Economic justification of the effectiveness of daily water distribution planning implementation

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INTRODUCTION

The recent years' disintegration of previously existing irrigated areas into a number of farms with relatively small irrigation plots, given furrow irrigation from gravity irrigation systems widespread in the region, have somewhat complicated water resources management at the so-called low level.
Water Users' Associations (WUA) have been established on a voluntary basis in order to coordinate the relationship between water users and water management agencies. The main purpose of the WUA's activity consists in equitable distribution of water resources among water users as well as their effective use.
Water users' demand associated with crop irrigation requirement can be satisfied only through efficient tradeoff between the schedules of water supply by WUA's canals and the schedule of water supply to WUA's offtakes from a main canal. A seasonal water use plan, the limits on which are set from above (Canal Management Organization), annually formed at the low level (WUA Administration) based on farmers' requests, serves as a basis for the achievement of conformity between the schedules of water distribution from the main canal with the schedule of water distribution through the WUA's irrigation network. Following the conformities, a compromise plan is accepted allowing for forecasted water availability; the WUA should rely upon it when organizing and managing water distribution within the WUA.
In order to accurately estimate crop irrigation requirement, belonging of a particular irrigated territory to one or another hydromodule zone (HMZ) has to be identified first. To this effect, the unified HMZ scale adopted by the Central Asian republics is applied, allowing for which HMZ areas are marked out by means of soil reclamation maps. Then the HMZ maps are combined with those of the WUA's irrigated area planning maps where irrigation and collector & drainage networks as well as irrigation wells are shown so that a particular irrigation contour can be referred to a corresponding HMZ.
When forming crop irrigation regimes, they proceed from a theoretical assumption that the design water application rate is evenly delivered to a particular crop over the entire watering/inter-watering period, i.e. at the daily rate of water supply to irrigate the crop; it is determined as follows:

$$Q_{i\,crop} = (\omega_i * m_i)/(86.4 * t_i)\ , \qquad (1)$$

where

- $Q_{i\,crop}$ - water supply rate required during the i^{th} watering period proceeding from the assumption of even delivery of daily portion of water application rate, l/s
- ω_i - area under the crop irrigated at the i^{th} water application, ha
- m_i - water application rate according to the irrigation regime at the i^{th} water application in a particular natural and climatic zone and hydromodule zone, m^3/ha
- t_i - the i^{th} crop watering period in a particular natural and climatic zone and hydromodule zone, days

It should be noted that such a "theoretical" regime of water supply spread over the entire period of each watering with meeting daily crop water requirement can be ensured only through drip irrigation.
Within one ten-day period, a situation is possible when crop watering is carried out for a few days with a hydromodule designed for this water application; and in the rest days of the ten-day period, crop watering is started with a new hydromodule designed for the next water application. In this respect, the ten-day hydromodule used in the calculation of a seasonal water use plan is computed using the following formula:

$$q_{dn} = (q_i * t_{idn} + q_{(i+1)} * t_{(i+1)dn}) / T_{dn} \quad , \qquad (2)$$

where

q_{dn}	- ten-day crop watering hydromodule for the n^{th} ten-day period from the beginning of the vegetation period, l/s/ha
q_i	- water application hydromodule of the i^{th} crop watering, l/s/ha
$q_{(i+1)}$	- water application hydromodule of the next crop watering, l/s/ha
t_{idn}	- number of the i^{th} crop watering days in the n^{th} ten-day period with a hydromodule q_i, days
$t_{(i+1)}$	- number of the next water application days in the n^{th} ten-day period with a hydromodule $q_{(i+1)}$, days
T_{dn}	- number of the days in the n^{th} ten-day period

Thus, when elaborating a seasonal water use plan, **ten-day crop watering hydromodule ordinates** (l/s/ha) are previously determined by using crop water application hydromodules (Annex 1, Table P1.1); those are required for the compensation of the water requirement of the crops present in the cropping pattern of the lands commanded by secondary offtakes[1] (Annex 1, Table P1.2).

When planning irrigation of many farms with relatively small irrigation plots, each farm is a separate water usage unit. If one follows a **traditional method of ten-day water distribution planning** oriented to large water usage units (50-150 ha), with which all water users are planned to be supplied with continuous flow water, a problem will occur with respect to small (7…35 l/s) irrigation water dispersal through a number of offtakes to the farm.

To achieve consistency of the main canal and WUA's irrigation network water distribution schedules and reduce irrigation water losses, including organizational losses, the ways of concentrated, technologically feasible water supply carried out with daily water distribution planning are implemented in accordance with the Method of Daily WUA Canal Water Distribution [1, 2].

Application of this water distribution technology creates conditions for:

- Reduction in unproductive losses of irrigation water;
- Increase of water availability for crops and, in the result, level of their yield;
- Reduction in the number of the points of simultaneous accounting of water supplied.

Thus, application of this water distribution technology can ensure additional economic effect as compared to dispersed water supply.

Let us consider possible effects from the application of daily water distribution planning as exemplified by one of SFMC offtakes.

