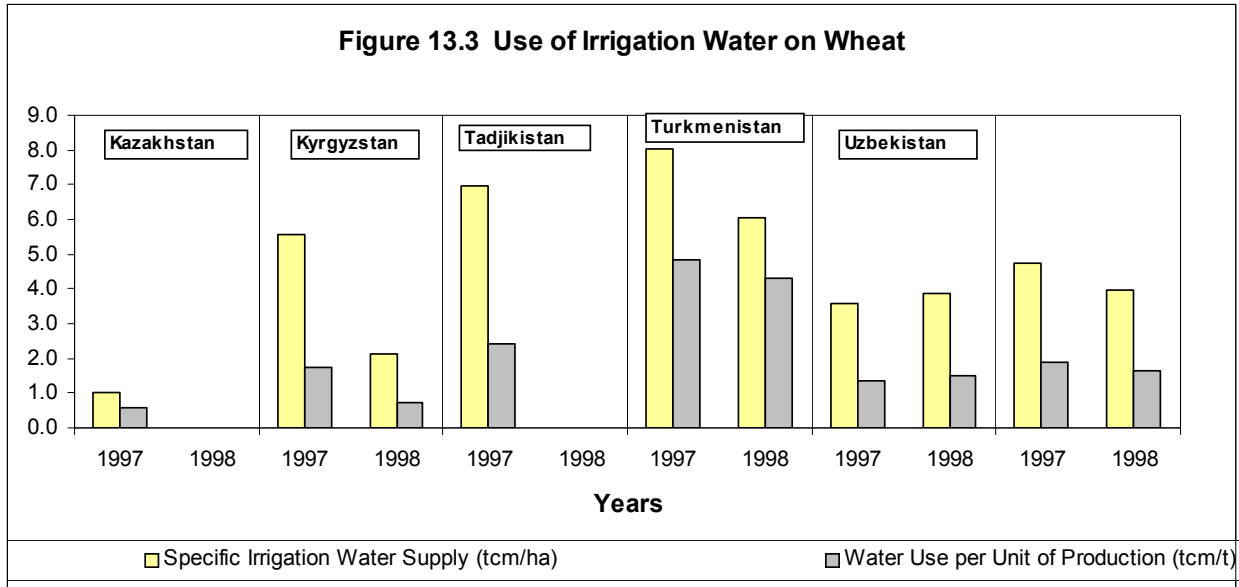
In Uzbekistan use of water per unit of production was slightly higher in 1998, 1.51 tcm/t as against 1.37 tcm/t in 1998.

At the same time there was some reduction of winter wheat yield:

- in Kyrgyzstan it was 2.91 t/ha as against 3.16 t/ha in 1997;
- in Turkmenistan it was 1.40 t/ha as against 1.67 t/ha in 1997;
- in Uzbekistan it was 2.57 t/h as against 2.60 t/ha in 1997.

In Kyrgyzstan return per unit of irrigation water used was reduced to 45.1\$/tcm as against 61.7\$/tcm in 1997.

In Turkmenistan negative return per unit of water used was increased to 4.9 \$/tcm as against 4.3 \$/tcm in 1997.
 In Uzbekistan negative return per unit of water used was decreased to 0.2 \$/tcm as against 18.4 \$/tcm in 1997.

