AGRICULTURAL WATER MANAGEMENT IN TAJIKISTAN

THE ROLE OF WATER USER ASSOCIATIONS IN IMPROVING THE WATER FOR ENERGY NEXUS

Technical Report

Agricultural Water Management in Tajikistan

The Role of Water User Associations in Improving the Water for Energy Nexus

Technical Report

Dushanbe, Tajikistan

Organization for Security and
Co-operation in Europe
Programme Office in Dushanbe

Contributors to the report:

Ronan Shenhav, University of Groningen, Groningen, Netherlands

Stefanos Xenarios, Stefanos Xenarios, Associate Professor, Graduate School of Public Policy, Nazarbayev University, Astana, Kazakhstan

Daler Domullodzhanov, National Consultant, Dushanbe, Tajikistan

Organization for Security and Co-operation in Europe (OSCE) Programme Office in Dushanbe https://www.osce.org/programme-office-in-dushanbe/

OSCE Programme Office in Dushanbe
Ahmadi Donish Str., 18/A
734012 Dushanbe, Tajikistan
Phone: +992 37 226-50-14/15
Fax: +992 37 226-50-19

Acronyms

ASL	Above Sea Level
ADB	Asian Development Bank
ALRI	Agency for Land Reclamation and Irrigation
DCC	Development Coordination Council
DRS	Districts of Republican Subordination
EBRD	European Bank for Reconstruction and Development
EU	European Union
GBAO	Gorno-Badakhshan Autonomous Oblast
GoT	Government of Tajikistan
GW	Gigawatt
kW	Kilowatt
kWh	Kilowatt per Hour
ISF	Irrigation Service Fee
IWRM	Integrated Water Resource Management
MEWR	Ministry of Energy and Water Resources
MW	Megawatt
NGO	Non-Governmental Organization
NSFPSP	National Center for Farms Privatization Support project
RBO	River Basin Organization
RBC	River Basin Council
SDC	Swiss Agency for Development and Cooperation
TJS	Tajikistani Somoni
UN	United Nations
UNDP	United Nations Development Programme
USAID	United States Agency for International Development
US$	United States Dollars
WB	World Bank
WUA	Water Users Association

Contents

Figures

Tables

Introduction

In Central Asia perhaps more than elsewhere, energy, water and food are inextricably connected. This is especially well illustrated in the mountainous landlocked country of Tajikistan. About half of Tajikistan's territory is located at 3,000 meters above sea level (masl), with mountains covering 93% of the country. Agriculture is mostly practiced in plains situated in lowland areas. Due to the differences in altitude, 44% of cultivated lands rely on irrigation pumps to supply them with water – the highest percentage in Central Asia (World Bank, 2017a). The irrigation pumps are rarely used for groundwater extraction and its main purpose is the water diversion to supply and drainage canals. Irrigation pumps require a steady energy supply to ensure proper functioning. This makes the agricultural sector the third largest energy consumer, accounting for about 20% of Tajikistan's summer electricity demand and 10% of the annual demand (about 1.5 billion Kw), according to the national integrated power company of Tajikistan, Barqi Tojik (Barqi Tojik, 2016a).

The energy in Tajikistan is supplied mostly from the country's rich hydropower sources. Although lacking in oil and gas, Tajikistan ranks one of the highest top in the world in hydropower potential per territorial unit. Total potential reserves of the county is 527 billion kWh per year (8th place in the world), 4% of the world's hydropower potential. Currently, hydropower plants (HPPs) cover more than 90% of the annual energy demand in the country. By developing this renewable energy, Tajikistan can achieve a high degree of energy independence and can largely do without fossil fuels. The river originating from Tajikistan or neighboring countries are mainly formed by snow melting from mountainous ranges in the summer period. River flows in winter period cannot generate sufficient hydropower to meet the increased electricity demands for residential heating, industrial production and to some extent agricultural needs. In addition, the country faces ageing hydropower plants and a deteriorating power grid, negatively affecting power supply throughout the year. Due to insufficient winter energy production, an estimated 74% of Tajik people, mostly in rural areas, were subjected to electricity shortages in winter until the last few years (World Bank, 2013). To address the shortage of electricity, Tajikistan has recently built a series of new hydroelectric power stations and thermal power stations and largely mitigated the limit on electricity consumption in the winter period 2017-2018. Still however, the power system is increasingly vulnerable to a major breakdown which could cause significant damages to the overall economy of Tajikistan including the energy-dependent agricultural sector. In this regard, it is necessary to increasingly develop the hydropower resources of Tajikistan for the generation of environmentally friendly energy sources.

In the face of climate change and the frequency of winter and dry summers, the impact on agriculture has been severely affected, for example in the recent past: in 2008, about 32% of the total rural population suffered from food shortages due to nominal crop production (WFP, 2009; GOT , 2010). Extreme weather conditions can be aggravated by wasteful use of water and energy resources.

