CRP 1.1. “Dryland Systems in Central Asia” Program

Period of January – December 2014

IMPROVING WATER USE EFFICIENCY OF DRYLAND SYSTEMS WITH HIGH POTENTIAL FOR INTENSIFICATION

(Fergana Action Site)

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List of responsible researchers

Akmal Karimov – Water Management Specialist, Head, IWMI CA

Mirzoolim Avliyakulov - Consultant Agronomist, Ph.D Student of TSAU

Botir Abdurakhmanov – Consultant Irrigation Specialist, Ph.D Student of TIIM

Oyture Anarbekov – Economist, Senior Researcher Officer, IWMI CA

Nozila Mukhammedova- Gender Specialist, Research Officer, IWMI CA

1. INTRODUCTION

Doubling population of Central Asia since 1980 increased demand for food, which escalated demand for water. Since all water resources in both main, Amudarya and Syrdarya, river basins are fully allocated between water users there are limited number of ways to increase food crop production in the region, one of them it is introducing drought tolerant low water consumptive crops. This strategy has different applications for diversified cropping systems with high potential for intensification and located in the upstream and midstream of the river basins and the degrading systems in the downstream. In the Dryland Systems Program (DSP) the first type of the systems of Central Asia is represented by the Fergana Action Site and the second type of the systems by Aral Sea Area Action Site. Low resource use efficiency, expressed in excessive use of inputs, including water, energy, fertilizers, labor and machinery are typical for the upstream DSs. Low crop productivity due to degraded soil fertility and shortage of fresh water is typical for the downstream DSs. Increasing productivity of the upstream DSs may be achieved through: (a) intensifying cropping systems, introducing high yielding varieties of crops; (b) timely irrigation using improved irrigation technologies; (c) identifying inputs non-productive losses and transferring them into productive use. The specific objectives of this study were as follows:

(1) To study a potential of improving water use efficiency (WUE) by double cropping winter wheat/legume (mungbean) crop using improved irrigation methods;
(2) To study the impact of institutional development in water management on productivity of DSs with high potential for improvement;
(3) To study water use at household level.

It was hypothesized that these studies covering four main research areas may provide system analyses of water use in the high potential DSs and disclose opportunities for improving WUE.

The reports starts with findings of the studies on winter wheat/mungbean double cropping. Then, the estimates of water and energy productivity are presented followed by assessing the impact of establishing WUAs on water use efficiency and socio-economic studies at house-hold level.

A. Improving WUE by double cropping winter wheat/mungbean

A.1. Introduction

Under growing water shortage conditions, improved water use efficiency represents a key factor in increasing crop productivity, which is highly correlate with water use efficiency (WUE). WUE, defined as a ratio of yield to irrigation water requirements (De Pascale and Maggio 2005) is studied for winter wheat /mungbean cropping system. Winter wheat (Triticum aestivum L.) is the most important cereal grown for making bread in Central Asia. Whereas worldwide about 65% of the produced wheat originates from irrigated agriculture, in Uzbekistan more than 90% of winter wheat is cultivated on irrigated land (FAO and WFP 2000). During the past 22 years, the area under irrigated cereals increased more than seven times from 221,000 ha to about 1.6 million ha, and gross yields rose from 1.54 in 1991 to 4.46 t/ha in 2012 (Statistical data, Uzbekistan 2013). This significant increasing the area under winter wheat resulted in grain self-sufficiency of the state however at the same time it reduced opportunity for farmers to grow other crops and diversify their products to be able to meet the growing market needs. Farmers, under such conditions, have two choices, first is concentrating market oriented food crops on their household plots and the second is cultivate the crops after winter wheat harvesting. These two areas were covered by the studies in 2014. Mungbean, one of the most important food crops and a component of the daily diet in Uzbekistan was studied at the Fergana Action site. It is already cultivated by farmers on more than 17 thousand ha area. (http://www.fao.org/newsroom/en/focus/2006/1000252/index.html).

Mungbean, low water consuming crop, is important for crop diversification and food security; it requires low inputs for cultivation and has ability to increasing soil fertility through symbiotic nitrogen fixation activities. In the Fergana Valley, the main cropping sequence is cotton/wheat production. Farmers of Fergana Valley, having the shortage of free land for cultivation of vegetables and fodders, cultivate them after winter wheat harvesting in mid-summer season if irrigation water is available. Shortage of water is limiting factor for increasing the area under second crops in the Fergana Valley, where winter wheat covers over 30% of the irrigated land.

Double cropping is one of the effective measures of converting evaporation losses from fallow land into useful crop transpiration. Growing period of winter wheat in Fergana Valley is from October to mid-June, around 255-265 days, when sum of temperatures has to exceed 3000^{o}C. The harvesting period of winter wheat is in mid-June when the high temperature causes high evaporation rate. After winter wheat, harvesting there is still 100-110 days with high temperature

and the sum of the temperatures from mid-June to mid-October averages 2600^{o}C, which is sufficient for cultivation of second crops. Converting evaporation losses during this period into useful crop transpiration may result in improved water use efficiency, enhanced food security and increased income of farmers. The objectives of the study in 2014 were two-fold: (1) to determine WUE for winter wheat under current irrigation practices, and; (2) to determine proper methods of irrigation of mungbean for increased water use efficiency.

Considerable research has been done on water-use efficiency, and many papers and reviews have been written (Taylor et al. (1983), (Faures and Svendsen, 2007). In irrigation, efficiency was first defined by Israelsen (1932). Efficiency is generally defined as the ratio of output over input, and is expressed as a percentage. In agriculture, water use efficiency may be defined quite differently by a farmer, a manager of an irrigation project or a river basin authority. For example, on-farm irrigation efficiencies and project efficiencies may be low, but substantial water losses may infiltrate in the soil, recharge the aquifers and may be pumped up again for re-use, either in the same project area or in another downstream. By recycling losses, river basin efficiencies could become very high. In water use a distinction should be made between technical efficiency and economic efficiency. On one hand, technical efficiency may be low in a project area, but may be high in the river basin if water is recycled. On the other hand, water losses in project area and recycling particularly when high pump lifts are involved may reduce economic efficiency. A third way to express water use efficiency is through crop production per cubic meter of water available for crops. This expression is used in the current report. Several papers suggested that in many irrigation schemes only about 45% of water diverted for irrigation actually reaches the crops *(*Levidow, Les, et al. 2014). De Pascale Maggio (2005) found that the loss percentages for different irrigation methods is as follows: drip irrigation 10-20%, sprinkler irrigation 30-50% and furrow irrigation 50-60%. The amount of water transpired by a crop may be increased either by reducing soil evaporation or by supplemental irrigation. Estimates of soil evaporation range from 20% to 70% of total water used (Cooper, 1983; Cooper et al., 1987a; Siddique et al., 1990). Soil evaporation can be reduced by crop structure (Siddique et al., 1990) and agronomic practices that stimulate early ground cover, such as application of fertilizers (Brown et al., 1987; Cooper et al., 1987a; Oweis et al., 1998), early sowing (Oweis et al., 1998) and increased plant density (Van den Boogaard et al., 1996).

Irrigation systems have been under pressure to produce more with lower supplies of water. Various innovative practices can gain an economic advantage while also reducing environmental burdens such as water abstraction, energy use, pollutants, etc. (Faures and Svendsen, 2007).

Policy mostly place great expectations upon technologies to improve water use efficiency. While, policies seek to lower water usage, and river basin managers try to allocate limited supplies, yet water saving is not a priority for most farmers (Luquet et al., 2005). They manage labour and other inputs to get better economic gains (Molden et al., 2010). Yet even WP remains distant from farmers' perspectives. They generally perceive 'irrigation efficiency' as maximizing net revenue rather than saving water (Knox et al., 2012). Some experiences indicate that water pricing have induced farmers to adapt appropriate practices for conserving water (Caswell and Zilberman, 1985). If agricultural water demand is inelastic, then policies which encourage changes in cropping patterns can be more effective than higher prices (Fraiture and Perry, 2007; Iglesias and Blanco, 2008; Kampas, 2012). Howell (2003) and Irmak et al. (2011) reported the attainable application efficiencies for different irrigation methods, assuming irrigations are applied to meet the crops' water needs. While evaluating WUE, this study looks for both, introducing low water demanding crop and improving irrigation practices of farmers.

A.2. STUDY AREA

The experiment was conducted in 2013-2014 at Odiljon Farrukhbek Sakhovati farm located in Komiljon Umarov Mirob Water Users Association, Toshloq district, Ferghana province. The farm is located in Fergana valley at latitude of 40^{o}31'59.9''N, longitude of 71^{o}47'4.1''E and elevation of 461 m (Figure-1). Climate is arid continental. The average temperature varies from 26-30^{o}C and the maximum temperature exceeds 45^{o}C in summer whereas the minimum temperature declines as low as -4^{o}C in winter. Long-term annual precipitation ranges from 50 to 150 mm, with 90% occurring from October through May (figure-2). Soil bulk density is 1.47±0.02 Mg m^{-3} in the top, increasing to 1.51±0.03 Mg m^{-3}at the soil layer of 0-50 and 50-100 cm (table-1). The farmer has 43.8 ha land and specialized to grow mainly cotton (23 ha), winter wheat (20.8 ha) and vegetables as a second crop after winter wheat if irrigation water is available. The main source of irrigation is canal water and groundwater. The farm, located in the tail end of the Southern Fergana Canal faces often water shortage issues. The groundwater table is shallow from 1.5-2 m below the ground. The farmer has access to groundwater from well, maintained for both, reducing the shallow water table and supplying water for crops.

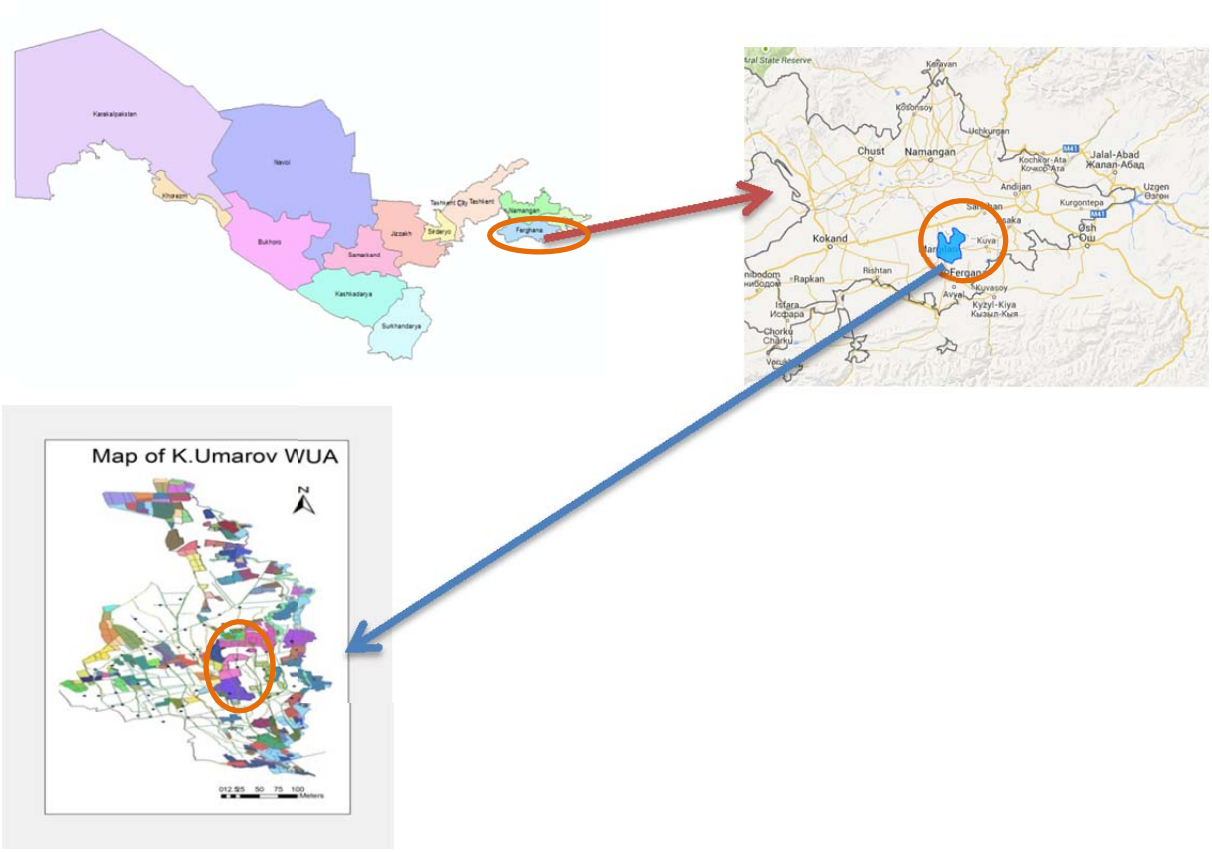


Figure -1 Location map of the study area

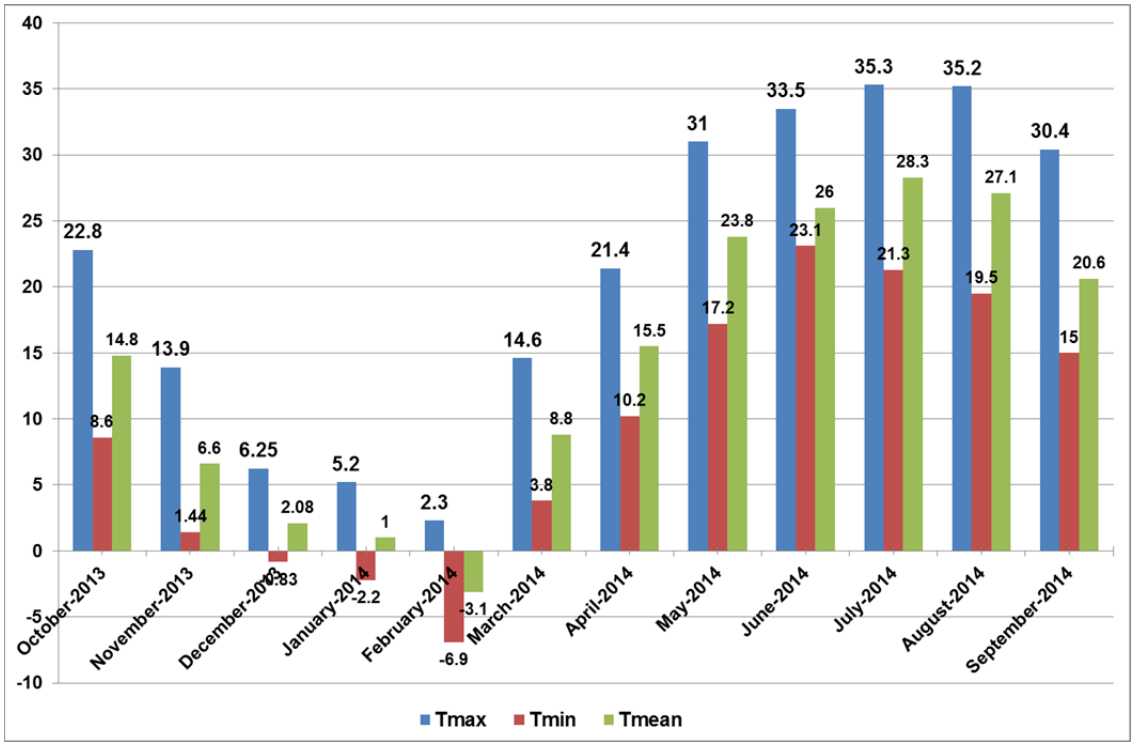


Figure - 2 Bar graph of monthly average temperature of Fergana province 2013-2014 (Source: Fergana district meteorological station).