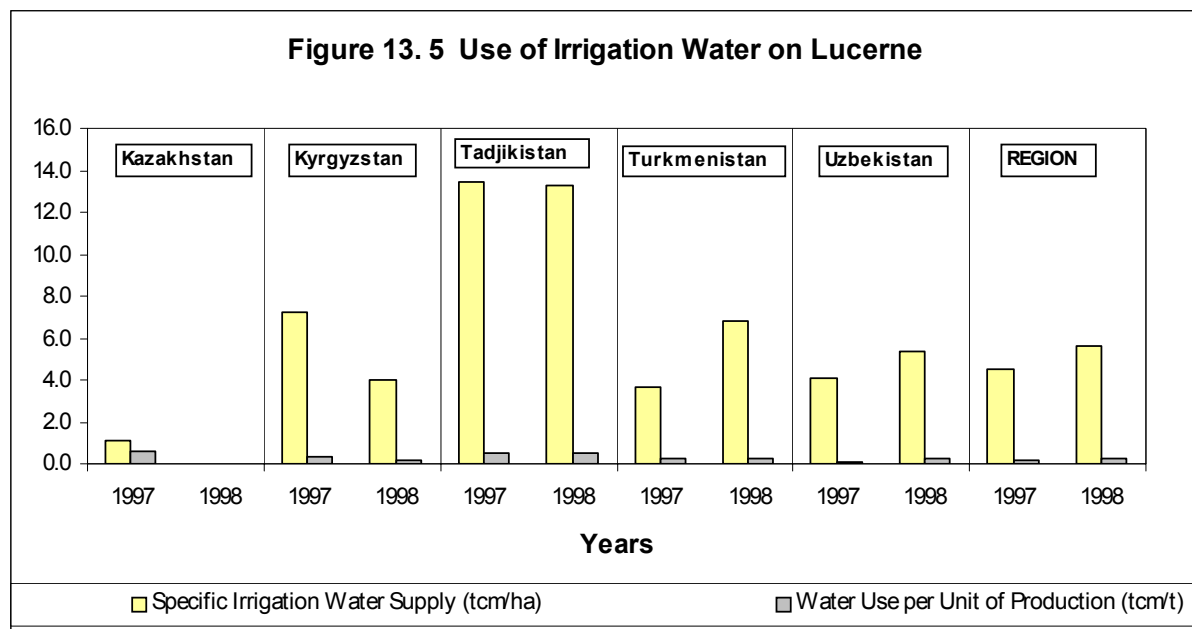


13.4 Lucerne

Evaluation was made on the basis of data for 14 lucerne fields in 1998 (in 1997 there were 20 lucerne fields). On average by all lucerne fields in 1998 gross water supply to field intake was 5.65 tcm/ha as compared with 4.51 tcm/ha in 1997. There was some increase of water use per unit of production from 0.20 tcm/t in 1997 to 0.22 tcm/t in 1998.

In 1998 productivity of water use (in physical term) was decreased to 4.50 t/tcm as against 5.01 t/tcm in 1997. But return per unit of water used was increased to 14.7 \$/tcm in 1998^{*)} (as against losses of 17.7 \$/tcm in 1997).

In Kyrgyzstan specific water supply to lucerne was almost halved, 3.99 tcm/ha as against 7.22 tcm/ha in 1997. Conversely, in Turkmenistan water supply was almost twice as much as compared with 1997, 6.81 tcm/ha as against 3.64 tcm/ha in 1997.



^{*)} This is because in the majority of field lucerne was grown for seeds in 1998.

In Tadjikistan there was some reduction of specific water supply to lucerne fields from 13.44tcm/ha to 13.28 tcm/ha in 1998. In Uzbekistan specific water supply was increased a little bit from 4.06tcm/ha to 5.35 tcm/ha in 1998.

Use of water per unit of production was reduced in accordance with reduction of specific water supply:

- in Kyrgyzstan it was 0.15 tcm/t as against 0.33 tcm/t in 1997;
- in Tadjikistan it was 0.52 tcm/t as against 0.53 tcm/t in 1997.

Use of water per unit of production was increased in Turkmenistan (from 0.22 tcm/t to 0.26 tcm/t in 1998) and Uzbekistan (from 0.12 tcm/t to 0.22 tcm/t in 1998).