ASSESSING THE EFFECTIVENESS OF DAILY WATER DISTRIBUTION PLANNING: CASE STUDY OF THE SINGIR-1 CANAL

Initial information

The Singir-1 canal, being an offtake from SFMC, is located in the WUA "S. Kasymov" in the Bulakboshi district of the Andijan province.

The area commanded by the Singir-1 canal is 291.7 ha; length of the canal system's distribution network, represented by earth canals, comes to 3.48 km. Water is supplied to farms and homestead lands by nine offtakes of the canal (Fig. 1).

[1] The hydromodule ordinates used for accounting of homestead land water use are taken equal to 0.45 l/s/ha irrespective of HMZ and month of vegetation period.

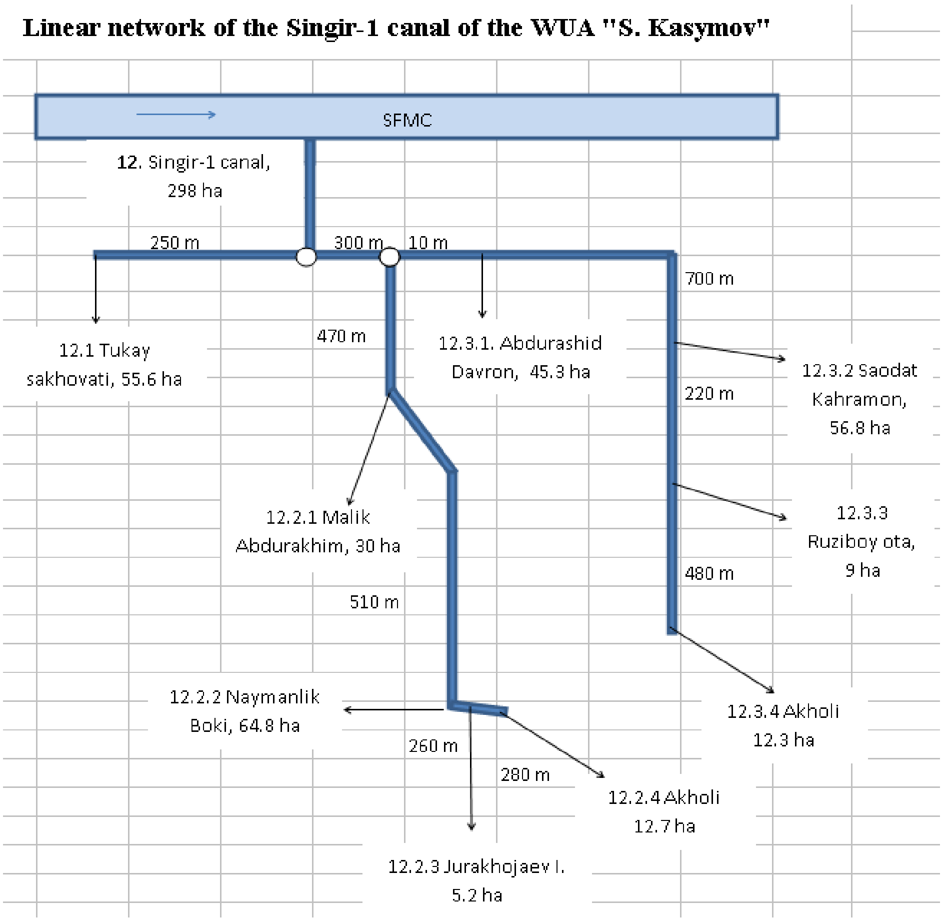

Figure 1. Linear network of the Singir-1 canal

Arrangement of water users on offtakes from the Singir-1 canal and cropping pattern in farms during the vegetation period 2011 are given in Table 1.

Table 1. Arrangement of water users on offtakes from the Singir-1 canal and cropping pattern in farms.

Offtake name	Water user name	Irrigated area, ha	in particular under:				
			cotton	wheat	orchard	vegetable	homestead lands
12.1	Tukay sakhovati	55.6	28	27.6			
Total for 12.1		***55.6***	***28***	***27.6***			
12.2.1	M. Abdurakhim	30	14	16			
12.2.2	Naymanlik Boki	33.7		31	2.7		
		31.1	31.1				
12.2.3	I. Jurakhujaev	5.2				5.2	
12.2.4	WUGs of community	12.7					12.7
Total for 12.2		***112.7***	***45.1***	***47***	***2.7***	***5.2***	***12.7***
12.3.1	A. Davron	45.3	22.1	21.2	2		
12.3.2	S. Kahramon	29.2	29.2				
		27.6		27.6			
12.3.3	Ruziboy ota	9				9	
12.3.4	WUGs of community	12.3					12.3
Total for 12.3		***123.4***	***51.3***	***48.8***	***2***	***9***	***12.3***
Total for the Singir-1 canal		**291.7**	**124.4**	**123.4**	**4.7**	**14.2**	**25**

All irrigated lands within the irrigation contour of the Singir-1 irrigation system belong to the second hydromodule zone. The crop irrigation regime for HMZ II, based on which a water use plan was calculated, is presented in Annex 1.