Table-1 Physical properties of the soil at the Odiljon Farrukhbek Sakhovati farm

Soil layer	Texture			FC	SBD	Porosity
	Sand	Silt	Clay			
cm	%	%	%	% of weight	g/cm^3	%
0-30	36.8	47.4	15.8	19.3	1.47	45.6
30-50	35.6	48.1	16.1	21.7	1.49	44.8
50-100	34.8	48.3	16.9	18.9	1.51	44.1

A.3. MATERIALS AND METHOD

A.3.1. Experiment design

The field experiment included two steps:

- monitoring farming practices for winter wheat, irrigation applications;
- field trial with two varieties of munbean and three irrigation methods.

In October 2013, the farmer sow winter wheat variety 'Tanya'. After harvesting of winter wheat the field experiment with mungbean crop variety Durdona and local variety was immediately started on 0.5 ha area with three different irrigation methods, including the farmer traditional practice, cutback furrow irrigation and alternate furrow irrigation. No fertilizers were applied at the mung bean field. Three treatments were placed into two tiers with three replications (Table-2). The size of each tier was 240 m by 240 m (480 square m), where one variant consists of 8 furrows with mungbean variety Durdona and 8 furrows with local variety; each furrow was 50 m long. The furrow width was 60 cm. According to methodology, 4 middle furrows were control furrows, two other rows in both sides were protective zone (Dospekhov 1989). Crop monitoring and phonological observations are taken into consideration only in the control furrows.

Table-2. EXPERIMENT LAYOUT (MUNG BEAN)

Treatment Sl. No.	Mungbean varieties	Irrigation treatments	Notes
1	Durdona Local variety	Farmer practice (control)	only accounting irrigated water amount
2	Durdona Local variety	Furrow irrigation with decreased flow rate	Flow rate of irrigation is decreased in order to reduce run-off
3	Durdona Local variety	Alternate furrow	1st irrigation will be taken in 1st furrow and 2nd irrigation from the next furrow to balance the root zone

A.3.2. Soil characteristics

Composite soil samples were collected from the field at the following depths: 0-0.15, 0.15-0.30, 0.30-0.50, 0.50-0.75, 0.75-1.0 m. Sampling was undertaken prior to the irrigation season and after the irrigation season. The collected samples were air dried and processed. The soil physical attributes consisted of particle-size analysis, field capacity, infiltration rate, saturated hydraulic conductivity, and bulk density. Particle-size analysis was determined on randomly selected samples from 0-0.15, 0.15-0.30, 0.30-0.50, 0.50-0.75, 0.75-1 m depths at five locations in each field by the sedimentation method using sodium hexametaphosphate as a dispersing agent. Field capacity was determined from one randomly selected location (2 m × 2 m) in each field by flooding, covering the flooded area with polyethylene sheet, and determining soil moisture in the following days over a period of 3-5 days until stabilization was achieved at all the soil depths. Infiltration rate and saturated hydraulic conductivity were determined using standard double ring metallic infiltrometers with an outer ring diameter of 0.4 m and inner ring diameter of 0.21 m. Both rings were buried in the soil to a depth of 0.5-0.10 m. Soil bulk density was determined on undistributed soil samples collected from each soil depth using the core method. Soil chemical analysis for organic matter content, Phosphorus and Potassium contents was done before the planting and after harvesting period. Irrigation water applications from the canal for winter wheat and from the well for mungbean were monitored using trapezoidal weirs of 'Chipolleti' at the field and the trial level and by triangle weirs of 'Thompson' for each variant.

A.3.3. Phonological observations

Phonological observations started from germination rates and dates of different growth stages. Crop parameters included: crop height (cm); fruiting branches (pieces); yield elements (flower, bean) (pieces); 1st beans above ground (cm); total grains in one bean (pieces); the weight of 1000 seeds. These observations were done only on control furrows selected label gibbet 25 plants in each variant and replications.

In experiment year the density of plants are done two times after germination and before harvesting period in each variant and replications by counting all the plants in control furrows. Canopy cover is identified by using 1m x 1m special wooden board with 10cm x 10cm grids. Photos are taken and processed by using ArcGIS tools to calculate the area of covered in percentage. Before harvesting period, the five average plants were collected and the weight of leave, stalk and husk of bean were examined separately.

A.3.4. Characteristics of mung bean variety Durdona.

The genus *Vigna* comprises more than 200 species of which 7 are of tremendous agronomic importance. These are grown mainly in the warm temperate and tropical regions of the world. Valued for their grains with high and easily digestible proteins, these crops are also known as forage, green manure, and cover crops. Due to a short life cycle, these are suitable as cash crops and also fit well in intercropping, mixed or relay cropping. However, despite of development of several improved cultivars in different *Vigna* crops, biotic and abiotic stresses still remain the major constraints in realizing their true yield potential (Pratap, A., 2014). Mungbean new varieties have been developed on the base of AVRDC germ plasm and released in Uzbekistan. One of such drought tolerant, early maturing varieties is Durdona. Characteristics of mung bean variety Durdona and agronomic management suggested by authors are given below.

Mung bean variety Durdona (Vigna radiata L.) was created by Uzbek Research Institute of Plant Growing. Durdona variety is a high-yielding, ultra-maturing, drought tolerant and resistant to diseases and pests and it is appropriate for spring and summer terms of sowing. Maturing period is 65-70 days. Beans are located in upper portion of the branches (25-30 pieces) which accelerate harvesting period. Grain yield is about 2.1t/ha. Seeds are larger than local variety seeds. The weight of 1000 seeds is 60 g. Protein content is 18.7 % whereas the starch content contains 1.7%. Durdona variety is appropriate for crop rotation including wheat production system. Beans can be used to cook several meals and the green mass is used as a livestock fodder.

Mungbean variety Durdona is suitable to grow on irrigated lands. High yields are assumed to be achieved on different soil, climatic conditions. Crop water requirement in spring term of sowing period is 1500 m^3 whereas in summer it totals 2000 m^3. Seed rate considering high density of transplants are 30 kg/ha (400 thousand/plant/ha). The preferable width of furrows is 70 cm, the width between plants is 10-15 cm. The sowing dates for Fergana Valley conditions are in spring ~ 10 April, in summer ~ 15 June. Soil cultivation and weed control are important farming practices for mungbean to save soil moisture storages. Fertilization practices recommended to complete before the phase of flowering. It is not necessary to apply ammonium nitrate. Phosphorus and potassium fertilizers are applied with the rate of 75 kg/ha each.

A.5. Farming practices

A.5.1. Field with winter wheat crop

The winter wheat variety “Tanya” sown area was about 20 ha. The agronomic practices were started with the preparation of the field only by cultivating because cotton harvesting period was not completed and cotton stalks were still remaining in the field. Duration of the land preparation was from 10-15th October, 2013. The farmer sowed winter wheat crop variety Tanya (20 ha) on 16-17-18th October 2013 with Tractor TTZ-80.

Table-3. Farming practices on the field with winter wheat crop 20 ha in K.Umarov WUA, Odiljon Farrukhbek Sakhovati farm are shown in Table 3

Farming practice	Practice date and quantity
Manual labour:	
Correcting and reshaping furrows	09-11.10.2013
Removing cotton stalks from the field	27.11.2013
Mechanical work:	
Land preparation by cultivating	10-15.10.2013
Transportation of seeds to field	16-19.10.2013
Sowing of seeds	16-19.10.2013
Applying fertilizers -1	16.10.2013
-2	23.01.2014
-3	04.03.2014
-4	04.04.2014
-5	14.04.2014
-6	28.04.2014
Irrigation: -1	21.10.2013
-2	28.10.2013
-3	15.11.2013
-4	17.12.2013
-5	15.03.2014
-6	01.05.2014
-7	10.05.2014
-8	20.05.2014
-9	25.05.2014
-10	05.06.2014
Harvesting with grain harvester combines -1	23.06.2014
-2	24.06.2014
Harvesting the green mass	24.06.2014

A.5.2. Field with mung bean crop varieties Durdona and local variety

The field trial was immediately started after harvesting of winter wheat on selected 0.5 ha area. The field was irrigated in order to accumulate the appropriate moisture storage in the soil and form conditions to plough up the field. Ploughing up was done on 05 July by using New Holland TS-135 tractor, which was followed by leveling with ‘Dlinabaz’ on 07 July. Furrows were made

on 09 July, 2014. Farmer sowed mung bean crop on 10-11 July, 2014 with a seed rate of 14 kg/ha. No fertilizers were applied in order to go towards producing ecologically pure products. Weed control was done on 22 August and repeated on 23 August, 2014. Biological pest control was done on 27 July, 2014. The farmer applied pesticides Acetaplan 150 g on 25 August, 2014. Farming practices on the field with mung bean are summarized in Table 4

Table 4. Farming practices implemented for cultivation of mungbean

Farming practice	**Practice date and quantity**
Manual labour:	
Sowing of seeds	10-11.07
Making distribution furrows	11.07
Biological Pest Control	27.07
Chemical Pest Control	25.08
Mechanical work:	
Ploughing up	05.07
Leveling with Dilnabaz	07.07
Making furrows	09.07
Cultivation -1	26.07
-2	06.08
Irrigation: -1	12.07
-2	21.07
-3	30.08
Harvesting: -1	02-03.10
-1	06-07.10
-1	09.10
-1	12.10
-1	15.10
-2	24.10
-2	25.10
-2	31.10

Irrigation water applications at each plot were measured using measuring triangle weir Thomson and at the tiral level by water measuring trapezoidal weir “Chipolletti” of 50 cm wide.

A.6. RESULTS AND DISCUSSION

Irrigation applications for different crops grown at the farm are given in Figures 3 and 4.

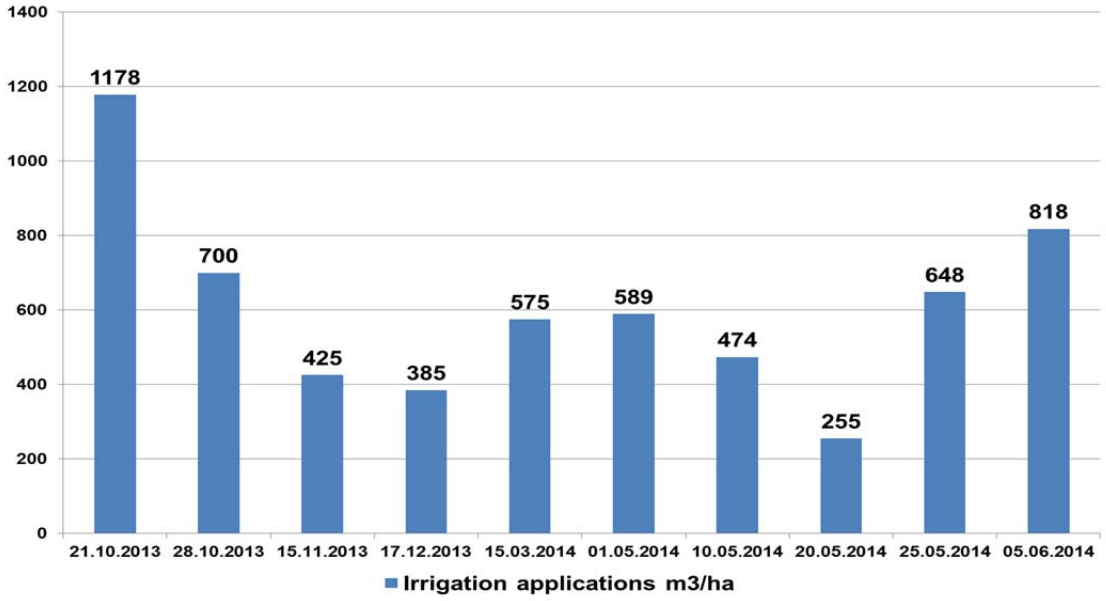


Figure-3 Irrigation of winter wheat at the Odiljon Farrukhbek Sakhovati farm (2013-2014) (Source of irrigation: Canal)

Data presented on Figure 3 shows that the farmer applied the highest rate of irrigation in germination phase with the rate of 1178 m^3/ha in order to get proper density of plants. Ten irrigation applications were applied with a rate of 255-1178 m^3/ha. In whole, 6047 m^3/ha was applied for winter wheat. Irrigation applications completed 20 days before the start of the harvesting period.

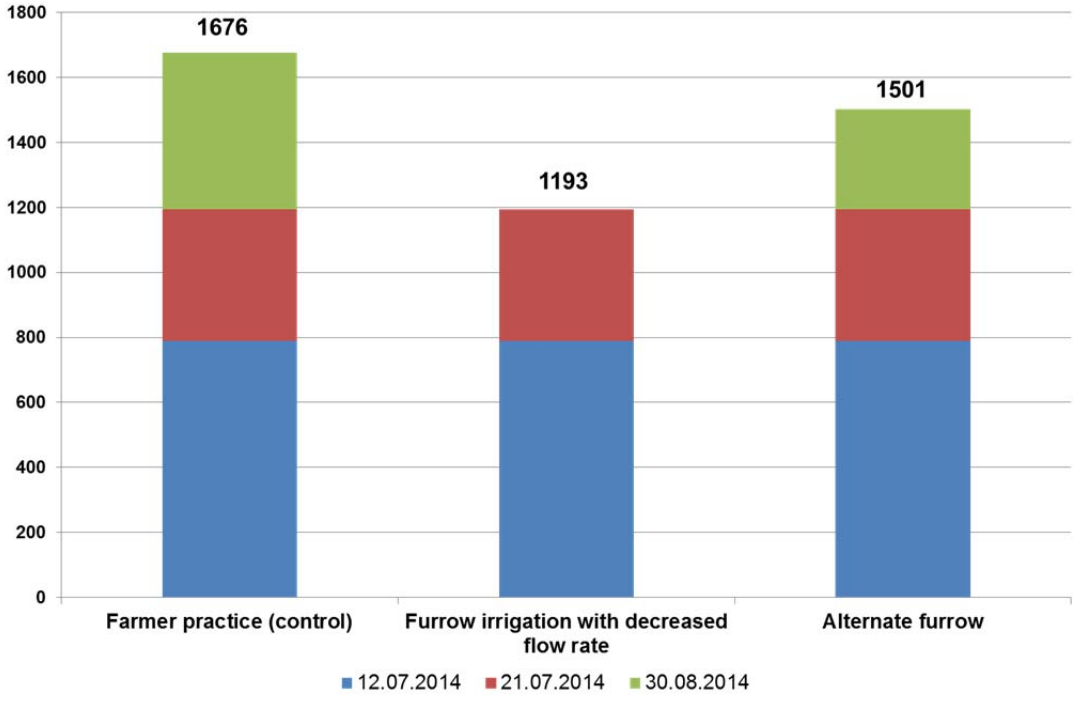


Figure-4 Irrigation of mung bean crop with different irrigation methods at the Odiljon Farrukhbek Sakhovati farm (m^3/ha, 2014) (Source of irrigation: Groundwater).

The data in Figure 4 indicates norms of irrigation, irrigation dates of mung bean crop by using three different irrigation methods. Groundwater table was at 1.6 m below the ground. Because of the water shortage in summer period the mung bean crop was irrigated from the well which was installed to maintain deep groundwater table. Irrigation according to farmer practice was selected as a control treatment where the irrigated water amount applied was 1676 m^3/ha. In the second treatment the crop was irrigated by using cutback furrow irrigation method where irrigation water amount applied was at minimum level, 1193 m^3/ha. Third irrigation method was alternate furrow irrigation where the rates of seasonal irrigation was 1501 m^3/ha. In alternate furrow irrigation, the irrigation was applied in first furrow and next time to the next furrow. Three irrigation applications were applied in farmer practice and alternate furrow irrigation methods with a rates of 403-790 m^3/ha, 308-790 m^3/ha respectively. In the 2nd treatment by using furrow irrigation method the irrigation events were one time less compared to other treatments. Irrigation intervals between 1st and 2nd irrigation events were 10 days and the intervals between 2nd and 3rd irrigation events were 40 days. In the 2nd treatment after 2nd irrigation the field had no irrigation 74 days till harvesting period and local variety crop leaves became yellowish but variety Durdona leaves were remaining greenish color. Crop vigor can be seen in figure-5.

Figure-5 Mung bean experimental field. Yellowish color is local variety (8 furrows) and greenish color Durdona variety (8 furrows) (Photo taken 18.09.2014).