According to World Bank estimates, in some cases only 35% of pumped water may reach cultivated lands, due to leakages and inefficient agricultural water use (World Bank, 2017a). The main reasons for this inefficient use are obsolete on-farm infrastructures in land reclamation, irrigation and drainage systems, worn out technical facilities and poor financial support of Water User Associations. Electricity provided for pumping irrigation is heavily subsidized by the Government of Tajikistan (GOT), and Tajikistan's energy prices are among the lowest in the world (World Bank, 2013). Current irrigation practices place a heavy financial burden on the country's national budget. Recognizing this problem, the government has invested heavily in rebuilding parts of the water supply network in irrigation systems and pumping stations. However, since funds for basic rehabilitation are limited, other financial, technical and organizational solutions are needed.

The study will therefore introduce and discuss some low or no-cost interventions which could address water and energy savings in agriculture. In particular, the current study highlights the role of Water User Associations (WUAs) as a suitable mean to balance and mitigate the agriculture-energy nexus. WUAs were established in Tajikistan in order to regulate services for operation and maintenance of on-farm irrigation systems for the benefit of water users (GOT, 2006a). As such, they are the first level of organization that can effectively challenge wasteful practices. However, currently most WUAs in Tajikistan are still underdeveloped and can hardly maintain the existent on-farm irrigation systems due to lack of management capabilities, insufficient funding and institutional constraints. Limited resources and capacities prevent them from becoming successful and representative organizations. Strengthening the management capacities of WUAs can enhance water and energy saving practices. The suggested methods of improving WUAs could be also applied to neighboring countries such as Kyrgyzstan and Uzbekistan, who are facing similar issues. This report also argues that energy savings can be multiplied by exporting electricity to neighboring countries. Tajikistan recently signed electricity trade agreements with Kyrgyzstan and Afghanistan to export large amounts of surplus hydropower in the summer at competitive prices. However, wasteful methods reduce the country's export potential for energy supply. WUAs can take energy efficient measures to save energy, which could be exported to other countries at high prices and offer substantial income. These revenues can be further invested in the agricultural sector by offering financing for infrastructure rehabilitation (World Bank, 2017a). Thus, increasing electricity exports could further increase energy efficiency in agriculture and minimize national food shortages.

The first chapter of this study sheds light on the water-energy nexus, focusing on the water and climate conditions of Tajikistan, the past and current hydropower generation, electricity demand and supply and regional energy trading. The second chapter addresses the energy-food nexus, focusing on electricity usage in agriculture, agricultural water management and its implications for Tajikistan's food security. Also, the policy reforms conducted by the Government of Tajikistan (GOT) are highlighted. The third chapter focuses on the role of WUAs can play in improving the agriculture-energy situation. The organizational, administrative and financial mechanisms of WUAs are described in order to understand their functioning.

The fourth chapter reviews the major challenges currently faced by WUAs while low or no-cost interventions are suggested to improve their functioning, and thereby increase energy savings in irrigation. The concluding remarks synopsize the current situation of the agricultural sector in Tajikistan, highlight the need for the enhancement of the role of WUAs and the contribution of energy export in improving irrigation and drainage systems in the country.

Chapter 1. The energy-water nexus: hydropower supply and demand

1.1 Water Resources and Climate in Tajikistan

The water resources in Tajikistan are endowed with a large network of rivers trespassing the entire country as presented in Figure 1. The freshwater sources are the basis of agriculture and hydropower energy. According to recent Water Sector Reforms that will be presented more thoroughly in Section 2.2, and given the hydrological boundaries of the country the river systems are divided into four river basins (Figure 1).

The Tajik part of the Syrdarya river basin consists of the Syr Darya river and its tributaries within the borders of the Republic of Tajikistan. The Syrdarya river basin, as a unit of management, includes in the territory of Tajikistan the Zerafshan river basin in the form of a sub-basin. Both rivers are of interstate importance, and the water resources management of the Syrdarya river is accordingly regulated by decisions of the Interstate Coordination Water Management Commission of the Central Asian countries (ICWC).

The Kafirnigan River Basin consists of the Kafirnigan river system and its tributaries, the Ilyak, Sorbo and Varzob. The lower part of the basin boundary is formed by the tributaries of the Kafirnigan. In the upper part of the Kafirnigan river basin there is the sub-basin of the Karatag river, which is transboundary between the republics of Tajikistan and Uzbekistan and is included in the upper reaches of the Surkhandarya river basin.

The basin of the Vakhsh River consists of the Vakhsh River and all its tributaries, except the uppermost part. The Tajik part of the Pyanj river basin includes a zone of the Pyanj River and its tributaries located in the Republic of Tajikistan. In the north and west, the basin borders the Vakhsh River basin, and in the south marks the border with Afghanistan. Accordingly, four sub-basins, namely, the Zerafshan, Surkhob, Kofarnihon and Karatag have been acknowledged.