When planning water distribution for water outlet from SFMC to the Singir-1 canal, BISA takes an efficiency factor (EF) as equal to 0.789 for accounting of water losses in the irrigation network of the Singir-1 system; and in its calculations, BISA assumes that water is delivered to the field outlets in the quantities adequate to the net irrigation requirement.

Suppose that the EF=0.789 (*based on which the rate of water supply from the WUA canal to an offtake is set*) includes as well $EF_{irrigation\ technique}$, then the EF=0.789 should accord with $EF_{distribution\ network}$=0.9 and $EF_{irrigation\ technique}$=0.8765 which is obviously impossible under usual furrow irrigation.

To determine technical water losses in the Singir-1 canal system, two options of the plans of water distribution during the vegetation period of 2011 were drawn up based on the water use plan: for ten-day water distribution planning and daily water distribution planning (Annexes 2 and 3).

Further, the values of water distribution through the Singir-1 canal offtakes were grouped broken down by the following discharge ranges: 6-9 l/s; 10-19 l/s; 20-29 l/s; etc.

Then, water losses per 1 km of the canal were calculated for the mean discharge values from the above ranges by the A.N. Kostyakov's formula [3] for medium water permeability soils:

$$\sigma = \frac{1,9}{Q^{0,4}} , \tag{3}$$

where:

σ - water losses per 1 km of the canal, %;

1.9 - the factor multiple of the canal seepage factor in medium-permeability soils;

Q - water discharge in the canal, m^3/s.

Results of the calculation of the water losses at dispersed water supply (based on ten-day water distribution planning) (Table 2)

Table 2. Water losses in the Singir-1 canal at ten-day water distribution (by continuous flow) per 1 km of the irrigation network broken down by water discharge ranges.

Offtake name	Water supply discharge range,	Water supply corresponding to discharge range		Water losses per 1 km of the irrigation network	
	l/s	ths. m^3	% of total water supply	%	ths. m^3
12.1	10-19	48.34	13.0	9.5	4.57
	20-29	192.38	51.9	8.4	16.13
	30-39	55.65	15.0	7.5	4.18
	40-50	74.10	20.0	6.8	5.06
Total for 12.1		**370.47**			**29.94**
12.2	10-19	19.11	2.4	11.5	2.20
	40-49	232.08	29.0	6.6	15.37
	50-59	289.91	36.2	6.1	17.58
	60-69	114.56	14.3	5.6	6.44
	70-79	75.31	9.4	5.2	3.94
	80-89	70.50	8.8	5.2	3.65
Total for 12.2		**801.47**			**49.18**
12.3	10-19	23.53	2.6	10.6	2.49
	40-49	124.69	13.9	6.5	8.08
	50-59	187.00	20.9	6.1	11.41
	60-69	278.90	31.1	5.7	15.99
	70-79	124.48	13.9	5.4	6.77
	80-89	158.07	17.6	5.0	7.97
Total for 12.2		**896.67**			**52.7**
Total for the Singir-1 canal		**2068.61**			**131.84**

Taking into consideration that the extension of the irrigation network in the Sangir-1 system is 3.48 km (Fig. 1) and an average extension of the irrigation network continuously operating during the vegetation period is 3.312 km *(for the last two ten-day periods of September, water is not supplied by the offtake 12.1),* total water losses would come to:

$$\mathbf{131.84\ ths.m^3/km\ *\ 3.312\ km = 436.7\ ths.m^3}$$

Results of the calculation of the water losses at concentrated water supply (based on daily water distribution planning)

Similar canal water loss calculation results at daily water distribution planning are given in Table 3.

Table 3. Water losses in the Singir-1 canal at daily water distribution (by concentrated flow) per 1 km of the irrigation network.

Offtake name	Water supply discharge range,	Water supply corresponding to discharge range		Water losses per 1 km of the irrigation network	
	l/s	ths. m³	% of total water supply	%	ths. m³
12.1	10-19	1.42	0.4	9.8	0.14
	20-29	2.30	0.6	8.1	0.19
	30-39	5.69	1.6	7.4	0.42
	40-49	15.33	4.3	6.6	1.01
	50-59	18.40	5.2	6.1	1.13
	60-69	22.12	6.2	5.7	1.26
	70-79	57.71	16.2	5.4	3.10
	80-89	52.67	14.8	5.0	2.66
	90-99	23.98	6.7	4.9	1.18
	100-109	53.00	14.9	4.7	2.51
	120-129	31.98	9.0	4.4	1.40
	130-139	58.70	16.5	4.2	2.48
	150-159	13.03	3.7	4.0	0.53
Total for 12.1		**356.33**			**18.01**
12.2	10-19	5.58	0.7	9.9	0.55
	20-29	26.39	3.4	8.2	2.18
	30-39	163.82	20.9	7.0	11.52
	40-49	61.76	7.9	6.6	4.07
	50-59	41.50	5.3	6.1	2.55
	60-69	39.31	5.0	5.7	2.23
	70-79	109.07	13.9	5.4	5.86
	80-89	95.93	12.3	5.1	4.88
	90-99	81.03	10.4	4.9	3.97
	100-109	89.79	11.5	4.7	4.22
	120-129	21.35	2.7	4.4	0.94
	130-139	47.20	6.0	4.2	1.99
Total for 12.2		**782.75**			**44.95**
12.3	0-9	0.66	0.1	13.4	0.09
	10-19	10.73	1.2	10.1	1.08
	20-29	21.13	2.3	8.4	1.77
	30-39	122.65	13.2	7.1	8.68
	40-49	68.11	7.3	6.6	4.52
	50-59	18.29	2.0	6.2	1.13
	60-69	151.05	16.2	5.7	8.58
	70-79	90.34	9.7	5.4	4.85
	80-89	64.83	7.0	5.1	3.33
	90-99	80.82	8.7	4.9	3.96
	100-109	125.71	13.5	4.7	5.91
	110-119	48.73	5.2	4.5	2.22
	120-129	43.78	4.7	4.3	1.90
	130-139	82.90	8.9	4.2	3.49
Total for 12.3		**929.73**			**51.49**
Total for the Singir-1 canal		**2068.80**			**114.45**