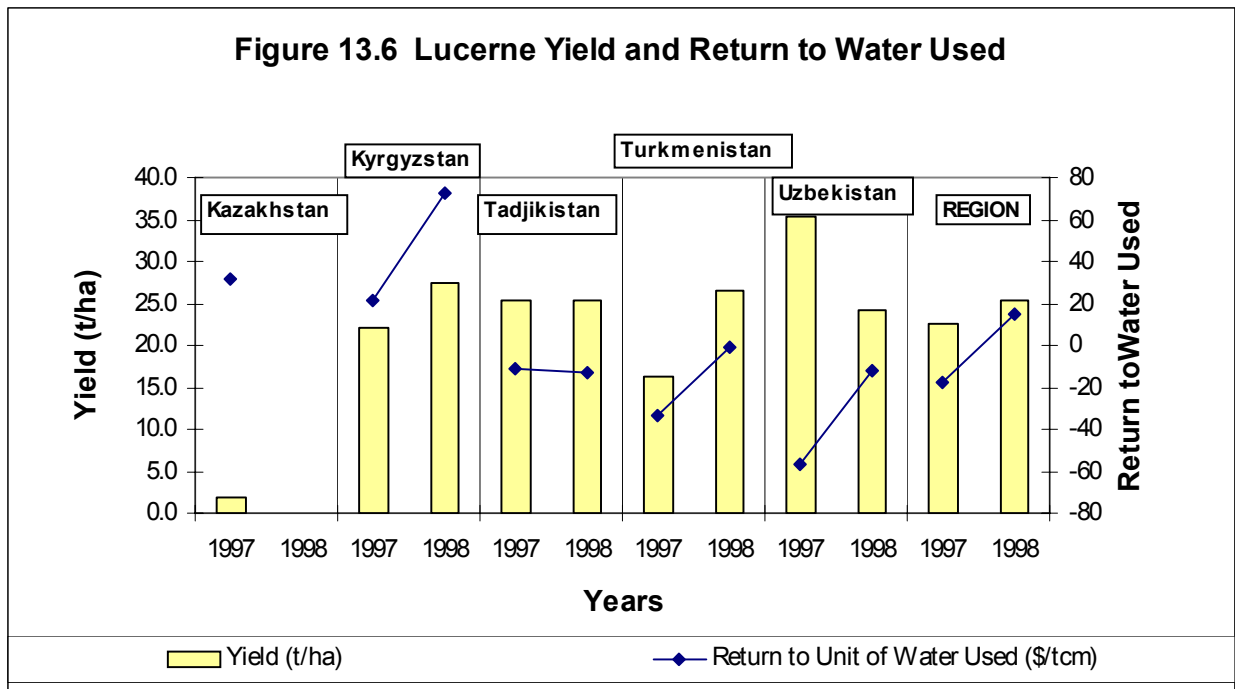
With overall average increase in lucerne yield up to 25.40 t/ha as against 22.58 t/ha in 1997, reduction of yield was recorded in Uzbekistan (from 35,27 t/ha to 24.22 t/ha in 1998. In the rest of republics lucerne yield was as following:

- in Kyrgyzstan it was 27.49 t/ha as against 22.04 t/ha in 1997;
- in Tadjikistan it was on the same level of 25.42 t/ha in 1997 and 1998;
- in Turkmenistan it was 26.47 t/ha as against 16.18 t/ha in 1997.

In Kyrgyzstan for the reason mentioned above return per unit of water used was significantly increased up to 72.4 \$/tcm as against 21.7 \$/tcm in 1997.

Negative return per unit of water used was reduced in Turkmenistan (from 33.8 \$/tcm to 1.3 \$/tcm in 1998) and Uzbekistan (from 57.0 \$/tcm to 12 \$/tcm in 1998).