Figure 1: Main river basins and its tributaries in Tajikistan (GOT, 2015a)

In total, there are 947 rivers in Tajikistan and the total length is about 28,500 km. The average annual flow in the central mountainous part of the country reaches 30–45 $lsec^{-1}$, and the average annual discharge of rivers in Tajikistan is about 53 km^3 (Hydromet, 2016). About 55% of the average annual water resources of the Aral Sea basin are formed in Tajikistan. The two main rivers, the Pyanj and the Vakhsh, dominate almost all the south-eastern and western regions of Tajikistan with the following characteristics:

Table 1: General Characteristics of Pyanj and Vakhsh rivers in the territory of Tajikistan

River	Length (Km)	Catchment area (km^2)	Annual discharge (m^3sec^{-1})	Annual runoff, (million m^3)
Pyanj	921	107,000	1,010*	31,9*
Vakhsh	524	39,100	604**	19,1**

*Measurement based on long-term data from gauging stations of Tajik Hydro-Meteorological Agency (Hydromet) in Panj River for the periods 1965-1967, 1969-1972,1976-1990 (Hydromet, 2016)

** Measurement based on long-term data from gauging stations of Tajik Hydro-Meteorological Agency (Hydromet) in Vakhsh River for the periods of 1949-1957,1976-199 (Hydromet, 2016)

For the period from 1961 to 2010, a decrease in the average annual flow is observed in the country decreased from 57.1 km3 per year1 to 52.2 km3 per year-1 (Hydromet, 2016). The greatest reduction in the average annual flow was observed in the Kyzylsu, Zarafshon, Vakhsh and Pyanj rivers by nearly 7%. To a lesser extent, a flow reduction was also observed in the Kofarnihon river to about 3%. In the Eastern Pamirs, the runoff practically remained unchanged and in some areas of the Western Pamir increased slightly to an amount of 0.5-1% (Hydromet, 2016).

The freshwater sources in Tajikistan are largely replenished by precipitation received either in the form of rainfall, snow and glacier melting. By calculating the mean precipitation for the period 1961-1990 Tajik Hydromet (2016) indicates that the annual volume may vary from less than 50 mm to over 1,000 mm within the country. Moreover, there are three distinctive regions with relatively high precipitation intake compared to the rest of the country as show in Figure 2. The driest parts of the Tajikistan on average are the eastern mountain area and southern lowland mostly receiving less than 200 mm of precipitation annually.

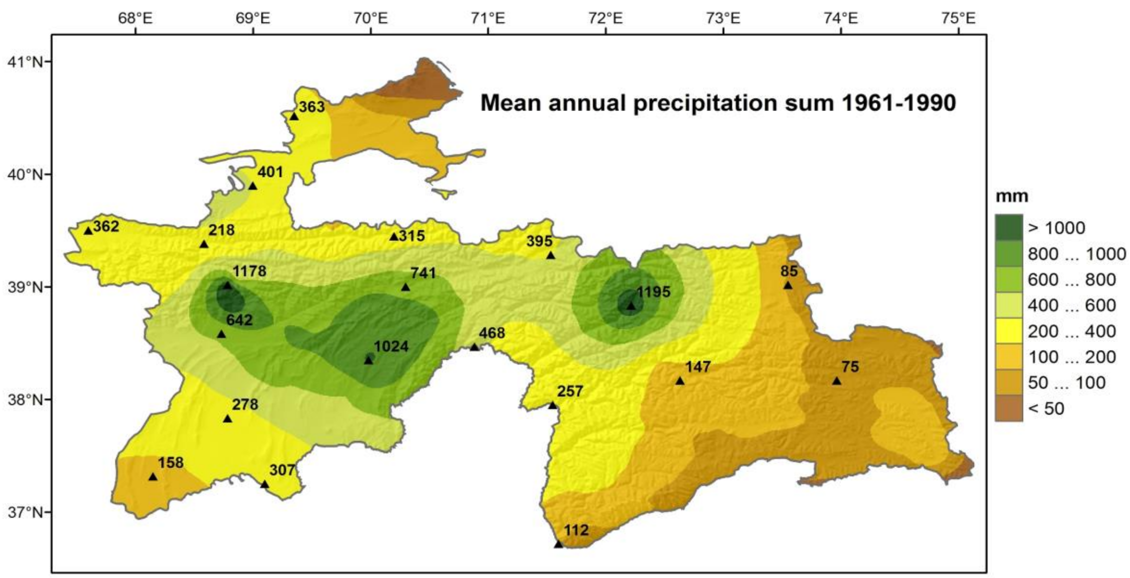

Figure 2. The mean annual precipitation sum in Tajikistan based on 1961-1990 (Hydromet, 2016; Aalto et al. 2017)

A recent study on precipitation and water resources trends in Tajikistan (Aalto et al. 2017) has shown that there is a significant intra-annual variability of flow in large rivers. Also, there are fluctuations of high and low water availability in large river basins every 2-3 years; continuous periods of water shortage occur every 4-5 years; the most protracted periods of low water level recur almost every 8 years. The years of 1974, 1976, 1980, 1988 and 2000 appeared to be dry periods according to official recordings and the most devastating ones were the 1969, 1972, 1990, and 1998. In 2000, lack of water has been observed in Tajikistan's rivers (40-85% lesser than the normal volume) due to low snow reserves in the mountains (50-70% lower than the normal) and a shortage of rainfall in the spring months.