With daily water distribution planning, an average length of the irrigation network during the vegetation period, through which water is supplied, is 55 % of the total irrigation network extension, i.e. water losses will occur at an extent of 1.907 km and come to:

$$\mathbf{114.45\ ths.m^3/km * 1.907\ km = 218.3\ ths.m^3.}$$

In the final analysis, the farmers-agricultural producers' concern is with the sufficiency of water supply for the crops irrigated personally by them. With such an assessment, effectiveness of daily water distribution by concentrated flow against dispersed water supply (ten-day water supply planning) is manifest. Since the WUA offtake is supplied with water from a canal (SFMC in this case) at a flow discharge designed for EF=0.789, but which is delivered to field outlets with less losses, the field is supplied with water in the quantity exceeding design net water requirement; thus favorable conditions for higher water availability for crops are created than with dispersed water supply. In other words, water withdrawal in the WUA is not increased, but favorable conditions for the attainment of increased water availability for cultivated crops are created (Table 4).

Table 4. Water distribution measures with dispersed (ten-day period) and concentrated (daily) water distribution through the Singir-1 canal system.

№	Measure name	Unit	Water distribution planning ways	
			Ten-day method	**Daily method**
1	Irrigated area	ha	291.7	
2	Extension of the irrigation/distribution network in the Singir-1 canal system	km	3.38	
3	Water volume adequate to the net irrigation requirement of the crops irrigated in the Singir-1 canal system	ths. m^3	1 632.1	
4	Water withdrawal to the Singir-1 canal's offtake during the vegetation period (according to the water distribution plan worked out by BISA)	ths. m^3	2 068.8	
5	Average extension of the Singir-1 canal system's irrigation/distribution network through which water is supplied during the vegetation period	km	3.311	1.907
6	Total water losses	ths. m^3	436.7	218.3
7	Reduction in losses in irrigation water transport under concentrated water supply *(daily water distribution planning)*	ths. m^3	-	218.2
8	Volume of the water delivered to the Singir-1 canal system's farm outlets	ths. m^3	1632.1	1850.5
9	Efficiency of irrigation water transport by the Singir-1 canal system's irrigation/distribution network	%	78.9 %	89.5%

Water availability for crops at two options of water distribution

Average water availability at the crop field outlet level is determined through the ratio of the volumes corresponding to the water use rate (*net irrigation requirement according to the irrigation regime*) to the volume of water supplied to the end irrigation network's outlets.

According to the data given in Table 4, 1632.1 ths.m^3 of water will be delivered to the Singir-1 canal system's farm outlets under dispersed water supply, i.e. the volume adequate to the net irrigation requirement, including:

- for cotton – 6200 m^3/ha
- for winter wheat – 5300 m^3/ha

Under concentrated water supply, 1850.5 ths.m^3 of water will be delivered to the Singir-1 canal system's farm outlets, i.e. the volume exceeding the net irrigation requirement and equal to:

- for cotton – 7029 m^3/ha (exceeding the net irrigation requirement by 825 m^3/ha)
- for winter wheat – 6009 m^3/ha (exceeding the net irrigation requirement by 709 m^3/ha)

Reasoning from that the average efficiency of furrow irrigation technique under the Fergana Valley conditions comes, according to our records, to 70 % [4], the average water availability for the crops cultivated on irrigated fields will be as follows:

- under dispersed water supply *(ten-day water distribution planning)* – 70 %
- under concentrated water supply *(daily water distribution planning)* – 79.4 % *(for cotton - 7029 m^3/ha /6200 m^3/ha *70%=79.4% and for wheat - 6009 m^3/ha /5300 m^3/ha *70%=79.4%)*

To determine the dependence of crop yield on irrigation rates, V.R. Shreder [5] applied the way to express the crop yield and irrigation rate values in relative numbers. Maximum crop yield and the value of irrigation rate adequate to it are taken as a unit. Ratio of the net irrigation requirement to the gross irrigation requirement at the crop field level is a water availability equivalent.