The crop status on Figure 5 indicates the water stress. Dominant crops at the farm are cotton and winter wheat. Canals first supply water for dominant crops where second crops i.e. mung bean or other crops are irrigated if irrigation water is available. The farmers had a high risk of yield and economic loss because of the water shortage. The District Water Administration apply timely water distribution called 'Avron' where water user associations (WUA) receive water for certain time of period. This practice was applied from September to October (2014) when the canal delivering water to the farm was dry. In this regards, selecting and releasing appropriate new, perspective, drought tolerant crop varieties such as mung bean Durdona variety for crop rotation including wheat production systems is mainly important challenge. Crop water requirement, effect of irrigation methods was also considered by doing phonological observations.

A.6.1. Phonological observations (mung bean)

Phenological data is given in Table 5.

Table-5 Mung bean crop growth and development (16 September, 2014)

Treatments	Average values according to treatment and replications													
	Crop height (cm)		Fruit branches		Elements				1st beans above ground		Density of plants (thousand/ha)		Grains in one bean	
					Flower		Bean							
	Durd	LV	Durd	LV	Durd	LV	Durd	LV	Durd	LV	Durd	LV	Durd	LV
Farmer practice (control)	42.3	26.3	5.1	4.5	3.3	0.2	22.1	24.8	18.9	8.3	70.2	101.3	10.3	10.1
Furrow irrigation	33.9	24	5	4.8	3.9	0	22.8	18	16.6	6.3	76.5	114.6	8.8	9.1
Alternate furrow	37.8	23.2	6	5	1.9	0.3	27.5	20	11.9	7.4	89.0	120.0	10.1	10.5

The data regarding to crop growth and development shows that in Durdona variety the highest crop height can be observed in farmer practice by means of 42.3 cm whereas in alternate furrow treatment the value were 37.8 cm. The lowest crop height could be seen in furrow irrigation treatment with value of 33.9 cm where the lowest irrigation rates were applied. Crop height values for local variety were lower than Durdona variety with values of 26.3, 24 and 23.2 cm in farmer practice, furrow irrigation and alternate furrow irrigation treatments accordingly. According to data given in Table 5 it can be seen that crop growth and development is directly interlinked with irrigation methods and norms. Crop height was higher by increasing the

irrigation rates and vice versa. Even in hot temperature Durdona variety beans could remain on the plant over month after maturation without loss of yield because of the hard husk in comparison with local variety where loss of yield in local variety could be observed in harvesting period as well.

Beans of Durdona variety were also located in the upper part of the crop. By measuring 1st beans above ground the values showed that Durdona variety beans were located two times upper than local variety. Local variety had the lower height and covered furrows which created difficulties during harvesting period. When beans are located at upper part of the plant the harvesting can be done by using grain harvester combines. This is one of the advantages of Durdona variety and this parameter of the crop can be very useful while disseminating the result into larger areas. The last phonological observation was related to root depth and development. Soil was dug till in order to identify the root zone of the crop. Soil samples were also collected in order to calculate soil fertility improvement (table- 6).

Table-6 Soil fertility improvement through symbiotic nitrogen fixation activities at the field with mung bean crop

Soil layer	Before planting			After harvesting		
	Humus	P_2O_5	K_2O	Humus	P_2O_5	K_2O
Cm	%	mg/kg	mg/kg	%	mg/kg	mg/kg
0-15	1.27	18.0	156.5	1.12	14.5	132.4
15-30	1.27	12.4	132.4	1.18	16.5	108.4
30-50	0.89	6.8	120.4	1.08	18.5	120.4

Table 6 gives information about soil chemical properties such as humus and Phosphorus and Potassium before planting and after harvesting. In the field with mung bean crop no fertilizers applied. Taking into account the fact soil fertility improvement can be related to only symbiotic nitrogen fixation activities. The data given in Table 6 indicates that organic matter increased in 30-50 cm soil layer because many additional branches of the root were located at the same layer.
At the end of growing season of mung bean, soil was dug in order to identify the root depth and development. Main root spread at the up soil layer 0-50 cm from the surface. Four root branches

developed from the main root and phonological observation showed that the additional root branches spread at 40-50 cm.

In 2014 year there was a sudden decrease in temperature from the end of September which led to loss of yield of Durdona variety. Phonological observations were done related to calculation of loss of yield. The results showed that in farmer practice treatment the loss of yield was 359 kg/ha whereas the highest yield loss was in the treatment with alternate furrow irrigation at 378 kg/ha; 2nd treatment with low irrigation rates had the lowest loss of yield.

A.6.2. Irrigation Water Use Efficiency

Irrigation Water Use Efficiency was calculated as follows:

IWUE= Yield (kg) / Total irrigation water applied (m^3/ha)

After the monitoring the irrigation applications of winter wheat at the farm Odiljon Farrukhbek Sakhovati the WUE for winter wheat crop was calculated (Table 7).

Table-7 WUE of winter wheat crop

Winter wheat variety Tanya Yield kg/ha	**Seasonal norms of irrigation (m^3/ha)**	**Water productivity (kg/m^3)**
6000	6047	0.99

WUE studies for double cropping were directed to convert evaporation loss into useful crop transpiration by using different irrigation technologies (Table 8).

Table-8 WUE of mung bean crop varieties Durdona and local variety with different irrigation technologies

Treatments	**Average yield according to variant and replications (kg/ha)**		**Seasonal norms of irrigation (m^3/ha)**		**Water productivity (kg/m^3)**	
	Durdona	LV	Durdona	LV	Durdona	LV
Farmer practice (control)	1394	1542	1676		0.83	0.92
Furrow irrigation	1181	1417	1193		0.99	1.19
Alternate furrow	1444	1653	1501		0.96	1.10

The results of the studies with mung bean crop showed that the highest productivity was under cut-back furrow irrigation treatment where one time less irrigation event were applied but the yield was less than in other treatments. The most appropriate irrigation method for mung bean was found to be alternate furrow irrigation. The crop yield was the highest and the applied water amount was at minimum level under this irrigation method.

The most crucial part of the research can be discussed below: (table-9).

Table-9 Filtration loss and pumping water up again for re-use for double cropping

	Mung bean (alternate furrow)	**Winter wheat**	**During the whole year**
Seasonal irrigation rates (m^3/ha)			
Actual applied rates	1501	6047	7548
In accordance with filtrated water amount	594	6047	6641
Difference (+,-)	907	0	907
Filtration loss and groundwater recharge			
%	-	15 (Ganiev K., 1979)	
(m^3/ha)	-	907	
Average yield kg/ha	1653	6000	
Water productivity (kg/m^3)			
Actual rates	1.1	0.99	
In accordance with filtrated water amount	2.78		
Difference (+,-)	1.68		

Winter wheat was irrigated from the canal with total irrigation norms of 6047 m^3/ha. At the same field mung bean crop was irrigated from groundwater. Substantial water losses may infiltrate in the soil, recharge the aquifers and may be pumped up again for re-use, either in the same project area or in another downstream. In this regards, Water Use Efficiency can be improved by this way as well.

A.6.3. Economic effectiveness

Table-10 Economic effectiveness: Comparison of single and double cropping

Crop	Harvest	Cost of 1kg yield	Total profit	Total cost of mechanical work	Total cost of manual working	Total cost of pesticides and biological control	Total cost of fertilizer use	Total cost of seed	Net profit
	kg/ha	Uz.sum	Uz.sum	Uz.sum	Uz.sum	Uz.sum	Uz.sum	Uz.sum	Uz.sum
Winter wheat	6000	418	3194000	1648237	174000	-	962903	168000	100860
Mung bean as a second crop (v-3)	1653	3000	4959000	430000	1215000	128000	-	14000	3172000
Double cropping			8153000	2078237	1389000	128000	962903	182000	3272860

One of the part of the research was to identify how double cropping can increase income of farmers. According to table-10, the results showed that drought tolerant second crops can increase income of farmers and reduce the risk of yield and economic damages.

CONCLUSION

Taking into consideration the data collected in the laboratory and field experiments conducted on silt loam soils where the ground water is located at the depth of 1.5-2.0 m and considering the climatic, soil, soil-reclamation hydro-geologic conditions of K.Umarov WUA, it can be concluded as:

Monitoring results of farming practices and irrigation applications with winter wheat crop showed that it requires further studies with field scale experiments. Determining the crop water requirement at summer term of sowing period by applying different irrigation technologies with mung bean crop results indicate that the highest yield and economic effectiveness as well as high water productivity can be achieved in alternate furrow irrigation.

Soil fertility can be improved by symbiotic nitrogen fixation activities. Mung bean seed multiplication in farm was achieved and the project results can be disseminated in larger areas.

Soil data and crop phonological observations showed that in order to get high yields not only irrigation technologies but also all agronomic practices should be taken into account. It is required judicious and optimal management of both land and water resources along with the use of high yielding variety seeds, proper density of plants, optimal fertilizer input, pest management, routinely mechanical work (tillage, ploughing, chiseling, harrowing,), appropriate procedure of irrigation and adequate labor force in order to increase productivity and to raise the quality index to meet the World Standard's requirements. This will ensure food security of population and raw materials for industry. The solution to this problem is very prominent not only for Uzbekistan but also for the worldwide.

Figure -6 Farmer was an active member of the research and showed the high interest on drought tolerant mung bean varieties (Photo taken at Odiljon Farrukhbek Sakhovati farm 16.09.2014).

Figure -7 Harvesting of mung bean with the help of labor force at the farm Odiljon Farrukhbek Sakhovati

Figure - 8 The last stage of harvesting of mung bean at the farm Odiljon Farrukhbek Sakhovati

Figure - 9 Green mass of mung bean at the farm Odiljon Farrukhbek Sakhovati

B. Impact of institutional development in water management on productivity of DSs with high potential for improvement

B.1. Introduction

Along CRP 1.1. program in Central Asia for 2014-2015, there is carrying out research directed towards understanding key potentials and limitations of WUAs in Ferghana Valley by assessing the role of institutions (formal and informal1) and related socioeconomic and environmental outcomes in view of enhancing collective action aiming at more sustainable water governance of on-farm irrigation water management.

The main direction of research is going to understand and show the linkage between on-farm water management institutional conditions including economic mechanisms and its impact on improvement the overall water management at on-farm level. Mainly, it links with the institutional and economic environment where the WUAs are operating and identifying what kind of rules and regulations should posses WUAs in order to operate sustainably. Development of appropriate institutions (set of rules and regulations) and good governance structures potentially guarantee the efficient use of irrigation lands in despite of its ownership.

There is need to mention that this research is also the topic of Oyture Anarbekov's PhD study at University of Bern, Switzerland.

Research is based on comparative case study approach in Central Asia, particular in Ferghana Valley. This approach is proposed in order to better understand the context and overcome the external validity issues. In addition, research is going to compare the water governance and its influence to the overall performance of WUAs as well as identifying the specific cases and driving forces behind of differences in each country of Ferghana Valley through selected case studies. Two pilot WUAs are selected in each country of Ferghana Valley within one hydrographic Small River or canal system basin. A unit of analysis is WUA located in the head tail and end tail of Small River or canal system. In Uzbekistan, it has been selected three WUAs due to length of main canal.

General hypothesis is that WUAs based in the tail –end of irrigation system should have less problems in organizing collective action, public participation and involvement public into the governance, operating and maintaining on-farm WUA infrastructure due to scarcity to access of water. Annual reports about each WUA's performance, interview water users and WUA officials will help in identifying the specific cases and driving forces behind of differences.

In order to accomplish this task, the author employs Collective Action theory to understand what are the key factors that restraint resource users to operate and maintain their on-farm infrastructure as collectively and manage as common pool resource in order to improve their water use efficiencies. In addition, the research will be also based on theory of New Institutional

[1] Informal institutions, for instance, included social khashars (collectively clean drainage systems or fix irrigation scheme. It was a free labor and voluntarily initiated activity). With the adoption of new rules, these activities are less practiced today.

Economics and Common Pool Resources Theory (D. North, Ensminger/Haller and Elinor Ostrom) which brought to better understanding the importance and the role of institutions in economies, and have elaborated the first widespread critique of the transition paradigm.

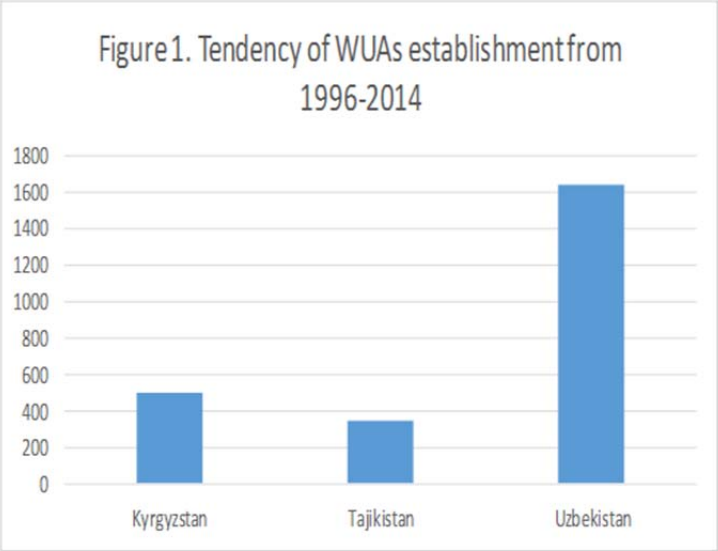
Field methodology is based upon three types of approaches to collect data:

a) Key informants interview and observations, i.e. collecting background information for drafting each WUA case-study;
b) Quantitative data collection: using questionnaire;
c) Qualitative data collection via using Focus Group Discussions

Annual reports of each WUA's, budgets, protocols of General Assembly meetings, Arbitrage and Revision committees collected in order to better understand the local realities.

B.2. Focus of Research

Since mid 1990's region's countries have started their agricultural reforms, former large scale collective farms has been transformed into different forms of individual farming. E.g., in Kyrgyzstan land has been distributed among the former members of collective farms, in Uzbekistan land was allocated through land distribution commissions into larger individual units of not less than 10 ha first however, starting from 2009 massive optimization of land process started and today the average size of farmer in Uzbekistan varies between 50 – 75 ha of lands, especially in the conditions of Ferghana Valley. Tajikistan was among Kyrgyzstan and Uzbekistan but the latest move more towards small land owner unit management of agriculture sector. The results of the land reforms has been triggering for the former on-farm water management system. The state water management organizations formerly delivering water to the collective farm gates were forced to deal with amplitude of hundreds of individual farmers, growing different crops, and applying different agronomic and water management practices. Therefore, the need for a new organizational arrangement to manage water at the on-farm level and to distribute irrigation water between new individual farmers became an obvious necessity.



The entire system of irrigation water management during the Soviet times was designed to deal with large collective farms. The land reforms have resulted in a situation, whereby along the main canals, instead of a few, mainly cotton growing collective farms, there are now hundreds of individual farmers in terms of Uzbekistan and Tajikistan and thousands in Kyrgyzstan who are cultivating different irrigation intensive crops such as rice, wheat and vegetables.

Figure 1 shows the tendency of WUA establishment in three countries of Ferghana Valley starting from 1996 – 2014.

This situation has increased problems with water distribution along the main canals, particularly when water scarcity frequently leads to clashes and conflicts between water users. Often, due to inefficiencies into the irrigation system and water application methods, the amount of water withdrawals into the administrative districts much higher than their water shares—locally called as "limits". The governments of the Central Asia mainly have followed the same route on overcoming of "water impacts" of the de-collectivization. They have issued decrees on organization of Water Users Associations (WUAs) in place of liquidated collective farms to fill water management gap. Thousands of WUAs have been registered within a few months in each country.