On the other hand, historically major floods and heavy snow melting were recorded in 1969, 1981, 1993, 1998, 2002, 2010, 2015 and 2016.
The mean annual temperature in Tajikistan varies between -13.7 and 17.3 degrees (Fig. 9) and is strongly constrained by elevation. The lowest values can be found at eastern mountains and the highest in the western low-lying parts of the country as also shown by Figure 3.

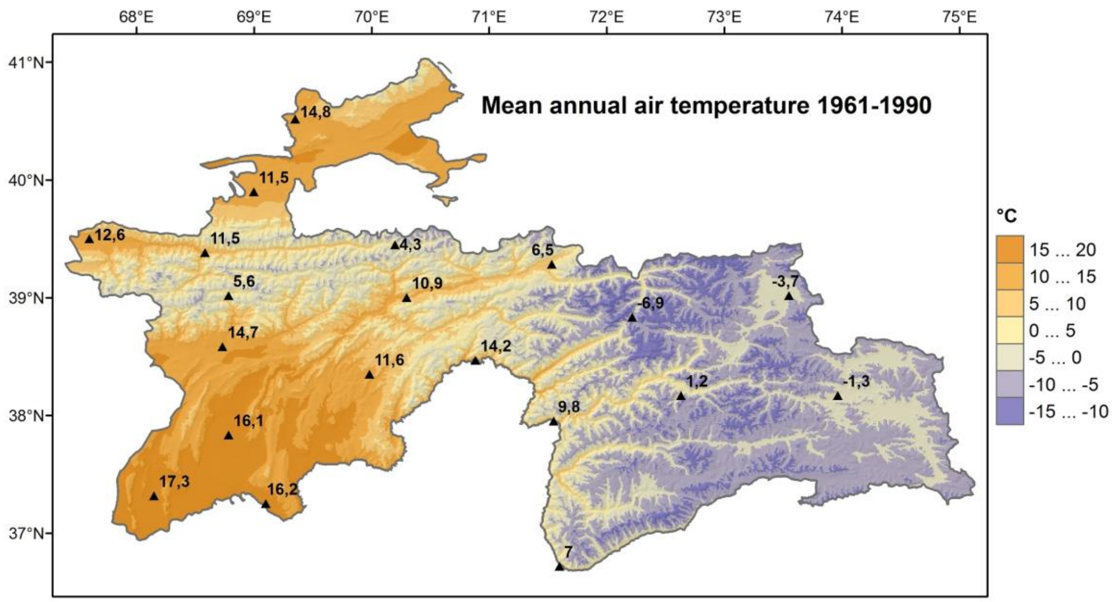

Figure 3. The mean annual temperature sum in Tajikistan based on 1961-1990 (Hydromet, 2016; Aalto et al. 2017)

The same study (Aalto et al. 2017) analyzed the data of 23 hydro-meteorological stations all over the country by showing that annual mean temperatures have risen in Tajikistan since the 1930s. The rate of change has been approximately 0.1°C $year^{-1}$ nationwide. This rise has been less profound during the winter season compared with other seasons. Unlike temperature, there was no clear signal on the annual precipitation trends during the last eight decades.

1.2 Energy produce in Soviet and Post-Soviet period in Central Asia

Tajikistan's electricity production has since long been dependent on hydropower plants of which most were built when Tajikistan was part of the Union of Soviet Socialist Republics (USSR). The seasonal fluctuations associated with hydropower were previously compensated by a Central Asian regional energy system. The Central Asia Power System (CAPS) was established in the 1970s and included all five former Central Asian Soviet republics: Kazakhstan, Kyrgyzstan, Uzbekistan, Turkmenistan and Tajikistan. During the Soviet period, internal borders were disregarded and the CAPS could meet the needs of the whole region.

In summer months, water-rich upstream countries, Tajikistan and Kyrgyzstan, were responsible for releasing water and generating electricity for the whole region. In return, they were receiving fossil fuels and surplus electricity in winter from the hydrocarbon-rich downstream countries, Uzbekistan, Kazakhstan and Turkmenistan. The high regional demand for irrigation was met throughout summer, while winter energy shortages in upstream countries were similarly compensated.
During the CAPS period, 60% of Tajikistan's electricity needs were covered by imports from other Soviet Republics (World Bank, 2013). Within this system, the region was provided with sufficient power generation at low costs, transforming Central Asia into a ''bread basket'' and main cotton-production center.

As part of the national development strategy in Tajikistan to ensure energy security in an attempt to gain energy independence, Tajikistan built the North-South transmission line, which connected the northern and southern regions, which were almost divided in half by high mountain ranges.