Dependence of crop yield on water availability, based on the investigations carried out in the Central Asian region, is shown in Table 5 by V.R. Shreder.

Table 5. Dependence of crop yield on water availability

Water availability, %	100	95	90	85	80	75	70	60	50
Y/Ymax	1	0.98	0.96	0.94	0.91	0.87	0.83	0.75	0.64

For the zone where the WUA "S. Kasymov" is located maximum crop yield values *(according to the data from the indicator-fields of the IWRM-FV Project)* [6] are known: for cotton – 40 mc/ha [2]; and for winter wheat – 50 mc/ha. Allowing for this and based on the values given in Table 5, one can use the following formulae to determine crop yield depending on actual water availability:

For cotton
at Ymax=40 mc/ha:

$$Y_{cotton} = -0.0034*WA^2_{actual} + 0.7955*WA_{actual} - 5.5992 \quad \textbf{(4)}$$

For winter wheat
at Ymax=50 mc/ha:

$$Y_{w.wheat} = -0.0042*WA^2_{actual} + 0.990*WA_{actual} - 6.999\ , \quad \textbf{(5)}$$

where:

Y_{cotton} - cotton crop yield corresponding to actual water availability, mc/ha

$Y_{w.wheat}$ - winter wheat crop yield corresponding to actual water availability, mc/ha

WA_{actual} - actual water availability for crops, mc/ha, %

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[2] Here, *mc* stands for metric centner.

Table 6. Results of the calculation of increment in main crop yields due to increased water availability against the option of dispersed water supply (ten-day planning).

Crop	Type of water distribution	Average water availability for crops WA_{actual}	Crop yield forecasted based on formulae 4 и 5	Increment in crop yield against the dispersed water supply option
		%	mc/ha	t/ha
Cotton	Dispersed (ten-day planning)	70.0	41.72	
	Concentrated (daily planning)	79.4	45.13	0.3408
Winter wheat	Dispersed (ten-day planning)	70.0	33.43	
	Concentrated (daily planning)	79.4	36.13	0.2703

Calculation of economic effectiveness of daily water distribution planning

Economic effectiveness of daily water distribution planning at the farm level is determined taking into account the effect from the increase of water availability for main crops (cotton and winter wheat) by the example of the lands irrigated from the Singir-1 canal (Table 7).

Table 7. Results of the calculation of economic effect from the application of daily water distribution planning (concentrated water supply to farms)

	Measures	**Unit**	**Cotton**	**Wheat**	**TOTAL**
1	Irrigated area	ha	124.4	123.4	247.8
2	Increment in crop yield due to increased water availability	t/ha	0.2703	0.3408	
3	Incremental product	t	33.63	42.05	
4	Average purchase price (2011)	ths.UZS/ 1 t	780	280	
		$ /1 t	440.9	158.3	
5	Value of incremental product	ths.UZS	26 227.7	11 775.3	38 003.1
		$	14 823.9	6 655.4	21 479.3
6	Incremental product collection costs	ths.UZS/ 1 ton	150	56	
		$ /1 ton	84.8	31.7	
7	Total costs of incremental product collection	ths.UZS	5 044	2 355	7 399
		$	2 850.8	1 331.1	4 181.8
8	Additional net effect from crop yield increment due to increased water availability	ths.UZS	21 184.0	9 420.3	30 604.2
		$	11 973.2	5 324.3	17 297.5
		ths.UZS /ha	**170.3**	**76.3**	**123.5**
		$/ha	**96.2**	**43.1**	**69.8**

Note: according to the Central Bank of the Republic of Uzbekistan as of 15.11.2011, 1 USD =1769.285 UZS.

Annual economic effect of possible reduction of water withdrawal in the WUA when implementing daily water distribution planning.

Annual economic effect of water saving is determined by the formula:

$$\mathbf{AEE} = \frac{\mathbf{\Delta W * S}}{\boldsymbol{\omega}}, \qquad \textbf{(6)}$$

where:

ΔW - water saving attainable due to possible reduction of water withdrawal to WUAs in case of the implementation of daily water distribution planning (from Table 4, ΔW=218 000 m^3);

S - «price of water» supplied from SFC comes, according to figures from M.A. Pinkhasov [7], to 4.52 UZS/m^3;

ω - the area irrigated by the Singir-1 canal, ha (from Table 1, ω = 291.7 ha).

$$\mathbf{AEE} = \frac{218200 * 4.52}{291.7} = 3381.1\ \mathbf{UZS/ha} = 1.91\ \$/\mathbf{ha}$$

As follows from these calculations, the effect that can be achieved by farmers through increasing water availability for the crops irrigated by them is much higher than that achieved through possible reduction of water withdrawal to WUAs.

CONCLUSION

Main effect of the implementation of daily water distribution planning shows at the farm level due to increased water availability for crops through raise in efficiency of irrigation water transport by the WUA's irrigation network (*by 10.6 % in the example described, Table 4*).