Although, in all countries of Ferghana Valley, it has been accepted that Water users association (WUA) is the key component in this restructuring process and are in charge of operating and maintaining on-farm irrigation and drainage infrastructure. Most of WUAs are still not able to take full responsibility, organize collective action, persuade water users with data/information and generate sufficient funding for operation and maintenance of its own collective infrastructure. Poor water governance, i.e. public participation and involvement in on-farm water management have led to farmers' dissatisfaction, lack of ownership of on-farm infrastructure, conflicts among water users (unsanctioned withdrawals of water by upstream or elite farmers) and between water users and WUAs, mistrust to the work of WUA (data transparency), reductions in crop yields and overall low rate of WUA irrigation service fee collection. Author believe that without proper internal rules and regulations within WUA it is almost impossible to improve water use efficiency at WUA level.

B.3. PROGRESS UP TO DATE: PERIOD JANUARY – DECEMBER 2014

A. **Tajikistan:**

Two pilot WUAs have been already selected in 2013 based upon agreed criteria along Khojabarkigan main magistral canal in Sughd Province. A unit of analysis is WUA located in the head tail and end tail of canal system. Because Khojabakirgan canal itself provides water for two districts, it was rational to choose one WUA from upper district, i.e. B. Ghafurov and second WUA from the tail part of canal, J. Rasulov district (please see below map of the location of WUAs along main canal). The name of WUA which is based in B. Ghafurov District is "Obi Ravoni Ovchi Qalacha" and name of WUA which is based in J. Rasulov District is "X. Olimov" successor of WUA "Gulyakondoz".

Based upon selected WUAs in Sughd Province along main canal Khojabakirgan and collected background information for the WUAs case-studies, there were made progress with the hiring local consultants to start the quantitative data collection using questionnaire in 2014. The approach of data collection in each WUA has been elaborated by identifying categories of water users to interview as well as number of them. Need to mention that in both WUAs, clear explanation of the research project objectives and outcomes have been explained to WUAs leaderships. In each selected WUA, i.e. WUA Obi Ravoni Ovchi Qalacha in B. Ghafurov District as well as WUA X. Olimov, successor of WUA Gulyakandoz in J. Rasulov district, there

have been identified 40 water users (totally in two WUAs 80 respondents) to interview using the designed questionnaire. Local consultants have been trained on each questions specific aim and approach how to ask each question of the questionnaire. The survey started in the mid of May 2014 and accomplished by the end of September 2014.

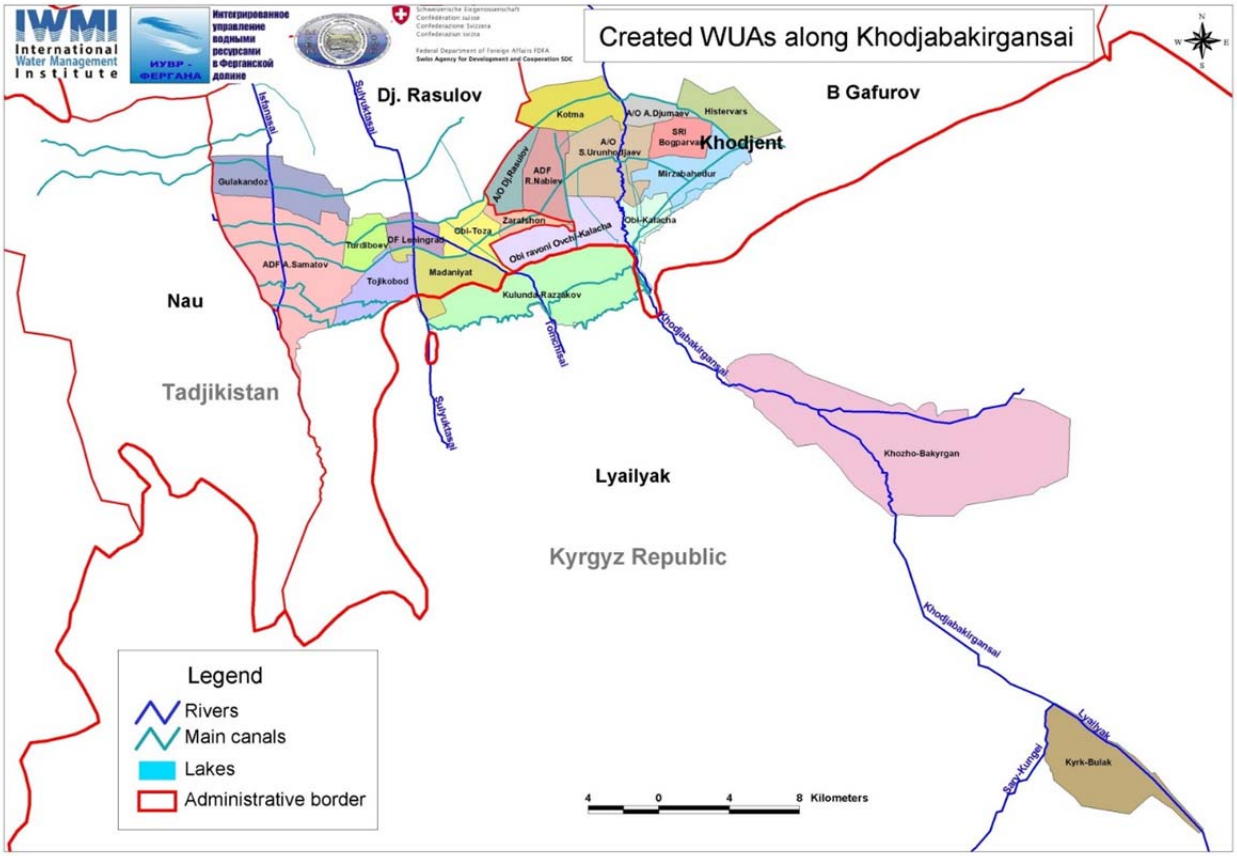


Figure 1. Created WUAs along Khojabakirgansay (source: IWRM-FV project)

B: Uzbekistan

There have been selected as case-study three WUAs along South Ferghana Main Canal (SFC). One of the reason for selection of three WUAs because SFC is the long canal, totally with 114.9 km long length and irrigated area of more than 94,000 ha. So basically, there were selected one WUA in the head part, second in the middle part and third in the tail part of SFC. The head part WUA is called Tomchi-Kuli which is based in Markhamat district, Andijan Province, middle WUA is called Kodirjon A'zamjon based in Quva district, Ferghana Province and tail WUA is called Komiljon Umarov which is based in Toshloq District, Ferghana Province. In all WUAs, there have been interviewed key informants, collected background data using specifically developed data collection sheet as well as available local materials. In addition, there have been able to conduct survey among farmers of WUAs.

Survey has been conducted among 53 farmers as well as rural settlement chairs (makhalla) in Tomchi-Kuli WUA, among 31 individual farmers of WUA Kodirjon A'zamjon and among 30 individual farmers of WUA Kodirjon Umarov. Field methodology accomplished to collect intensive data collection in order to draft case study of each WUA. There have been also explained in detail the research project objective and outcome to the WUAs leaderships. Local

consultant in each WUA has been identified and hired for the conduction of extensive questionnaire. Jointly with WUA leadership and local consultants identified and selected different category of water users as well as their numbers to interview based upon research approach. Local consultants have been trained on each questions specific aims and approach how to ask each question of the questionnaire. There have been interviewed totally 114 water users in three WUAs using the questionnaire. The survey started in the mid of May 2014 and accomplished in December, 2014.

B. 4. PRELIMINARY RESULTS FROM THE FIELD STUDY

These results are based upon survey conducted among WUA directorate, first initial key informants' interviews and observations. Key informants are water users such as deqkhan farmers, individual farmers, kitchen-garden plot owners represented by chairmen of local rural settlements, Canal Management Organization employees. There is expected to provide results that are more comprehensive and recommendations after the processing and analysing quantitative data which were collected via questionnaire from different type of water users and staff of five selected WUAs including focus group discussions. Totally, there were surveyed 194 farmers in two countries.

Tajikistan:

- Important role is playing Djamoats, i.e. Rural Settlements in organizing collective action in the territory of WUA, such as social khashars (collective action to clean on-farm canals) in WUA X. Olimov;
- Due to deqkhan farmers dismantlement process, the process of collective action is becoming more difficult and complex. WUAs are facing challenge organize farmers into the governance body of WUA;
- More and more there is appearing the need to establish Water user groups in order to unite water users along tertiary canals for the collective action within WUAs;
- A question of on-farm irrigation and drainage network ownership is becoming more and more important;
- The main actors in main canal water allocation and use are followings: Management of Khojabakirgan Main Canal (CMO), WUAs, deqkhan farmers with its Association of Deqkhan farmers (ADKh Khojabakirgan), lessees from deqkhan farmers, presidential land owners, kitchen-gardens and other water users, such as Djamoats/makhalas;
- The formal and in-formal structure of WUA governance is better organized in the tail WUA along KhBC. In majority of WUAs, the chairman of WUA Council is working on voluntary basis however in WUA X. Olimov (previous Gulyakandoz), water users decided to pay salary for Chairman of WUA Council work. They have realized and understood the importance of this body operation;
- There is also high interference by Water Unit of Rayvodkhozes for the work of WUA;
- Furthermore, there is systemic and organized work of WUA Council and its Board of Governors in WUA X. Olimov (former Gulyakandoz) with proper protocols, minutes of meetings. These aspects directly relate to the improved water management inside WUA incomparison to WUA Obi-Ravoni Ovchi Qalacha.
- Farmers, i.e. deqkhan farmers in the tail WUA X. Olimov are more adhere to follow the accepted rules and regulations within WUA in comparison to head WUA. The leadership of WUA including its farmers strongly confident that they don't allow massive water stealage, violation the rules accepted in WUA and if it happens they could handle it within WUA;

- In both WUAs there are exist external interferences in water allocation to the deqkhan farmers however, extend of interferences is hugely different in head WUA in comparison to tail WUA. More external interference to the work of WUA is occurring in WUA Obi Ravoni Ovchi Qalacha in comparison to WUA X. Olimov (former Gulyakandoz), mainly and due to presence of WUA governance in tail WUA. The external interferences are basically followings: Local authorities such as Governors (Xokims), Prosecutor and other authority of District call and ask WUA management to provide water first to his/her relatives, friends or to his/her lands;
- In general, one can conclude that governance is better organized in WUA X. Olimov (tail ender) in comparison to WUA Komiljon Umarov (head tail). WUA X. Olimov has better collective action, existence of penalty system, governance structure such as court of Aqsakals (eldermens), all these contribute to the success of WUA governance;
- In both WUAs, Deqkhan farmers mentioned that there is need to revise the formal organizational structure of WUAs with its governance and management bodies. Both WUA deqkhan farmers agree that there is need to be WUA governance body but not in current organizational structure content. It should be more real and not just on the paper;

In both WUAs, Deqkhan farmers indicated that they use other different water governance mechanisms in contrast to accepted one in order to find solutions for the different problems related to water allocation, such as work closely with Djamoat leadership and Association of Deqkhan Farmers leadership. It is highly recommended to revise proposed WUA governance structure taking into consideration local context and indegineous knowledge. There is potentially reconsider current governance structures in WUAs taking into consideration important informal institutions. It is also expected to provide more in-depth findings and recommendations for WUA governance improvement.

Uzbekistan:

- All water users consider that it is important to have WUA Governance and its meetings. Specifically, during the General Assembly of farmers there are discussed the water use situation, the contractual relationships between WUA and water users, the irrigation service fee collection rates, preparedness of irrigation and drainage networks for the upcoming vegetation season as well as get reporting of executive as well as governance body such as WUA Directorate as well as WUA Council accordingly.
- There is need to mention that in all WUAs there is symbolic payment for the use of water by kitchen-garden plot owners. Individual farmers basically compensate the cost of provision of irrigation water to kitchen-garden plot owners.
- There is agreement within WUA that water first delivered to the fields of farmers starting from 06:00 – 21:00 and later from 21:00 – 06:00 water is provided for kitchen-gardens.
- The important role plays as well the leadership of WUA. Water users stressed that it is important to have a good leader who could adhere the order as well as discipline in the WUA.
- One of the most spread methods of getting irrigation service fee paid by WUA, is the closure of the outlets and not provision of water by WUA directorate.
- One of the issues in Uzbekistan WUAs is the typical form of agreement/contract which is disseminated in all WUAs to make a contract between WUA and farmers.
- Majority of farmers within WUAs are cotton and wheat producers. These two crops are considered State quota crops, therefore State purchases cotton and wheat from the farmers. This process sometimes takes long time therefore, there is delay to payment for irrigation service to WUAs.

- Because people live within one society, they would like to solve conflicts and disputes within their societies.
- Need to mention that although WUA Tomchi-Kuli is based in head of Canal and ideally WUA management shouldn't be active but in WUA Tomchi-Kuli management is better organized due to its leadership.
- Survey has revealed that leadership plays important role in governing and managing water resources inside WUA. According to survey, WUA Tomchi-Kuli is better organized in comparison to WUA K. Umarov. Water users are would like to approach more directorate of WUA Tomchi-Kuli to resolve the conflicts at least.
- In both WUAs, farmers indicated that there is interference of State Water Inspection especially with regard to on-farm instrastructure maintenance and water allocation based on limit.
- However, in both WUAs there is need to revise the governance structure taking into consideration local indigenous knowledge and informal institutions.

After discussion with water users, it is clear that WUAs are still demanded organization which should exist and agricultural organization that operates by farmers themselves. Farmers gradually understand that it is their organization and that they need to support. However, there is State interference to the work of WUA, starting from making sure that WUAs have in place all documentations (contract with farmers; demand, supply and limit documentations; day-to-day water allocation schedule, water use planning as well as water scheduling), control the proper operation and maintenance of irrigation and drainage infrastructure within WUAs and others. There is basically less problem with regard to difference between head and tail WUA. There is similarities of State interference in all three WUAs and revision of current Governance structure. If there will be disappear Governance body, WUAs could not operate in the viable conditions.

Below table shows the initial comparison of design principles of common pool resource instititutions application in three countries of Ferghana Valley via case-studies of above WUAs. Need to mention that information on Kyrgyz case-study WUAs has been taken outside of Ferghana Valley part of Kyrgyzstan.

Initial Comparison of Design principles CPR institutions application in three countries

Principles of Institutions	Kyrgyzstan	Tajikistan	Uzbekistan
1) Clearly Defined Boundaries	-Territ vs Hydro; Canal vs local source; Small farmers	- Still process of Reform – towards KG	+ Re-registration, optimization of farms
2) Proportional Equivalence between Benefits and Costs	+ No-State Quota; contractual arrangem	+ Highest ISF in the region	- State Quota + Contracts
3) Collective-Choice Arrangements	+ General Assembly, Meeting of Aqsakals	- Tail end WUAs active	- Once GA in a year
4) Monitoring	- Inadequate Capacity	- Inadequate Capacit	+ Strong Govt
5) Graduated Sanctions	+ Collectively: Court of Aqsakals	- Interference Irrigation Auth, debt	+ State Org interference
6) Conflict-Resolution Mechanisms	+ Zonal representat; Court of Aqsakals	- Not recognition int-rules. External costly	+ State Authority interverence
7) Minimal Recognition of Rights to Organize	+ Strong Leaders, Ayil Okumety linkage	- LA don't recognize	+ Strong Government
8) Nested Enterprises	+ Zonal Representation	- Towards Kg case	- Optimization of farmers
9) Bargaining Power	Less practiced	Between	High interference

Table 1. Initial Comparison of CPR design principles applications in three countries

From comparison of nine principles, table shows that Kyrgyzstan WUAs has less Government interference to the work of WUA in comparison to Tajikistan and Uzbekistan. However there is issues such as hydrographic versus command-territorial water management. Tajikistan is leading in terms of rate of irrigation service fee, however it doesn't guarantee that Tajikistan WUAs are better off in terms of financial resources. Kyrgyz WUAs directly relate their activity based upon direct payment of irrigation service fee by water users in comparison to Uzbek WUAs where Government guarantees payment of state quota agricultural crops's irrigation fee. In all three countries there is indigenous knowledge as well as informal institutions that are more active and helpful versus official formal ones. Among such structures in Kyrgyzstan is Court of Aqsakals, in Tajikistan Djamoats, in Uzbekistan Qishloq Fuqaroral Yigini. It is clear that there are institutional aspects which could be exchanged and learned between WUAs in the region such as collective action of Kyrgyz WUAs, State support and state positive interference of Uzbek WUAs and from Tajik WUAs setting the irrigation service fee.