1.3 Hydropower opportunities and challenges

Facing energy isolation in the post-Soviet era, Tajikistan has suffered from increasing energy shortages. As a result of lacking maintenance, rehabilitation and investments, many hydropower plants are currently producing below their potential output, while the electricity network often fails to transfer power to large parts of the country. Most of Tajikistan's HPPs have been in operation for an average of 45–50 years without major rehabilitation and maintenance. This has significantly decreased the energy capacity of the country. Indicatively, according to oral communications and information provided by the national integrated power company (Barqi Tojik), in 1990 Tajikistan's total energy production was 18.2 billion kWh (of which 18.0 billion kWh was produced by HPPs). The country's energy output has been gradually decreasing since independence and in 1998 the total energy output was 14.4 billion kWh as presented in Table 1 (GOT, 2007). There was some fluctuation throughout the years but seems that the production till the year 2015 has not surpassed the 1990 levels (see Table 2). It should be mentioned however that in 2017 the electricity production amounted to 18 billion kWh. Also, throughout 90s the electricity losses have been increased: in 1991 the electricity loss to the deteriorating grid amounted to 10.1% of total energy consumption, while the losses were had risen to 15.2% in 2000 (GOT, 2004).

Table 2. Energy generation in Tajikistan 1998-2015 (billion kWh per year)

	1998	1999	2000	2001	2002	2003	2004	2005	2006
Total	14.4	15.8	14.3	14.4	15.3	16.5	16.5	17.1	16.7
Hydropower	14.2	15.6	14.1	14.1	15.0	16.2	16.3	16.8	16.5
	2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Total	17.3	14.7	14 .2	14.4	13.9	14.4	14.2	13.8	14.4
Hydropower	16.9	14.5	14.0	14.4	13.9	14.4	14.1	13.6	14.1

(GOT, 2007; 2011; Barqi Tojik, 2016a)

Tajikistan's current installed total hydropower capacity amounts to 5,346 MW with which it is able to produce 17.2 billion kWh of electricity (Barqi Tojik, 2016b). However, due to low levels of river volume in winter months and the high electricity demand, the energy system cannot adequately respond to the seasonal needs. The mean energy generation in winter period is only around 70% of the level of summer generation, and can be as low as 40% in some run-of-river HPPs. With declining conditions of the ageing facilities, this shortage is predicted to further increase in coming years. Electricity demand is predicted to increase as long as the population and the economy will continue to grow.

Photo 1. The Nurek HPP spillways and power substation. The HPP is responsible for over 75% of Tajikistan's energy supply (Photo: Ronan Shenhav, 2016)

Economic growth since early 2000 ranged between 6-8% and although slowly stagnating, still stood at a firm 6% in 2016 (World Bank, 2017b). The population has risen from 5.3 million in 1991 to 8.5 million in 2016, with an increase of 26.3% over the last fifteen years, and it is estimated to rise to 10 million by 2020. In 2012, winter shortages were estimated at 2,700 MW, but if current trends continue without adopting energy efficiency measures, these deficits could increase to over 6,800 MW by 2020 (World Bank, 2013).

The seasonal imbalance is partly mitigated by large reservoirs that store enough water for hydropower purposes in the winter period. Nurek HPP on the Vakhsh River in central Tajikistan, with a 10.5 billion m^3 capacity reservoir and an installed 3,000 MW generation capacity, is currently the largest dam in Central Asia and produces over 75% of Tajikistan's energy supply. Still, Nurek's reservoir cannot supply enough power during winter months to meet national demand (World Bank, 2013).

A difficult situation arose in 2008, when Tajikistan experienced the coldest winter since 1969, and there was a serious lack of energy. Temperatures down to -20C, combined with high food and fuel prices, have exacerbated energy difficulties for many. Although the situation has significantly improved after 2008, Tajikistan still had to engage until 2016 an electricity rationing during winter.

The attenuation of CAPS' trade capacity and the energy supply frictions between CA countries have motivated Tajikistan to reinvent itself as one of the forerunners of hydropower generation. The government has set hydropower investment and rehabilitation as a national priority and increasingly invested in hydropower facilities in recent years, including the rehabilitation of the Nurek Dam. The country has taken significant steps in improving its hydropower capacity with the construction of the Sangtuda-1 HPP, which added 670 MW of capacity after its completion in 2009, and the Sangtuda-2 HPP, which added another 220 MW in 2011. Other recent projects have incremented the installed capacity in 2015 to 5,346 MW (see Table 3).

Table 3. Installed power generation capacity in Tajikistan 2010-2015 (MW)

	2010	2011	2012	2013	2014	2015
Total capacity	5,024	5,070	5,135	5,136	5,346	5,346
Hydropower	4,706	4,752	4,816	4,818	4,928	4,928
Thermal power	318	318	318	318	418	418

(GOT, 2011a)

The aforementioned capacity levels will significantly rise by 65% with Tajikistan's largest hydropower investment yet, namely the Roghun Dam to be constructed in Vakhsh river. This ambitious 3.9-billion-dollar project struggled to collect funds until the construction phase which initiated in October 2016. Once completed, the prestigious dam will overtake Nurek in height and will become the world's tallest dam at a height of 335m. The Roghun Dam will add another 3,600 MW of generation capacity, nearly doubling Tajikistan's electricity production.