Additional effect of the crop yield increment due to increased water availability illustrated by the example of main crops irrigated from the Singir-1 canal comes to 69.8 $/ha per composite hectare (including: for cotton – 96.2 $/ha; for winter wheat – 43.1 $/ha).

The effect that can be achieved by farmers through increasing water availability for the crops irrigated by them under daily water distribution planning is much higher than that of possible reduction of water withdrawal to WUAs (*simultaneous achievement of the both effects in the result of the application of daily water distribution planning is impossible*).

In addition to the mentioned economic effect, with concentrated water supply at daily water distribution the coefficient of daily water supply rate stability approaches unity, since the rates of water withdrawal to the offtakes are constant within the day.

Daily water distribution planning provides irrigation management with important opportunities for starting and completing water supply to furrows and switching water supply over to the irrigation of next irrigation plots only in daylight hours.

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ANNEX 1

Table A 1.1. Fragment of the statement of crop irrigation regime for HMZ II (desert zone, C-2A).

Crop	Irrigation rate, m^3/ha	No of water application	Water application rate, m^3/ha	Water application time		Water application period, days	Water application hydromodule ordinate, l/s/ha
				beginning	end		
Cotton	6200	1	800	13.05.	05.6.	23	0.403
		2	800	6.6.	20.6.	15	0.617
		3	800	21.6.	3.7.	13	0.712
		4	800	4.7.	16.7.	13	0.712
		5	900	17.7	29.7.	13	0.801
		6	800	30.7.	12.8.	14	0.661
		7	800	13.8.	31.8.	19	0.487
		8	500	1.9.	10.9.	10	0.579
Winter wheat	5300	1	600	24.10.	11.11.	19	0.365
		2	700	25.3.	9.4.	16	0.506
		3	700	10.4.	22.4.	13	0.623
		4	800	23.4.	3.5.	11	0.842
		5	800	4.5.	13.5.	10	0.926
		6	800	14.5.	24.5.	11	0.842
		7	800	25.5.	6.6.	13	0.712
Small vegetable	4500	1	500	10.4.	27.4.	18	0.322
		2	500	28.4.	13.5.	16	0.362
		3	500	14.5.	26.5.	13	0.445
		4	600	27.5.	5.6.	10	0.694
		5	600	6.6.	14.6.	9	0.772
		6	600	15.6.	23.6.	9	0.772
		7	600	24.6.	2.7.	9	0.772
		8	600	3.7.	14.7.	12	0.579
Orchard and vineyards	5000	1	500	11.4.	30.4.	20	0.289
		2	500	1.5.	15.5.	15	0.386
		3	600	16.5.	31.5.	16	0.434
		4	600	1.6.	15.6.	15	0.463
		5	600	16.6.	30.6.	15	0.463
		6	600	1.7.	15.7.	15	0.463
		7	600	16.7.	31.7.	16	0.434
		8	600	1.8.	15.8.	15	0.463
		9	500	16.8.	5.9.	21	0.276

Table A 1.2. Fragment of the statement of ten-day hydromodule ordinates (l/s/ha) when irrigating crops in HMZ II.

Crop	April			May			June			July			August			September		
	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III
Cotton					0.309	0.386	0.502	0.617	0.712	0.712	0.748	0.776	0.661	0.522	0.487	0.386	0.193	
Winter wheat	0.444	0.534	0.696	0.788	0.759	0.664	0.374											0.194
Orchard				0.370	0.370	0.363	0.356	0.356	0.370	0.370	0.363	0.356	0.356	0.312	0.312	0.156		
Intercrops		0.161	0.322	0.322	0.322	0.515	0.676	0.781	0.703	0.766	0.360							
Double crops									0.827	0.903	0.953	0.905	0.874	0.772	0.698	0.367	0.367	0.367
Homestead lands	0.450	0.450	0.450	0.450	0.450	0.450	0.450	0.450	0.450	0.450	0.450	0.450	0.450	0.450	0.450	0.450	0.450	0.450
Industrial and technical needs*	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038

* Stock watering, environmental releases, etc.

ANNEX 2

Table A 2.1. Ten-day plan of Singir-1 canal water distribution of the WUA "S. Kasymov" for the vegetation period (NET discharges (l/s)).