Finally, there is need futher research to come up with proper governance structure to each country of Ferghana Valley. Research is still continuing in 2015.

One of the outputs in 2014 was publication of article at ICID Congress Meeting in Korea.

Mochalova, E. [NARS]; Anarbekov, Oyture [IWMI]; Kahhorov, U. [NARS]; 2014. Institutions as key drivers of collective action in WUAs [Water User Associations] of Uzbekistan. [Abstract]. In International Commission on Irrigation and Drainage (ICID). 22nd International Congress on Irrigation and Drainage: securing water for food and rural community under climate change, Gwangju, Korea, 14-20September 2014. Transactions. Volume 1. Question 58 and 59. New Delhi, India:International Commission on Irrigation and Drainage (ICID). pp.228-229. (ICID Transaction 31(A)).

Full article is accessible via web-link at: http://cac-program.org/files/9cb119a2382c3d446cc1e81eedf957c7.pdf

C. WHAT BUILDS INTO THE WATER USE EFFICIENCY AT THE HOUSEHOLD LEVEL - BASELINE ANALYSIS

Contributing to activities under:

CRP Dryland systems program, activity: Improving Water Use Efficiency in Central Asia

Action site: Ferghana Valley

Prepared by: Nozilakhon Mukhamedova, Research Officer/Gender specialist
CGIAR Center: International Water Management Institute

Short summary

Improving water use and management practices, protecting the ecosystems require considering gender disparities and achieving livelihood and food security among the most vulnerable groups of population. Rapid population growth in Ferghana Valley remains as one of the demographic trends which indicates to increases in demands and intensified use of water resources. Efficient and productive water use becomes key not only for large farming but also for expanding small home farming systems and other uses. Issues with non-maintained irrigation infrastructure and inconstant supplies of water by the water managing institutions indicate to the issues of unreliable water for both kitchen gardening and drinking.

Current report is the first step to contribute to a CRP DS Central Asia flagship activity aimed at improving Water Use Efficiency in Central Asia with a research report specifically looking at gender disparities. Objectives of research activities were 1) to identify water use behaviors, cost and benefits, technologies and approaches applied by the household members in the rural irrigated areas. Understand reasons, disparities and triggers of efficient/non efficient water use along gender lines; and 2) to analyze women's productive roles within small holder farming or kitchen gardening. The report is still in an on-going stage and has been contributing to IDOs 2,6 and 8).

Key words: Gender, Water Use Efficiency, Households, Uzbekistan, Ferghana Valley.

Acronyms and Definitions

WUA –Water User's Associations. In Uzbekistan WUAs were renamed/reorganized as Water Consumer's Associations following decree 02.02.2010 decision of the Government ЗКУ-240 on the implementation of the Law of the Republic of Uzbekistan dated December 25, 2009 №, by the

(№ 03/1-314, 02.02.2010).

Mahalla – community unit in Uzbekistan

Tamorka - Tamorka or private subsidiary plot to which all citizens were

entitled with expanded rights after introduction of land reforms after the independence. The acreage allocated to households was expanded more than twice compared to 1989. The legal size of private plots was increased at first from 0.06 hectares to 0.25 hectares, and eventually 0.35 hectares of irrigated land and 0.5 hectares of non-irrigated land (Kandiyoti 2002).

C.1. Introduction

C.1.1. Gender and resources

Different roles, responsibilities and knowledge in managing natural resources characterize specific gender patterns, similarities or gaps (Agarwal 1994, Zwarteveen 2008). These also identify the gender division of labor, and how the agricultural outputs are distributed. So far, gender research has shown that water

decision making and irrigation management are dominated by men almost everywhere in the world (Bustamante et al., 2005; Meinzen-Dick & Zwarteveen, 2001; Shyamala & Rao, 2002). At the same time, medium and small subsistence farming and irrigation as well as water used for other multiple uses are often observed to be managed by women (Alimdjanova 2009, Mukhamedova &Wegerich, 2014a).

Conventionally, positive effects of individual rights and formal access to and control of females over land and water resources is considered contributing to welfare improvements and enhancement of the bargaining power of women in the society (Kabeer 1995). However, such described constraints in ownership of land or rights do not restrict women in their involvement in agricultural works that allow them still to earn some income and increase their bargaining power among the household and in community members.

C.1.2. Water use efficiency and rural households

The term “water use efficiency” in the literature is often related to economic parameterization and “efficiency” terms used for indicating “the level of performance” of a system when water is transported, consumed and/or used in the process of production of a specific good. Although there are various ways of considering water use efficiency through its connection to hydraulic performance (conveyance and distribution) or agricultural parameters including different scales, the relationship between the crop growth development and the amount of water used. The term applied in farming which is more connected with water productivity: increase yield production per hectare per unit of water used, is considered to be crucial for arid and semi-arid regions such as Central Asia where limited water supply, frequently constrains farmers are to apply deficit irrigation strategies and to manage water supply in accordance with the sensitivity of crop’s growing stages to water stress. Therefore, the term also includes any measure that reduces the amount of water used per unit of any given activity, consistent with the maintenance or enhancement of water quality.

Water efficiency has been less analyzed on the household level and takes into account more of the urban households rather than rural. Water user efficiency within urban and domestic buildings (Schuetze & Santiago-Fandiño 2013) is understood in connection to water conservation, in other words any socially beneficial reduction in water use or water loss (Baumann et al. 1979), water saving technologies, secondary water use. These parameters being valid for urban cannot always cover all the particular context existing within the rural areas. For example this concerns mixed water sources used different for irrigation and drinking, water delivery and transportation issues. Therefore water use efficiency requires an interdisciplinary

approach (Dinar 1992)[2] that would include environmental, social (education, gender), and economic factors (public financing, industry and business development) as well as looking at more internal household parameters such as the structure of different water uses and characteristics of users.

According to Tate M.[3] (2000) there are five basic physical parameters in the water use cycle of any activity which are: gross water, intake, recirculation, discharge, consumptive use. However, not all are applicable.

Gross water use refers to the total amount of water used to carry out an activity, such as producing a manufactured product, doing a load of laundry, or growing a particular crop. It is composed of two basic sources: intake, the amount of "new" water taken into the operation under consideration; and recirculation, the amount of previously used water employed in the activity. Likewise, the two remaining parameters relate to the release side of the water use cycle: discharge, the amount of water allowed to exit the activity or process, and consumptive use, the amount used up during the process as steam, incorporation into product, or other means.

Water use can mean the amount of water used for a given task or for the production of a given quantity of some product or crop. In light of the water shortages in various parts of the world, it is important to consider water use and water efficiency. See the article "Virtual water" for more information on this topic.

C.2. Background

After the breakup of the Soviet Union, Uzbekistan agricultural system has been restructured. New reforms have taken place also within the irrigation management. Privatization processes and appearance of Water User Associations have created new relations and new approaches to water use and distribution. In Uzbekistan, issues of irrigation and drainage are key to agricultural production, and limited water resources affect food security. The Uzbek government envisioned Water User Associations to be the most suitable unit of irrigation management for maintaining on-farm irrigation infrastructure and for improving water allocation to villagers (Zavgorodnyaya, 2006). It was expected that this policy reform would contribute to the overall national agricultural development strategy and ultimately facilitate poverty reduction and provide “social assistance to the most vulnerable groups” (ADB, 2001, p. 11).
Women are important working force in the feminized farming systems of Central Asia (Mukhamedova & Wegerich, 2014b) and represent large portion of water users for agricultural production however they make up only a small minority of WUA members and or water managing leaders.

In Uzbekistan this can be observed due to seasonal labor migration of male workers to Russia, Kazakhstan, Korea or to urban areas, where they find more attractive off-farm income generating activities. Male out-migration for waged work means that women undertake new tasks such as

[2] Dinar, A. 1993. Economic factors and opportunities as determinants of water use efficiency in agriculture. *Irrigation Science.* 14(2), p. 47-52. Springer-Verlag. http://dx.doi.org/10.1007/BF00208397

[3] Tate, M. 2000. Principles of Water Use Efficiency, Council of European Professional Informatics Societies, CEPIS web page, October 13, 2000. http://www.cepis.ops- oms.org/muwww/fulltext/repind48/principles/principles.html.

soil fertilization, planting, irrigating and harvesting, and learning to organize their time to accomplish their intensified work. Studies on time-use show that women spend almost three fold more time than men engaged in unpaid work. Besides the unpaid works there are also informal or non-accounted paid works such as agricultural works or works performed in kitchen gardens (tamorqas) on growing livestock or market oriented fruits and vegetables.

According to a recent ADB report (2014) "a significant portion of the population [in the rural areas] relies on hand pumps, public standpipes, and wells, and receives intermittent water supply or contaminated water". The report underlines that the "inadequacies in water supply and sanitation system affect entire populations but particularly affect women because they are primarily responsible for water collection and storage as well as other domestic tasks such as cooking, cleaning, washing, and the hygiene of children and other family members" (ADB 2014). According to UzHydromet (2014) with the expected climate change scenarios expected outcomes for Uzbekistan are hardening of the water resource deficit, worsening of the water quality; increase of dangerous risks, extreme hydrometeorologic events (droughts, floods, snow slides, etc) and decreases in the productivity of modern varieties of agricultural crops, and productivity of pastures and livestock, increased the risks of food security.

The Ferghana province had a total area of 680,000 hectares and a total irrigated area of 361,978 ha in 2010. The general increase of population and more rapid growth within densely populated areas like Ferghana Province where, population reached 3 074 600 (2014) and has been increasing by nearly 0% since independence (Figure 1) is triggering more demands for land and water resources leading to further expansion of settlement areas.

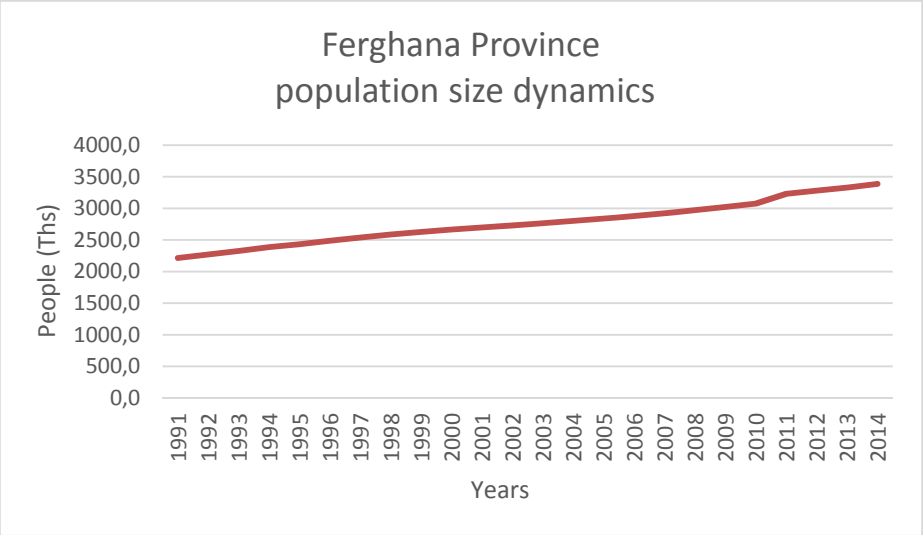


Figure 1. Population in Ferghana Province, Uzbekistan
Source: authors calculations, State Statistics Committee of Uzbekistan

Of the 11,126 farms registered in Ferghana Province in 2010, only 516 were women-headed (Scientific Information Center 2011). Since 2000, the population of the province has increased from 2.7 to 3.1 million in 2010; in the same period, the number of settlements (community centers) has increased from 312 to 395 (Scientific Information Center 2011). Until recently, settlements expanded into irrigated areas (Table 1). Given the reduced employment opportunities

in rural areas due to privatization and optimization, there is a high rate of seasonal migration. Seasonal migration is gendered and the majority of season migrants are men (Reeves 2010).

Table 1: Changes in land allocations to kitchen gardens in Ferghana Province

Years	Total irrigated area, ha	Irrigated crops and kitchen garden lands (ha)						
		Cotton	Wheat	Alfa-Alfa	Orchards	Other Crops	Kitchen garden	Kitchen garden/Total irrigated area %
1980	323049	188822	0	39925	22487	53190	18625	5.77%
1990	354151	140698	0	52821	37744	68911	53977	15.24%
2000	357736	126384	90793	9977	33435	147953	39987	11.18%
2010	361978	103600	111700	3718	47628	144718	62314	17.21%

Problem statement

Improving water use and management practices, protecting the ecosystems require considering gender disparities and achieving livelihood and food security among the most vulnerable groups of population. Rapid population growth in Ferghana Valley remains as one of the demographic trends which indicates to increases in demands and intensified use of water resources. Efficient and productive water use becomes key not only for large farming but also for expanding small home farming systems and other uses. Issues with non-maintained irrigation infrastructure and inconstant supplies of water by the water managing institutions indicate to the issues of unreliable water for both kitchen-gardening and drinking.

C.2.1. Expected outcomes

Improved water use efficiency and productive uses by small land holders (kitchen gardens) through gender disaggregated analysis of water use efficiency components, dependencies and

C.2.2. Objectives of research activities

1. To identify water use behaviors, cost and benefits, technologies and approaches applied by the household members in the rural irrigated areas. Understand reasons, disparities and triggers of efficient/non efficient water use along gender lines.
2. To analyze women's productive roles within small farming or kitchen gardening
3. Through interactive workshops to Increase awareness and knowledge of men and women small land holders in understanding water and energy efficiency and related trade-offs and provide recommendations on new practices and approaches on improved water and energy use efficiency.

C.3. Related Gender Responsive Objective of the project (based on the gender strategy of CRP 1.1)

Based on the gender responsive objectives of the Gender strategy of the CRP Drylands systems program, the research aimed to (1) "contribute to developing and implementing more effective interdisciplinary ex-ante diagnostic methods that integrate gender analysis and ensure gender equity in targeting and prioritizing the CRP's research programs" by developing semi-structured questionnaire that could be applied also in other projects within the same region. (2) "Improve knowledge/understanding of the key cultural, ideological, normative and institutional factors and emerging changes and trends in these, that lead to gender inequalities and identify effective gender-responsive and transformative ways of addressing these to increase production, incomes and food security and women's share of these benefits".

C.3.1. Research questions by specific topics

(1) Resources and uses*:* Which types of resources, irrigation infrastructure used and what is their conveyance? Who are the main users and uses (drinking, irrigation, other domestic productive and non-productive uses, waste water uses) of these resources
(2) Practices and technologies: How do men and women irrigate (including energy and water amounts spent)? What are the determinants, gaps and constraints in water and energy resource utilization as well as, responsibilities, technologies and practices (including conservation) applied by male household members. What are their needs, potential and possibilities to improve efficiency of water use in sustainable manner.
(3) Decisions and participation*:* Who makes the decisions on when, how and with which source to irrigate and which technology/ approach to use for irrigation? What is the role and participation degree of each member? Who contributes and who benefits more from agricultural production?
(4) Willingness to adapt and improve water use efficiency*:* Are households ready to improve their current conventional uses of water resources? What are alternative approaches which they know or they are willing to adapt.

C.3.2. General information in the study area:

Toshloq district is situated in the North-Eastern part of the Ferghana Province (Figure 1). It is a densely populated area, which has in itself 6 smaller villages, each of which consists of few other villages. In total Komiljon Umarov Water Consumers Association has 5 canals which take water from South Ferghana from which mainly 3 canals are used for feed this area: Akhshak, Besarang and Varzak. The water from the South Ferghana canal is not the only source of irrigation, drainage and artesian water are also Water users include large and medium farms as well as households and other non-agricultural users.