1.4 Energy trading

With Tajikistan's recent investments in hydropower capacity, the country hopes to secure not only its energy security, but to become a leading regional exporter of electricity, potentially supplying growing economies in Afghanistan and Pakistan with high electricity needs. The inauguration of the first phase of the Central Asia – South Asia electricity network (CASA-1000) on May 12, 2016, has made it possible for Tajikistan to export its summer electricity surpluses at lucrative prices. CASA-1000 is a US$ 1.16 billion project that connects Kyrgyzstan, Afghanistan and Pakistan through high-capacity transmission lines, enabling large power flows from north to south. Tajikistan and Kyrgyzstan are expected to annually supply up to 5 billion kWh of summer electricity to Afghanistan and Pakistan via this power transmission line (SNC-Lavalin, 2011; Barqi Tojik, 2016c). Furthermore, Tajikistan is discussing possibilities to connect its energy system with Iran, enabling the country to export to another significant economy. Although CASA-1000 is expected to be fully operative only by the end of 2019, Tajikistan's energy exports have been already steadily increasing since 2010 due to the rehabilitation of major power lines.

Indicatively, in 2011 the share of electricity exports in total revenue was only 0.1% and amounted to 190.9 million kWh worth US$ 4.3 million (Energy Charter Secretariat, 2013). By 2016 however, almost 15% of the total summer-time electricity surplus was exported, and was risen almost sevenfold up to 1.3 billion kWh. Nearly all energy export was delivered to Afghanistan, while a small portion of 50 million kWh was delivered to Kyrgyzstan. The total additional revenue coming into Tajikistan in these summer months was estimated to be US$ 50 million (Barqi Tojik, 2016c). Currently, Barqi Tojik has two power purchase agreements (PPA) with its neighbors: one with Afghanistan and one with Kyrgyzstan. It has been agreed to sell a total of 600 million kWh of electricity in the period from May to September to Kyrgyzstan, which is updated on an annual basis. The first PPA with Afghanistan has been agreed on an amount of 1 billion kWh of electricity, of which 651 million kWh should be granted in the period from April to October (Barqi Tojik, 2016c).

The electricity imports and exports of Tajikistan for the period 2005-2016 are presented in Table 4. As shown in Table 4 there is a positive trend on the energy export since 2010 and onward although with some decrease in 2016 due to technical constraints. There is also a noteworthy import volume since 2012 which is largely resulting on the energy trading with Kyrgyzstan for the coverage of energy needs in winter periods.

Table 4. Electricity import and export in Tajikistan 2005-2016 (in million kW)

	2005	2006	2007	2008	2009	2010
Export	798	948	969	1,054	1,232	179
Import	1,042	1,557	1,057	1,917	1,276	1,954
	2011	**2012**	**2013**	**2014**	**2015**	**2016**
Export	189	676	985	1334	1,353	1,281
Import	2,216	2,366	2,372	2,494	2,564	2,191

(GOT, 2011; Barqi Tojik, 2016c)

According to the recently signed agreements, Tajikistan will be able to sell electricity in the future for up to US$ 0.05 per kWh. This price is much higher than what the government is charging farmers for pumped irrigation domestically, which only stood at US$ 0.0030 per kWh in 2016 (see Table 8).[i] Inefficient water use practices in the agricultural sector are therefore coming at a heavy cost to an already stressed national budget. As the World Bank has put it "Energy use in Tajikistan during summer, previously not recognized as a concern because of the excess energy availability in summer, has been propelled on the national agenda, as energy wastage now comes at a high opportunity cost" (World Bank, 2017). The current and future energy policy of Tajikistan is delineated in the following section.

In 2011, the government of Tajikistan adopted the "Programme for the efficient use of hydropower resources and energy 2012-2016", aiming to improve energy efficiency and energy saving as a means to reduce energy losses and gain full energy independence (GOT, 2011b). The government's main objective was to eliminate the country's dependence on energy imports and become self-sufficient. The government estimated that up to 3,200 million kWh of electricity could be saved by 2016 through energy efficiency measures.