No of offtakes	Water users	HMZ	Crop	ha	April			May			June			July			August			September		
					1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
12.1	Tukay sakhovati	II	Cotton	28					8.7	11	14	17	20	20	21	22	18	15	14	16		
			Grain	27.6	14	17	22	25	24	21	12											
Total for 12.1				**56**	**14**	**17**	**22**	**25**	**33**	**32**	**26**	**17**	**20**	**20**	**21**	**22**	**18**	**15**	**14**	**16**		
12.2.1	M. Abdurakhim	II	Cotton	14					4.4	5.5	7.1	8.7	9.9	9.9	10	11	9.2	7.3	6.9	8.1		
			Grain	16	8.3	9.9	13	14	14	12	6.8											
12.2.2	Naymanlik Boki	II	Grain	31	16	19	25	28	27	23	13											
			Orchard	2.7			0.8	0.8	0.8	0.9	1.2	1.5	1.5	1.5	1.5	1	1	0.7	0.7	0.4		
			Cotton	31.1					9.7	12	16	19	22	22	23	24	21	16	15	18		
12.2.3	Jurakhojaev, I.	II	Vegetable	5.2	3	3	3	3	3	2.7	3	3	3	3	3.6	3.3	3	3	2.7	3	3	3
12.2.4	**Community WUGs**	**II**	**Homestead lands**	**12.7**	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7
Total for 12.2				**113**	**33**	**38**	**47**	**52**	**64**	**63**	**53**	**38**	**42**	**42**	**44**	**45**	**40**	**33**	**31**	**35**	**8.7**	**8.7**
12.3.1	A. Davron	II	Cotton	22.1					6.9	8.6	11	14	16	16	16	17	15	12	11	13		
			Grain	21.2	11	13	17	19	18	16	9											
			Orchard	2			0.6	0.6	0.6	0.7	0.9	1.1	1.1	1.1	1.1	0.8	0.8	0.5	0.5	0.3		
12.3.2	S. Kakhramon	II	Cotton	29.2					9.1	11	15	18	21	21	22	23	19	15	14	17		
			Grain	27.6	14	17	22	25	24	21	12											
12.3.3	Ruzivoy ota	II	Vegetable	9	5.2	5.2	5.2	5.2	5.2	4.7	5.2	5.2	5.2	5.2	6.2	5.7	5.2	5.2	4.7	5.2	5.2	5.2
12.3.4	**Community WUGs**	**II**	**Homestead lands**	**12.3**	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5
Total for 12.3				**123**	**36**	**41**	**50**	**55**	**70**	**68**	**58**	**44**	**48**	**48**	**51**	**52**	**45**	**38**	**36**	**41**	**11**	**11**
Total for the Singir-1 canal				**292**	**84**	**96**	**119**	**132**	**167**	**162**	**137**	**99**	**110**	**110**	**116**	**118**	**103**	**86**	**81**	**92**	**19**	**19**

Table A 2.2. Ten-day plan of Singir-1 canal water distribution of the WUA "S. Kasymov" for the vegetation period (GROSS discharges (l/s))

No of offtakes	Water users	HMZ	Crop	ha	April			May			June			July			August			September		
					1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
12.1	Tukay sakhovati	II	Cotton	28					11	14	18	22	25	25	26	28	23	19	17	21		
			Grain	27.6	18	22	28	32	30	26	15											
Total for 12.1				**56**	**18**	**22**	**28**	**32**	**41**	**40**	**33**	**22**	**25**	**25**	**26**	**28**	**23**	**19**	**17**	**21**		
12.2.1	M. Abdurakhim	II	Cotton	14					5.5	6.9	9	11	13	13	13	14	12	9.3	8.7	10		
			Grain	16	11	13	16	18	18	15	8.6											
12.2.2	Naymanlik Boki	II	Grain	31	20	24	31	35	34	30	17											
			Orchard	2.7			1	1	1	1.1	1.5	1.8	1.8	1.8	1.8	1.3	1.3	0.9	0.9	0.5		
			Cotton	31.1					12	15	20	24	28	28	29	31	26	21	19	23		
12.2.3	Jurakhojaev, I.	II	Vegetable	5.2	3.8	3.8	3.8	3.8	3.8	3.5	3.8	3.8	3.8	3.8	4.6	4.2	3.8	3.8	3.5	3.8	3.8	3.8
12.2.4	**Community WUGs**	II	Homestead lands	**12.7**	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
Total for 12.2				**113**	**42**	**48**	**59**	**66**	**82**	**79**	**67**	**48**	**53**	**53**	**56**	**57**	**50**	**42**	**40**	**45**	**11**	**11**
12.3.1	A. Davron	II	Cotton	22.1					8.7	11	14	17	20	20	21	22	18	15	14	16		
			Grain	21.2	14	17	21	24	23	20	11											
			Orchard	2			0.7	0.7	0.8	0.8	1.1	1.4	1.4	1.4	1.4	1	1	0.7	0.7	0.3		
12.3.2	S. Kakhramon	II	Cotton	29.2					12	14	19	23	26	26	28	29	24	19	18	21		
			Grain	27.6	18	22	28	32	30	26	15											
12.3.3	Ruzivoy ota	II	Vegetable	9	6.6	6.6	6.6	6.6	6.6	6	6.6	6.6	6.6	6.6	7.9	7.2	6.6	6.6	6	6.6	6.6	6.6
12.3.4	**Community WUGs**	II	Homestead lands	**12.3**	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
Total for 12.3				**123**	**46**	**52**	**64**	**70**	**88**	**86**	**74**	**55**	**61**	**61**	**65**	**66**	**58**	**48**	**46**	**52**	**14**	**14**
Total for the Singir-1 canal				**292**	**106**	**122**	**151**	**168**	**211**	**206**	**174**	**126**	**140**	**140**	**148**	**150**	**131**	**109**	**103**	**117**	**25**	**25**

ANNEX 3

Table A 3.1. Fragment of daily water distribution plan (net discharges (l/s)) used for water supply to the farms of the Singir-1 canal system.