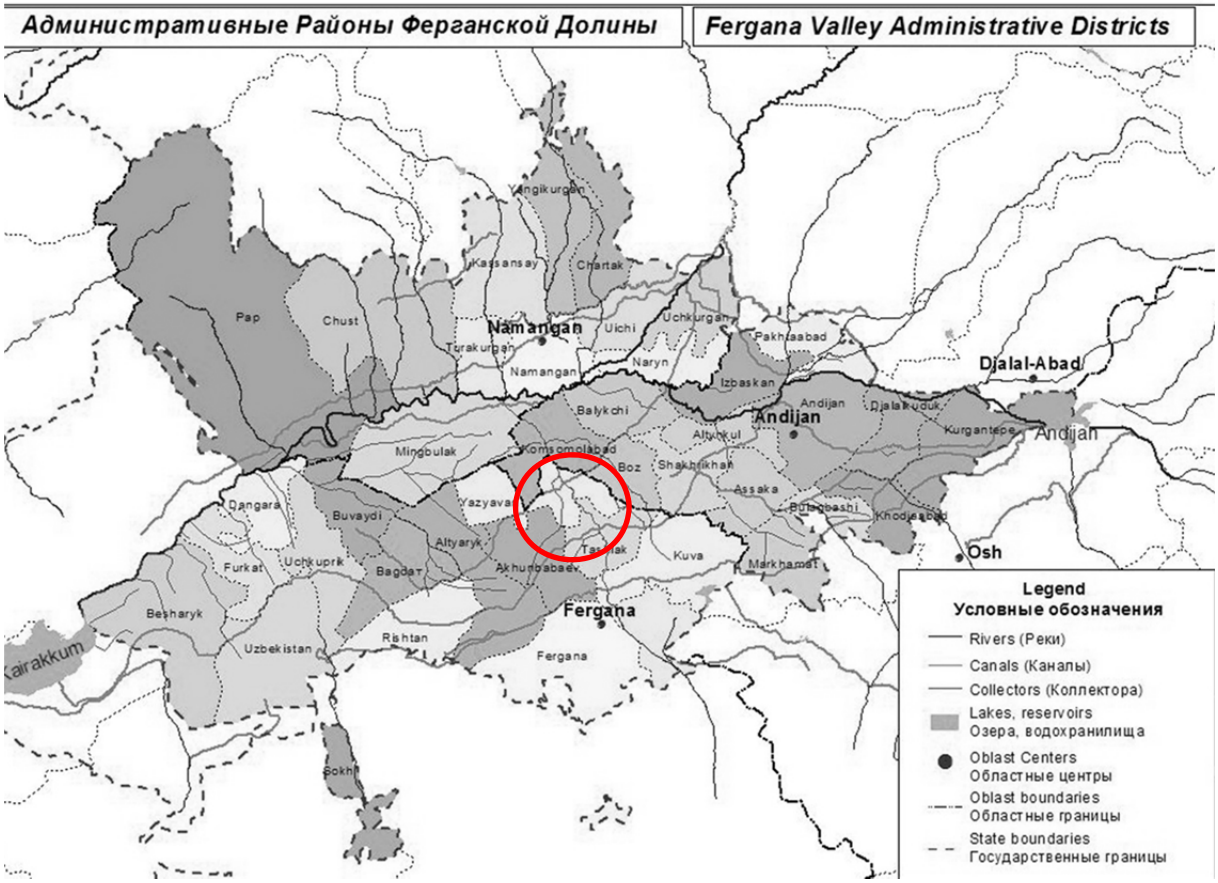


Figure 2. Freghana Valley administrative districts with a red circle on the Tashlak district

Project l Location	Uzbekistan, Fergana Province, Toshloq District, Komiljon Umarov WUA
Villages	3-villages, 6-large communities consisting of 18 small mahallas
Water sources	1 level: South Ferghana Canal 2 level: Yangisoi, Varzak, Besarang, Akhshak Over 50 wells serving the both farmers and households
Population	Households- 11 343 People: 58 667 : females - 51%, males-49%
Total area occupied by kitchen gardens	26% from total WUA's irrigated land (4 063 ha) Average kitchen garden area: 0,15 ha

WUA members	47 farmers, 16 mahallas

C.4. Methodology

In order to target water use efficiency on the household level we decided to cover all three villages situated within the Komiljon Umarov WUA. Research employed mixed methods of analysis including semi-structured interviews and case studies on assessment of water use efficiency of households within one WUA in the Ferghana province, Uzbekistan and filing the data into one database using Google drive application (Figure 3).

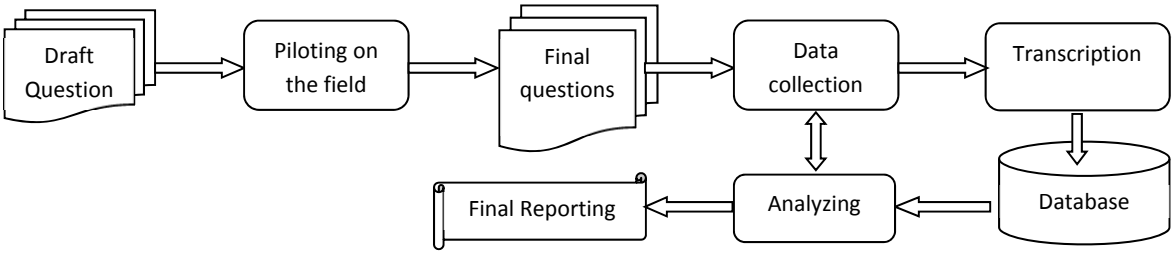


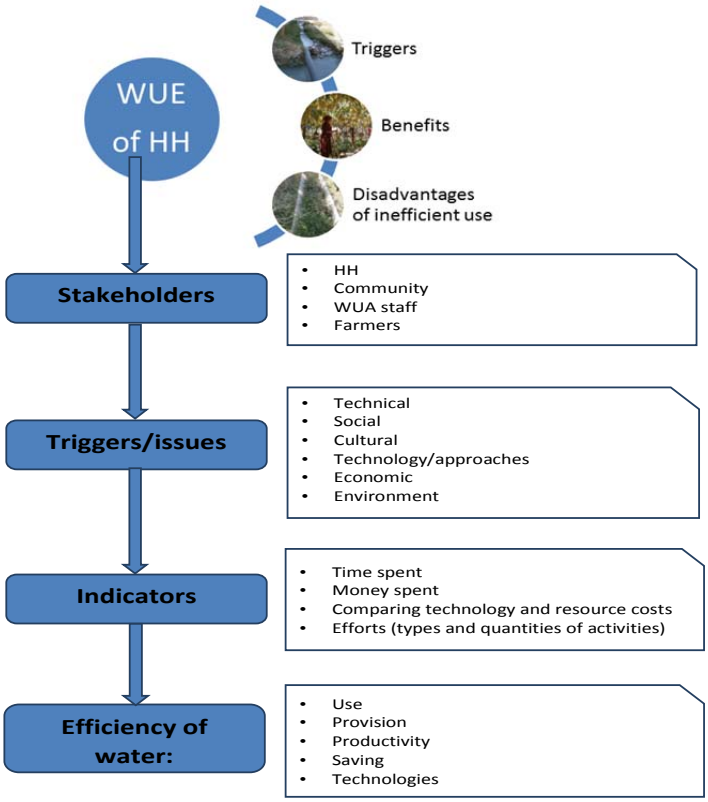
Figure 3. Main data processing sequence consisted of the following structure.

The main sequence of topics and indicators under which semi-structured and open ended questions were designed and were analyzed following the structure below (Figure 4):

Figure 4. Questionnaire design structure.

The figure signifies a structure of methodology that starts from learning the triggers of efficient or inefficient uses of water (triggers), at the same time research seeks to reveal the benefits of efficient use and how its reached from the point of view of household members (Benefits) and study the cases of inefficient water use or management (Disadvantages of inefficient use).

The structure also identifies internal and external connection points of various actors, indicators and other factors influencing the WUE.



The key informants composed of female and male household members as well as some of the community members and WUA representatives. Responses of each interview were filled in into answer sheets which were later coded into Google Drive application. At the same time all interview data was audio recorded and later transcribed verbatim. Field observations and ground truth data have been noted within each area interviewed to verify the opinions of interviewees and assumptions. Verification of the interviews analyzed is projected to happen with the trainings which will be organized in the beginning of the year 2015.

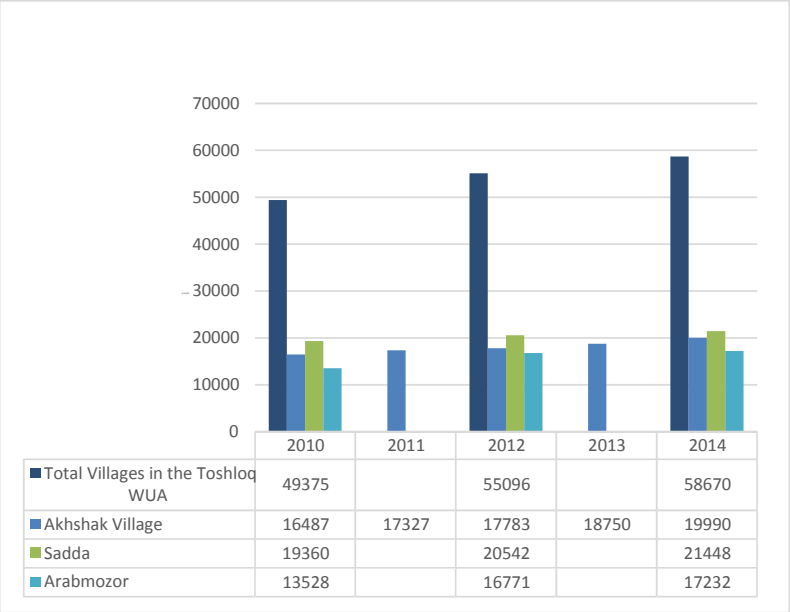
Water use efficiency will be estimated with series of questions designed to: assess water use by casual approximations by the household members, measurements based on the water providing entities and actual participant observations; to identify conventional water use technologies; to gain knowledge on understanding of water use efficiency and productivity (history, culture, family/community values and formal and informal norms. Counting of hour women and men are involved in various households and agriculture activities could be applied for assessment of productive contributions.

Selection: Selection of households which were interviewed was based on first identifying existing water sources (gravity, lift irrigation, mixed); location in relevance to the water source (head, middle, tail) and in some cases irrigation infrastructure in use (artesian wells, drainage pumps). Both female and male household members above 18 years old were chosen to participate in the interviews and were chosen by random sampling.

Survey Design: Design of a questionnaire has been developed in close consultations with IWMI senior staff and piloted together with local partners from the communities of the Toshloq district and with couple of households and revising them to fit into the context. Following the correction the questions were translated into Uzbek language (Attachment 1). Meetings with main beneficiaries and stakeholders of the project were conducted in the inception visit to the site. As a result of these discussions we were able to establish partnerships with community leaders for receiving official support in conducting the interviews and organizing a joint training by the end of the research.

C.5. Data and analysis

Data used: Participant and community observations, GPS locations points for mapping household-respondents, photos, interview results (interview schedule Figure 2), statistical data from the district authorities. In total 97 interviews were conducted with household members from 3 big community village gathering (*mahalla fuqorolar yig'ini*), namely: Ahshak, Arabmozor and Sadda, in which there were over 12 small communities (Figure 5).



	2010	2011	2012	2013	2014
Total Villages in the Toshloq WUA	49375		55096		58670
Akhshak Village	16487	17327	17783	18750	19990
Sadda	19360		20542		21448
Arabmozor	13528		16771		17232

Figure 5. Demographic data for Toshloq district

Initially it was planned to interview in the break-up quantity of 50% male and 50% female population within the WCA villages. However, during the random sampling of the households mostly women were found within the households, since most of the men were absent due to migrant works. Therefore, the actual interviewed respondents consisted of mainly female (over 75%) and male (around 25%). General characteristics of respondents based on gender, age, education, occupation and location were brought in the Attachment 2 .

The spread of age of respondents showed a difference between males and females interviewed with male falling between 40-50 (39.13%) 50-60 (43.48%) year ranges and female with the biggest shares falling under 30-40 (22.97%), 40-50 (21.62%) and 50-60 (27.03%) year ranges. This can be explained by several factors: 1) usually the eldest in the household is given the word to speak with somebody unknown; 2) young women with children or mothers in law/grandmothers looking after children; 3) migration of men for seasonal works reflects often the data of more elder men between 50-60 present in the house, since this age range is usually the final for the those who are doing seasonal works in Russia (according to the IOM (2013) age ranges of the male migrants from Uzbekistan to Russia were: 666 000, 17-25 years old and 568 000, 26 - 35 years old[4]. The education of respondents was found not to be different based on their gender division with secondary education reaching 73.91% men and 93.24% women consequently.

For all three villages, major occupations/employment status (based on formal employment) can be classified to the 5 main categories and percentages within each can be calculated from the total population: services (25.77%), house (30.93%), agriculture (14.43%), pension (12.37%) and local governance (9.28%). However, gender disaggregated data shows that for female, house work remains as the most popular answer (39.19%) and only after services (20.27%) and pension

[4] IOM. 2013. Migrants of Uzbekistan occupy the first place in Russia overrunning Azerbaijan and Kyrgyzstan. Article in Russian language: "Мигранты из Узбекистана заняли первое место в России, обогнав Азербайджан и Киргизию", 02 января 2013 г. . www.iom.tj

(13.51%). For male respondents the pattern changes the order with services (43.48%) prevailing, then agriculture (21.74%) and construction (13.04%). Service category also has many subcategories that can be divided to more male and to more female occupations such as taxi driving (male) or trading in the market (female).
Prevailing presence of women in house works repeats the general trend persistent to the age group of women interviewed and shows that women's economic opportunities are still greater in the informal sector, where main activities are: home farming, handicrafts. Presence of more men with agricultural occupation as their formal work indicates more to the ownership status of male in farming. This fact also is proved by the fact of absence of women as farmers and members of studied WCA and more performing the agricultural works informally.

C.6. Results and discussion

C.6.1. Resources and uses

Majority of respondents from all three villages stated that they have access to water resources. Out of six identified water sources which were identified available by the households for various needs River/canal water and hand pumped sources are used interchangeable and in parallel. Some households have access to artesian and drainage wells as well as to standpipe. The first question that was asked from the households was whether they had access to water sources? The answer for female and male respondents' answered very similar (Figure 6.) with majority of household representative giving the answer that they have access.

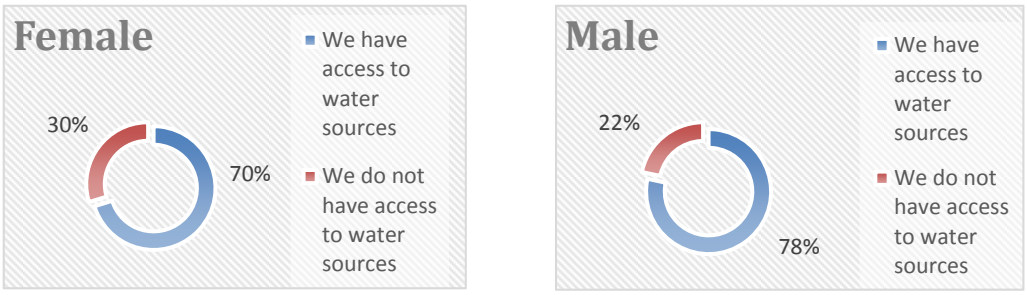


Figure 6. Answer to the question: "Do you have access to water sources?"

Women and men both equally were aware of all the available water sources. In general, from all the sources coming to the households the most used are nearby river/canal, hand pumps, and finally artesian/drainage wells (Figure 7a). Not all households had access to all of the sources at the same time, for some only one or two sources were available and for others, the availability of used sources was more diversified.
Figure 7b shows the structure of used water sources for drinking purposes here the answers were that majority of households rely on hand pumps installed within the their plots and artesian and drainage wells.