1.5 National energy policy

The Tajik government annually allocates more than US$ 300 million or 15% of its state budget for the development of the energy installations and infrastructure (GOT, 2014). As mentioned above, large investments have been made in hydropower and regional electricity networks. In combination with the rehabilitation of hydropower facilities and the expansion of power lines, improved energy efficiency has been a priority in recent years. However, in addition to these investments, the current energy subsidy system comes at an additionally high cost to the national budget. Table 5 below describes the average energy tariffs per KWh:

Table 5. Electricity prices and share by sector in 2015

	Consumption per sector (million kWh)	Electricity price (US$/kWh)
Industrial	4,621	0,029
Public buildings	556	0,023
Irrigation pumps	2,726	0,0054
Residential	4,914	0,021

(Barqi Tojik, 2015d)

The Ministry of Energy and Water Resources (MEWR), Barqi Tojik and the Antimonopoly Agency are the main regulatory agencies to supervise the tariff systems of different sectors in Tajikistan. The electricity tariffs are kept artificially low for all sectors due to a subsidization policy in energy provision. Subsidies are especially high in the irrigated agricultural sector where the subsidies for 2015 were estimated to cover up to 70% of the energy costs (World Bank, 2017). This subsidy system is established to stimulate agricultural production and alleviate pressures on rural households. However, these subsidies aggravate the energy security negatively in two ways. First, there is limited financial incentive for the agricultural sector to improve efficiency, thereby further increasing wasteful practices of water and energy resources. Secondly, the subsidies add to the already huge financial strains Barqi Tojik, which hinders its ability to allocate necessary funds to maintenance and rehabilitation (Akhroroval et al. 2013).

In effect, the provision of direct and indirect subsidies has put Barqi Tojik under immense financial pressure. Between 2005 and 2013, only 21% of energy expenses were paid to Barqi Tojik. Annual expenses of pumping irrigation are estimated to amount to US$ 11M. Out of these, the farmers could provide only up to US$ 5.2M through Irrigation Service Fees (ISF) collected by WUAs and additional charges set by the regional branches of the Agency for Land Reclamation and Irrigation (ALRI) which is the main irrigation agency in the country. Both these charges will be explained in more details in Section 2.4. The rest of the US$ 5.8M amount is covered by the state budget by entailing large economic deficits.

Aside from the high costs of the subsidy scheme, the national budget is strained further by debt cancellations provided to the irrigation sector. The government has cancelled the accumulated energy debts of agriculture twice in recent years. The first debt of US$ 5.1M in 2009 accounted for the unpaid Service Irrigation Fees (ISF) from WUAs to ALRI. The second debt of US$ 48.2 million in 2014 is consisted of unpaid energy expenditures of ALRI to Barqi Tojik. In total, debt cancellations for unpaid power fees, combined with forgone profits due to the subsidized electricity tariffs in pumping irrigation, amounted to US$ 281.98 million to the national budget between 2005 and 2013 (World Bank, 2017). Pumped irrigation and its limited cost recovery therefore comes at a high cost to the national budget.

Without financial incentive for farmers to reduce their consumption, and with increasing need to rehabilitate the country's irrigation facilities, the gap between the costs and agricultural output continues to widen. To mitigate this development, the government of Tajikistan has agreed to gradually increase prices, thereby incentivizing consumers to increase energy efficiency. A more compensatory tariff system is currently being designed. The new guidelines are about to surge the tariffs by 300% in all sectors until 2020 so as to compensate for the consumption and partly the investments in the energy supply of the country (GOT, 2015b). However, increasing electricity prices in agricultural sectors may prove to be problematic. A sudden increase in prices may result in a decrease of productivity in the irrigated agriculture sector, as it is highly dependent on energy. Subsistence farming and food security may be also questioned as will be presented in the following chapter.

Chapter 2. The energy-food nexus: agricultural water management

2.1 Agricultural water use in Central Asia and Tajikistan

Central Asian countries are among the highest water consuming economies in the world. The intensification of agricultural water usage has resulted in environmental consequences like desertification and salinization with the most representative example the shrinkage and salinity of Aral Sea in the northern parts of Central Asia. The Aral Sea Basin comprised the drainage area of two major rivers, the Amu Darya and Syr Darya which cross all the Central Asian countries. The rivers originate from the Tien Shan Mountains and the Pamirs and run through Tajikistan, Kyrgyz Republic, Afghanistan, Uzbekistan, Turkmenistan and Kazakhstan. The Aral basin is home to almost 60 million people, and provides irrigation to 11.4 million hectares.