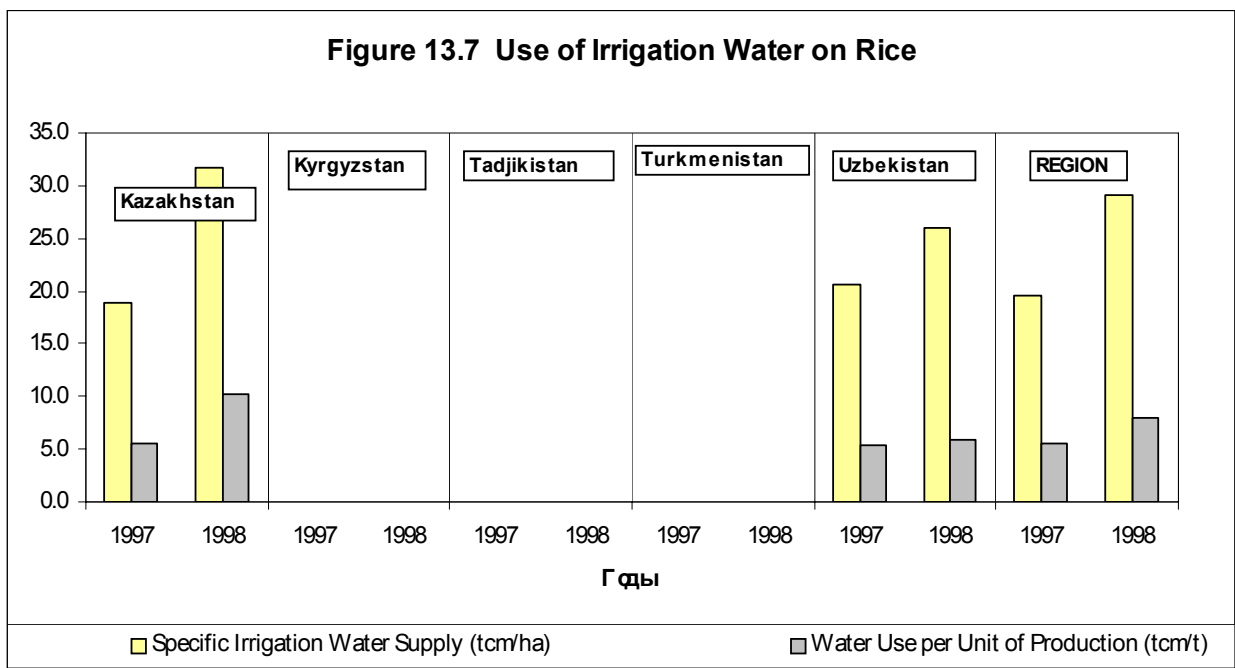
In Turkmenistan negative return was increased from 11.0 \$/tcm to 13.4 \$/tcm.



13.5 Rice

Evaluation was made on the basis of data for 20 rice fields in 1998 (in 1997 there were 22 lucerne fields) in Kazakhstan and Uzbekistan. On average by all lucerne fields in 1998 gross water supply to field intake was significantly greater than in 1997 (29.17 tcm/ha as compared with 19.52 tcm/ha in 1997).

Use of irrigation water per unit of production was increased up to 7.88 tcm/t as against 5.50 tcm/t in 1997.



In 1998 productivity of water use (in physical term) was decreased to 0.13 t/tcm as against 0.18t/tcm in 1997, but at the same time return per unit of water used was increased a little bit (from 16.1 \$/tcm to 16.7 \$/tcm in 1998). Specific water supply to rice fields was increased in Kazakhstan

(from 18.88 tcm/ha to 31.74 tcm/ha in 1998) and Uzbekistan (from 20.65 tcm/ha to 26.04 tcm/ha in 1998).

Use of water per unit of production was also increased in Kazakhstan (from 5.60 tcm/t to 10.17tcm/t in 1998) and Uzbekistan (from 5.39 tcm/t to 5.92 tcm/t in 1998).

With overall average increase of rice yield up to 3.70 t/ha as against 3.55 t/ha in 1997, reduction of yield was recorded in Kazakhstan (from 3.37 t/ha to 3.12 t/ha in 1998).

At the same time in Kazakhstan return per unit of water used was increased up to 14.1 \$/tcm as against 11.3 \$/tcm in 1997 and decreased in Uzbekistan to 19.8 \$/tcm as against 24.5 \$/tcm in 1997.