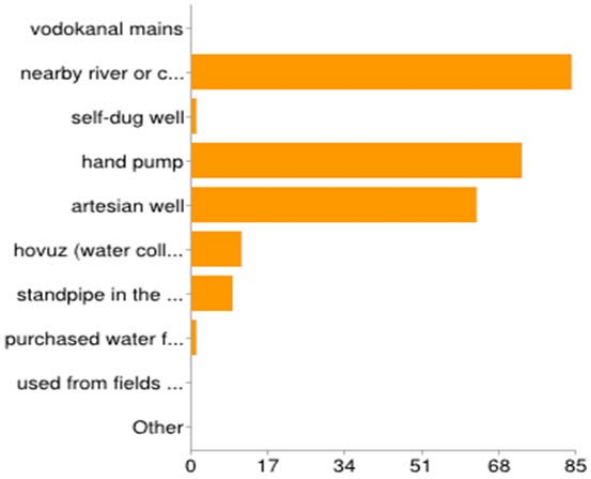


Figure 7a. Do you know the source of water coming to your house?

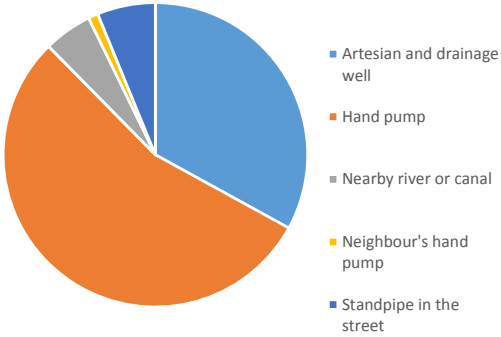


Figure 7b. Can you tell which is the most used water source for **drinking** if there are several?

Majority of hand pumps within the households are installed in 10-15 (54.92%) meters and less with a depth of 5-10 (29.57%) and 15-20 (15.49%). This might naturally be connected with different levels from which the shallow ground water can be found. Basically most of the population uses hand pumps sometimes to diesel/electric pump. However canal water (main source: South Ferghana Canal) and artesian, drainage wells still remain as an important source for kitchen gardens.

Households utilize mixed source for irrigating their kitchen gardens. Responses indicated a slight difference in answers provided by male and female respondents in regards to the identified sources for irrigation, however the most used were canal/river and pumps within the households (Figure 8).

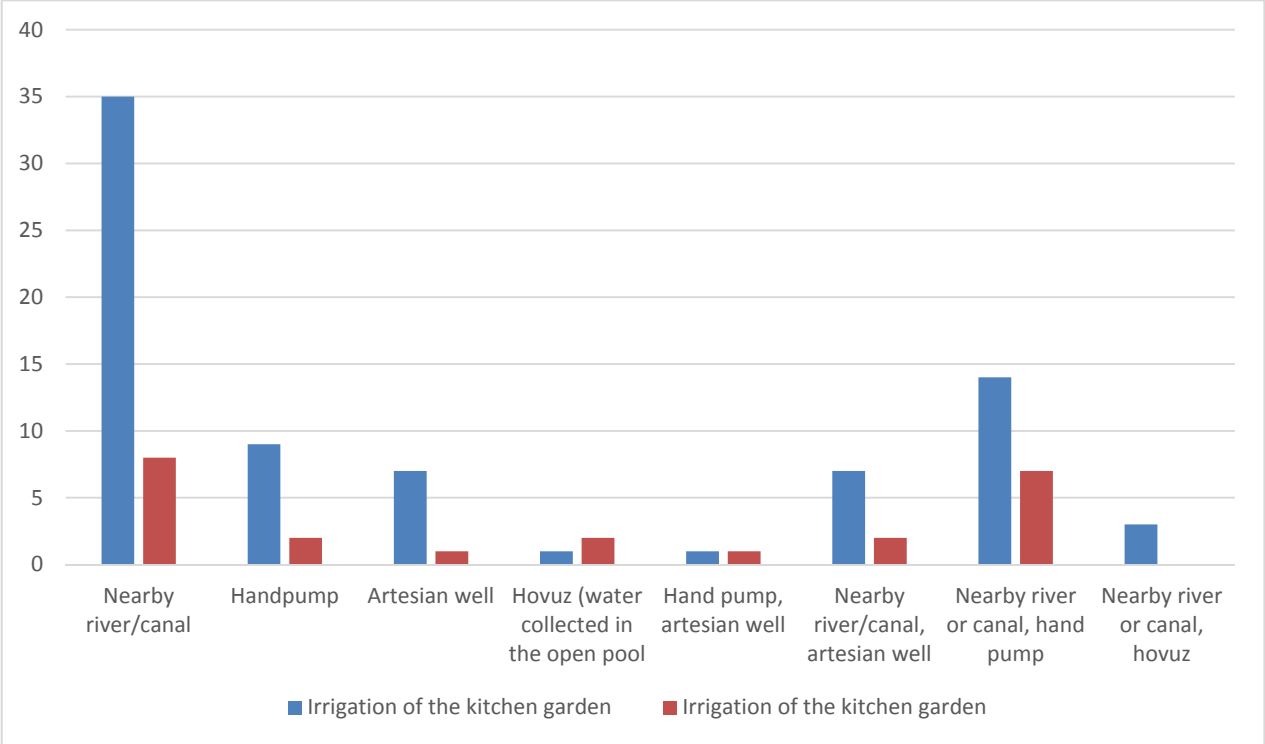


Figure 8. Water use for kitchen garden irrigation by sources and disaggregated by gender.

It has been stated that in general there is sufficient water within the district, however, the difference in the soil quality, availability of various alternative additional sources or consistency in availability of water sources seems to be correlated with how much and how often the water is used. There are some conflicts on the matters of water use and maintenance of irrigation infrastructure existing between households and farmers which use common sources.
Water use behavior characteristics suggest that currently households do not participate as members of WUA and almost 58%, especially women, and are not aware of its existence.

Households using surface irrigation waters from the Akhshak, Besarang, Varzak canals do not pay for any water provision services. As the water has no cost but the provision of water delivery and system maintenance have costs, Water Consumers' Associations according to the set legislation and their charters should their members which are farmers, population and other entities or businesses which might be using the water sources under their management.
Based on the structured question "Do you pay for water?" (Figure 9.) was given to reveal whether the efficiency of water use and conveyance could be characterized by the payment patterns. As shallow wells with hand pumps used for irrigation and drinking needs were installed by the households, 65% of male respondents and 61% of female respondents identified that they did not pay for water. Only few respondents announced payments for irrigation water (20% of men and 19% of women).
12% of male and 19% of female respondents mentioned fees for the maintenance of artesian and drainage infrastructure. Interestingly, the percentage of respondents who claimed that they pay for water they drink was too little. (3% for women and 0% for men).

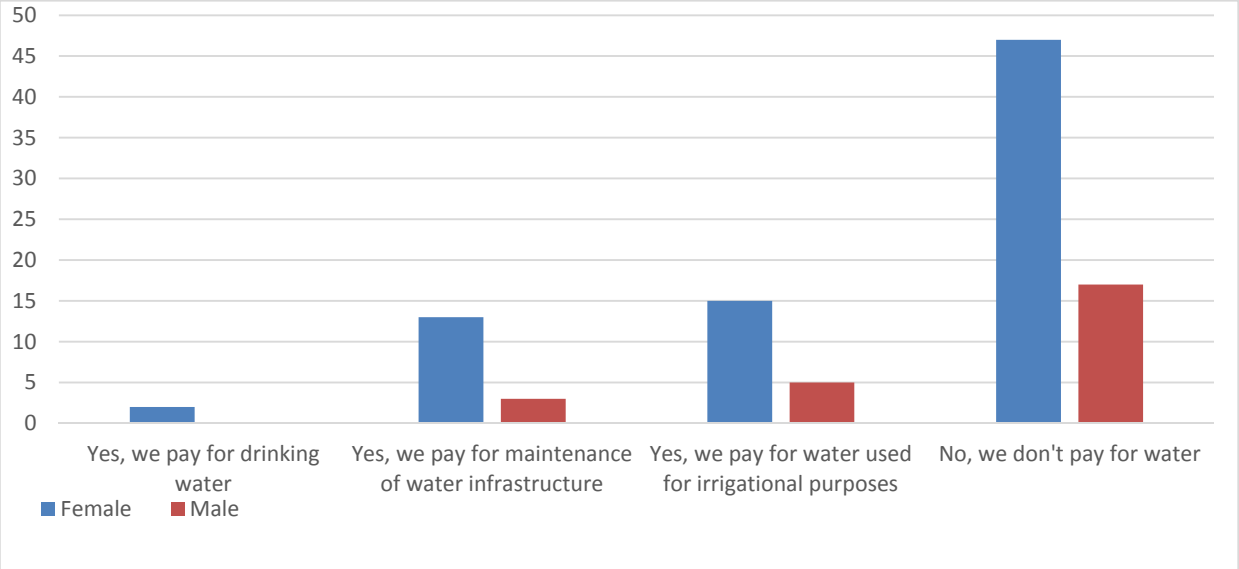


Figure 9. Gender disaggregated drinking water payment patterns.

All of these payments were relevant to multiple drainage wells which are currently in the property of local water authorities but are put under the responsibility and control of large farm holders. The drainage water can be used both by the farmers and households and expenditures for maintenance and major repair costs are shared by the users. The maintenance and repair fees

are gathered by the responsible farmers[5] attached to multiple drainage wells. Households which share the costs for maintenance and repair services informed that the monthly payments range from 3000 to 5000 sums. Artesian wells are set under the responsibility of mahalla, and only maintenance fees are collected by the representative of the local community governance (Interview scripts Attachment 2). In cases when households did not have home pumped water source, the alternative choices were listed as: artesian wells (65%), bringing the water from the neighbors (21%) and standpipe situated in neighborhood, for which they make payments (8%). Women identified that they have to spend from 5 to 30 minutes (55% respondents' answers) 1-3 times per day to bring water from the distance ranging from 40-200 meters for their household uses. The water usually is carried using buckets (72%), less with metal containers (45%) and plastic jars (8%). Efficiency of water conveyance in terms of its transportation is low since majority of women (62%) have to spend in average from 30 minutes to 1 hour every day to bring the water to their households.

Out of total respondents 66 % of women and 82 % of men identified that the water for household needs is always available. Signifying that women have higher sensitivity to the absence of water. The efficiency of water provision is identified not only by its availability but also by its pressure which allows entrance into the household ditches. Around 70% of the respondents identified that they have middle pressure of water coming to their ditches (river/canal or drainage water sources mentioned). Less mentioned is the low (8%) and very low pressure (3%). When the data was disaggregated by gender, men seemed to be more optimistic in their answers about the pressure of water (Figure 10.).

There are not so many technologies which are applied by the households. The ones identified included drip irrigation system for planting cucumbers, using a 200 liter container which is hanged upside down with water and mixed with liquid fertilizers. The users (only 3 respondents) of such system underlined that for irrigating the kitchen garden crops during the whole day spending 8-200 liters.
There are major differences between the 3 villages in most cases hand pumps which are available in the local market (Chinese) are available -Image below). Hand pump which also have the possibility to be connected to diesel or electric power are used first of all for drinking, bathing,

livestock and often for irrigation (with the electric pump) when other water sources coming from ditches are not available or inconsistent.

Over 49% of the household use electric pumps from bringing water from the ditches or from the hand pumps (Figure 17). This tendency seems to grow since electric pumps are widely available

[5] After the farm restructuring and institutional changes most of the infrastructure including the artesian and drainages wells have been put into the account of Irrigation Departments within the districts, however, the management and maintenance was left with the new farmers (Interview with the WUA Director).

in the local markets and imported from China. Only respondents mentioned that they use drip irrigation in their households.

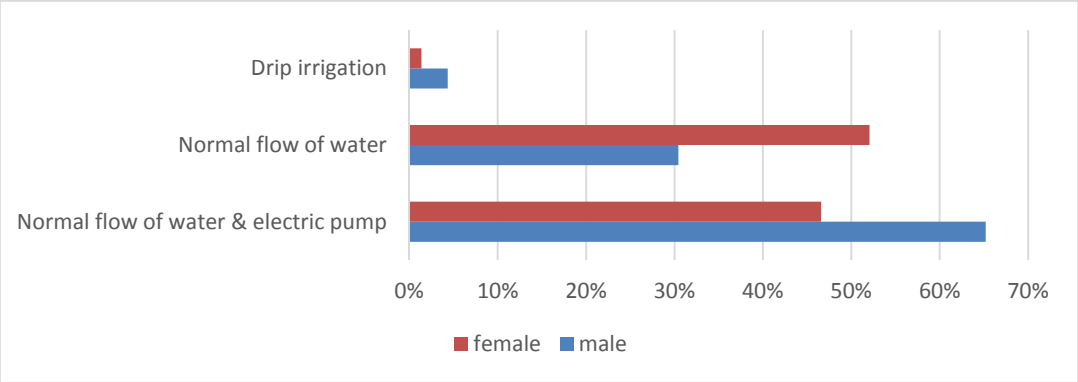


Figure 17. Means (technologies) of irrigation in the kitchen garden

Depending on the plot size the electric pump is used from 0,5 to 3 hours per one irrigation.

Considering variety of standard crops planted in the kitchen gardens, the irrigation from the ditch source is performed once a week by 46% of respondents

From all the respondents 45% did not use electrical pumps to irrigate their kitchen gardens; Frequency of irrigation seems to be the same if water from the pump is used. Kitchen gardens do not use manual pumps nor irrigate their garden plots with buckets. Only 2% of the households use drip irrigation in their households.

Tools and equipment used within the plots contribute to the outcome of the efficient water use (Figure 18).

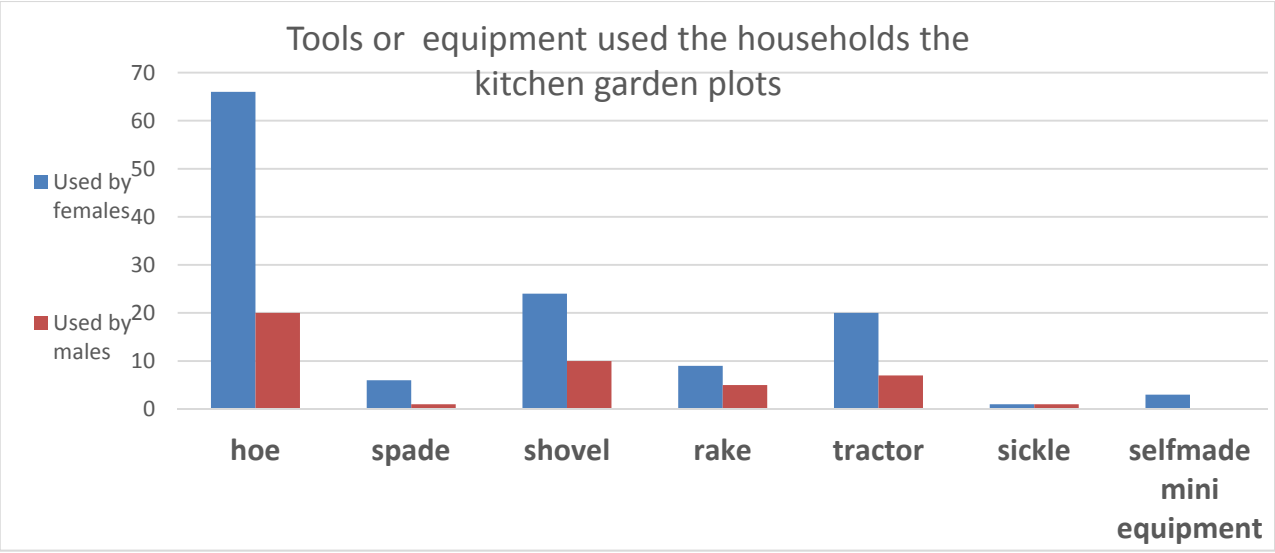


Figure 18. Tools or equipment used the households the kitchen garden plots.

During the cotton season the households are aware that the water will be scarce and their irrigation is adapted to be done once a month or given at times when the farmers' irrigation is stopped.