No of offtakes	Water users	Crop	ha	June																													
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
12.1	Tukay sakhovati	Cotton	28										43	77	69	37	33										26	110	110	13			
		Grain	27.6	71																													
Total for 12.1			**55.6**	**71**									**43**	**77**	**69**	**37**	**33**										**26**	**110**	**110**	**13**			
12.2.1	M. Abdurakhim	Cotton	14	44															59	41	30												57
		Grain	16																														
12.2.2	Naymanlik Boki	Grain	31	22	70	58	70	67																									
		Orchard	2.7											22																22			
		Cotton	31.1																	28	39	99	69										
12.2.3	Jurakhojaev, I.	Vegetable	5.2									30											30							30			
12.2.4	**Community WUGs**	**Homestead lands**	**12.7**		**30**					**30**					**30**					**30**					**30**					**30**			
Total for 12.2			**112.7**	**66**	**100**	**58**	**70**	**67**		**30**		**30**		**22**	**30**				**59**	**99**	**69**	**99**	**99**		**30**					**82**			**57**
12.3.1	A. Davron	Cotton	22.1														66	99	40											15	80	58	53
		Grain	21.2		37	49	67	43																									
		Orchard	2													32											32						
12.3.2	S. Kakhramon	Cotton	29.2						50	32	39	75	74											58	80	80	52						
		Grain	27.6					27	87	75	68																						
12.3.3	Ruzivoy ota	Vegetable	9									32	20											52								52	
12.3.4	**Community WUGs**	**Homestead lands**	**12.3**			**30**					**30**					**30**					**30**					**30**					**30**		
Total for 12.3			**123.4**		**37**	**79**	**67**	**70**	**137**	**107**	**137**	**107**	**94**			**62**	**66**	**99**	**40**		**30**			**110**	**80**	**110**	**84**			**15**	**110**	**110**	**53**
Total for the Singir-1 canal			**291.7**	**137**	**137**	**137**	**137**	**137**	**137**	**137**	**137**	**137**	**137**	**99**	**99**	**99**	**99**	**99**	**99**	**99**	**99**	**99**	**99**	**110**	**110**	**110**	**110**	**110**	**110**	**110**	**110**	**110**	**110**

Table A 3.2. Fragment of daily water distribution plan (gross discharges (l/s)) used for assessing water withdrawal to the Singir-1 canal.

No of offtakes	Water users	Crop	ha	June																													
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
12.1	Tukay sakhovati	Cotton	28										54.5	97.6	87.5	46.9	41.8										33	139	139	16.5			
		Grain	27.6	90																													
Total for 12.1			**55.6**	**90**									**54**	**98**	**87**	**47**	**42**										**33**	**139**	**139**	**16**			
12.2.1	M. Abdurakhim	Cotton	14	55.8															74.8	52	38												72.2
		Grain	16																														
12.2.2	Naymanlik Boki	Grain	31	27.9	88.7	73.5	88.7	84.9																									
		Orchard	2.7											27.9																27.9			
		Cotton	31.1																	35.5	49.4	125	87.5										
12.2.3	Jurakhojaev, I.	Vegetable	5.2									38											38							38			
12.2.4	**Community WUGs**	**Homestead lands**	**12.7**		**38**					**38**					**38**					**38**					**38**					**38**			
Total for 12.2			**112.7**	**84**	**127**	**74**	**89**	**85**		**38**		**38**		**28**	**38**				**75**	**125**	**87**	**125**	**125**		**38**					**104**			**72**
12.3.1	A. Davron	Cotton	22.1														83.7	125	50.7											19	101	73.5	67.2
		Grain	21.2		46.9	62.1	84.9	54.5																									
		Orchard	2													40.6											40.6						
12.3.2	S. Kakhramon	Cotton	29.2						63.4	40.6	49.4	95.1	93.8											73.5	101	101	65.9						
		Grain	27.6					34.2	110	95.1	86.2																						
12.3.3	Ruzivoy ota	Vegetable	9									40.6	25.3											65.9								65.9	
12.3.4	**Community WUGs**	**Homestead lands**	**12.3**			**38**					**38**					**38**					**38**					**38**					**38**		
Total for 12.3			**123.4**		**46.9**	**100**	**84.9**	**88.7**	**174**	**136**	**174**	**136**	**119**			**78.6**	**83.7**	**125**	**50.7**		**38**			**139**	**101**	**139**	**106**			**19**	**139**	**139**	**67.2**
Total for the Singir-1 canal			**291.7**	**174**	**174**	**174**	**174**	**174**	**174**	**174**	**174**	**174**	**174**	**125**	**125**	**125**	**125**	**125**	**125**	**125**	**125**	**125**	**125**	**139**	**139**	**139**	**139**	**139**	**139**	**139**	**139**	**139**	**139**