Responses have divided almost into 50/50% in regards to existence of irrigation schedules. Answers related to having a schedule were tied with farmers' irrigation schedules and regulated by farmers water masters. This may signify that households hold certain responsibility for water spent and the limits for kitchen garden irrigation. Households diversify their crops to secure their primary food items and also to be able to have excess of marketable fruits and vegetables which are either sold in the local market or can be sold to exporting companies.

Disaggregated by gender the kitchen garden items categorized crop types also can indicate to the nutritious value of what is consumed by the households. At same time the graph reveals that women are planting more vegetable items which are of the most of use for food and fodder.

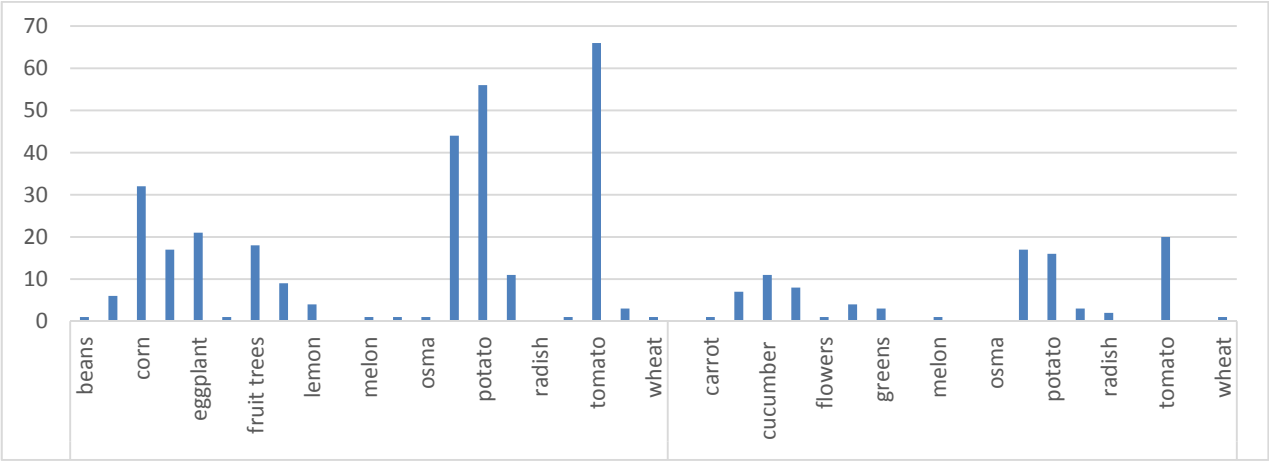


Figure19.

Looked from the prioritization angle, top ten list of the most planted in the kitchen garden plot includes: tomatoes, potato, pepper, corn, eggplant fruit trees (including grapes), cucumbers pumpkins, greens and carrots (Figure 20).

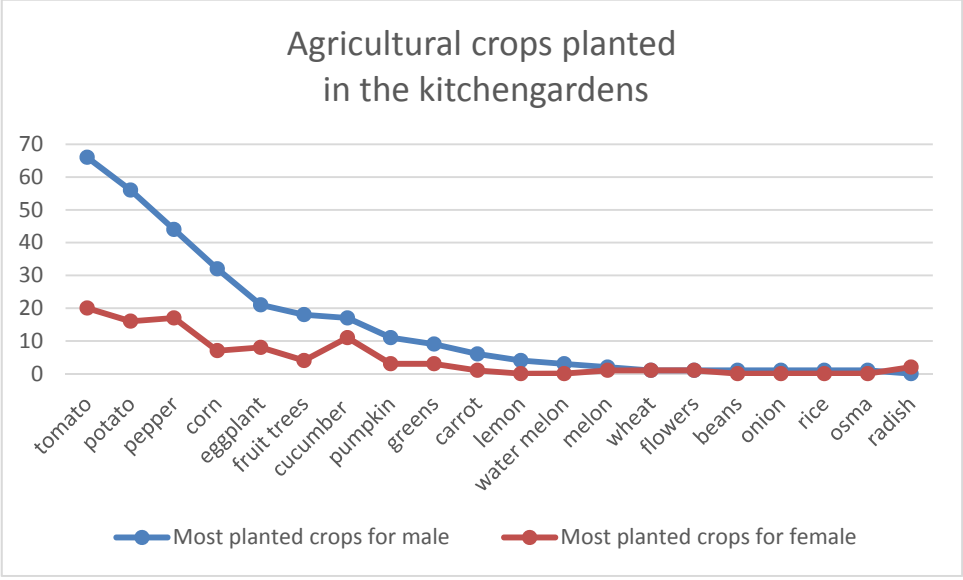


Figure 20. Agricultural crops planted in the kitchen gardens

In terms of crops which are considered by households to me the most water consuming, some of the answers coincided with the most planted, at the same time this question revealed lack of knowledge of some women in regards to crop irrigation norms as some answered that all crops are irrigated in an equal way (Figure 21).

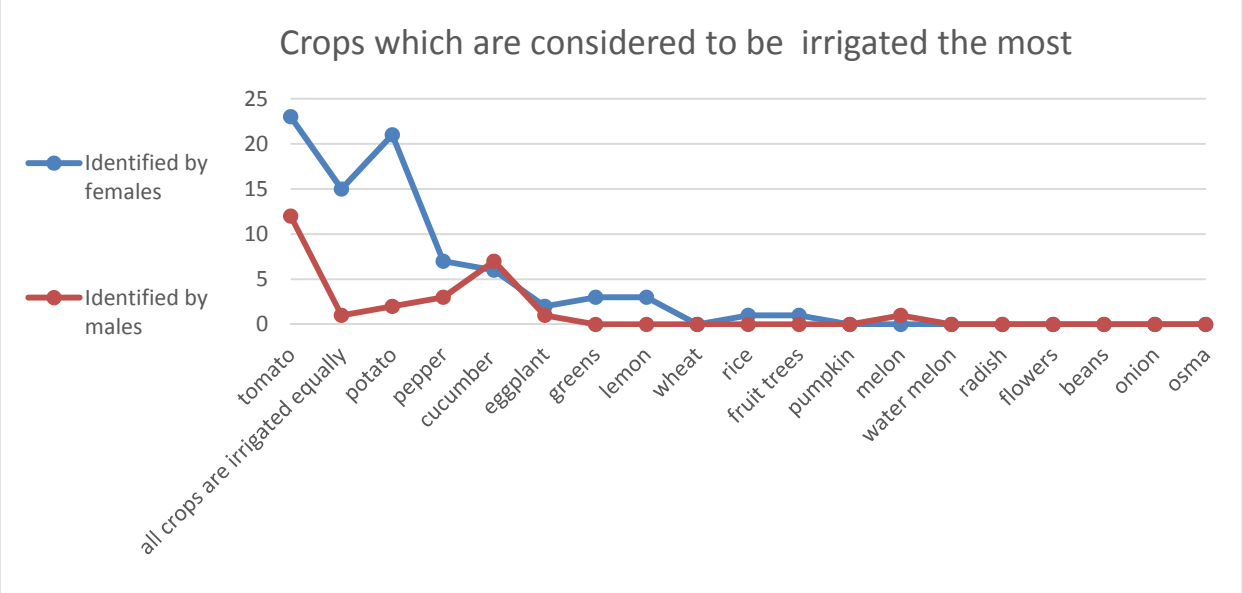


Figure 21. Crops which are considered to be irrigated the most

Individual perceptions about efficient use of water resources reflect attitudes and potential possibility of adapting water saving or other smart technologies, thus respondents were asked about what do they do for efficient use of water resources. Household members understood efficient use to be related more to canal/river water or potable water sources. There are several responses which mention technologies which technologies applied or which could serve to be saving water source: “We switch off the hand pump, don’t use water purposelessly, and take only what we need. As electricity is also expensive, we don’t use the pump too often.” (Interview: #45, female, Ahshak, Pahtakor mahalla). Women recognized efficient use related to understanding that it’s a common and scarce source and that it should be economized and saved: “We economize water. We don’t spend water unless it is urgent. We use artesian water for only drinking” (Interview: #55, female, Ahshak, Pahtakor mahalla). For other purposes we try to use hand pump. Male respondents related the efficient use with water wisely used for irrigation and also that currently the water is used as much as needed and not more since it is not always available: “We use water when we really need it. When you have less water you will automatically save it” (Interview:# 40, male 59, Akhshak, Khotinqumi mahalla, Navoi street).

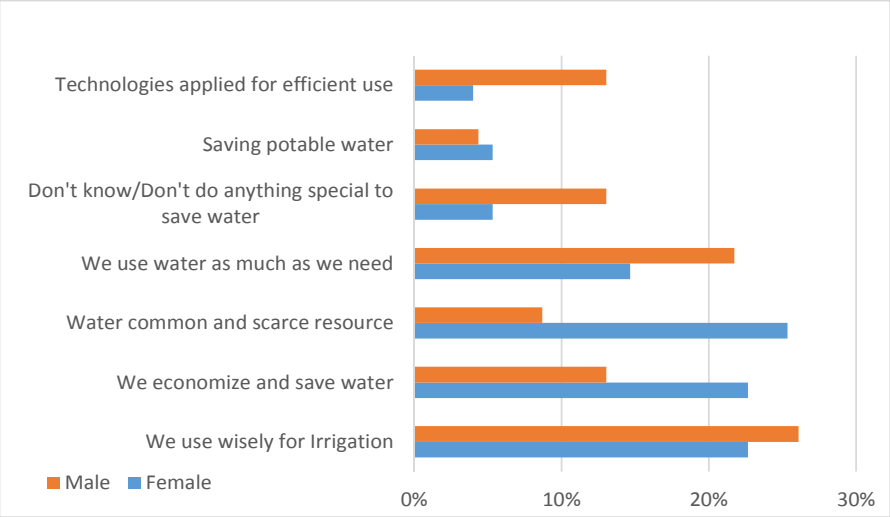
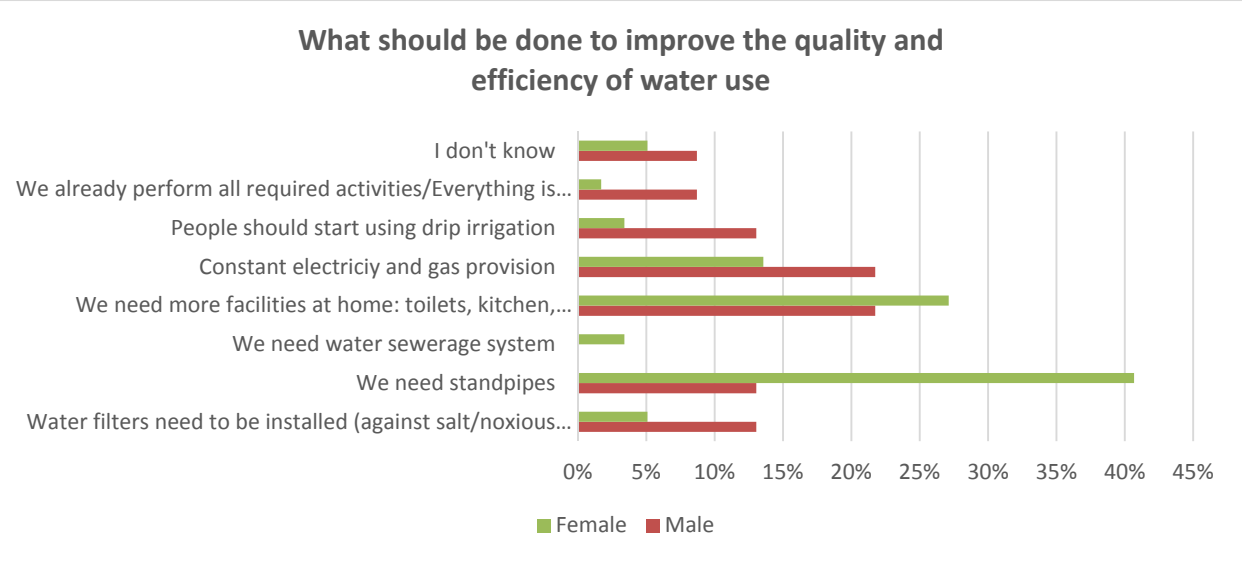


Figure 22. What do you do for efficient use of water resources?

Looking at the perspective or future of efficient water use, the households were asked the question: "What do you think what should be done to improve the quality and efficiency of water use?" was a way to understand what household think they might need and think would be improved. Female representatives being the ones in charge of presence of water for their daily use answered that it would be good to have standpipes in each household, also they indicated that for efficient use of water facilities as kitchen, bathrooms and toilets inside the house should be built.



C.7. Next steps/ Capacity building/ Uptake

Interactive workshops are proposed to be planned for the next year with the objective of increase awareness and knowledge of household female and male members on the topics of water and energy efficiency and provide recommendations on new practices and approaches on improved water and energy use efficiency. Interactive workshops can also include presentation of results will help to validate gathered data from the interviews and can serve to design up-take activities for the beneficiaries of the project and also for initiating similar surveys in other Dryland Systems Program activity sites. With this in mind the household members were asked to indicate suitable and available time for participating in such workshop. Both men and women preferred

winter time, however the timing during the day differed with women preferring the workshops to be in the mornings and men in the evenings.

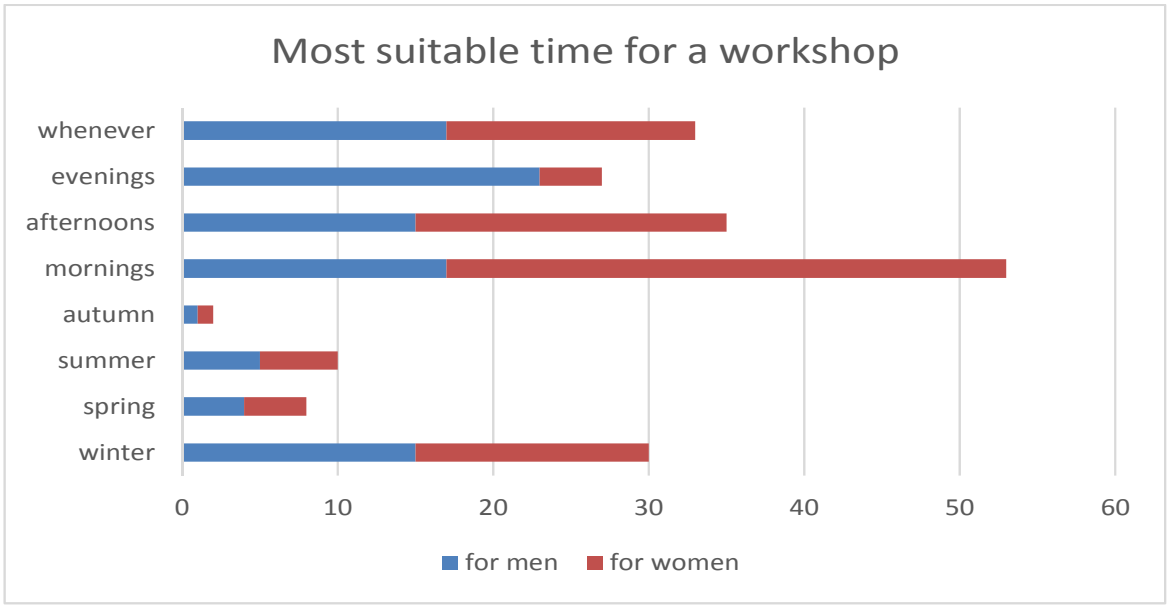


Figure 23. Workshop participation timing preferences

The workshop will include community and local authority representatives, Water Consumers Association as well as specialists (related to: gender, water saving technologies, ground water, crops and trees).

The database of responses needs further deeper analysis and also should be compared with similar data gathered from other WUAs to understand more the water use efficiency indicators impacted by the performance/ conveyance of water by the WUAs or weather the efficiency lies more in how water is used and which technologies are applied within the households.

Note: Attachments are available upon official requiest from the International Water Management Institute and CRP Dry Land Systems Central Asia representatives.

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