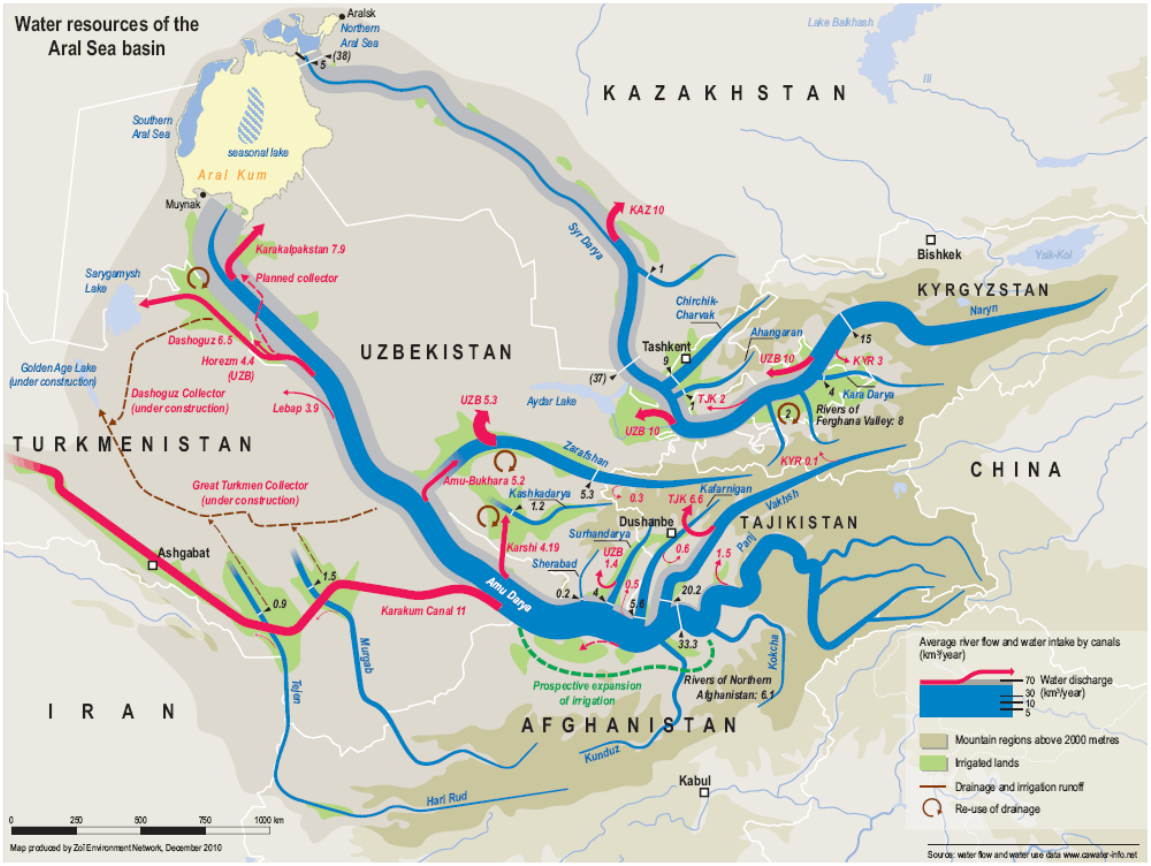

Figure 4. Water resources in the Aral Sea basin (cawater-info.net,2017)

Irrigated agriculture uses 90% or 140–160 km^3 of Aral basin's water sources and is one of the key drivers of economic growth, employment, poverty reduction and food security in the region (FAO, 2012; USAID, 2010).

The upstream countries of Tajikistan and Kyrgyzstan are heavily relying on hydropower energy beyond irrigation needs. At the same time, the downstream countries of Uzbekistan, Turkmenistan and to lesser extent Kazakhstan are much dependent on the upstream water sources for irrigation purposes. At regional level, the annual water availability per person is currently estimated at 2,500 m^3, and is expected to decrease to 1,700 m^3 per person per year by 2030, the internationally recognized level for water stress. [ii]

The irrigation efficiency in the region is estimated at about 30% (i.e., only 30% of the withdrawn water reaches the plant roots), and the average annual abstraction for irrigation is over 15,000 m^3 per hectare (World Bank, 2017). Tajikistan is the poorest country in Central Asia, with 49% of its rural population living below the poverty line. Approximately 73.6% of the country's population of 8.55 million reside in rural areas, where paid jobs are scarce (GOT, 2016a). About 46.5% of the overall population is employed in agriculture, while productivity in the sector represents 21% of national GDP (World Bank, 2014).

Photo 2. Farmer picking cotton near Dusti, Khatlon region. Cotton is one of the main exporting commodities of Tajikistan (Photo: Ronan Shenhav, 2016)

Agricultural land in Tajikistan covers about 4.6M hectares (ha), with a potential irrigable land of 1,57M ha (GOT, 2001)However, currently only 753,083 ha of irrigated land and 201,370 ha of rain fed arable land is cultivated due to technical and economic constraints (GOT, 2016a). The average amount of arable land held per person was 0.08 hectares for the year 2016. Due to differences in climatic conditions the agriculture in Tajikistan is dependent on irrigation, which in some regions is highly energy intensive due to the reliance on irrigation pumps.

2.2 Land and water policy reform

In the Soviet era all the expenditures for maintaining large canals and drainage systems were covered by the state and educated personnel were equipped with some technical capacity. Before independence in 1991, the main land owners were around 600 collective and state farms. However, land reforms after independence, especially intensified in the late 90s, reshaped the ownership status of farmlands towards a more privatized profile.

According to the Land Code of Tajikistan, the land use rights were gradually moved to private (dehkan) farms and associations through long-lease agreements (GOT, 1996a). In general, three different types of private land use have evolved as of below:

1. Creation of new private (dehkan) farms based on small (husband, wife, children) or extended (relatives included) families with an average size of 0.2 – 1 ha of land per farmer;
2. Retaining the existing structure of the old stated collective (sovkhoz/kolkhoz) farms, based on a cluster of farmers, usually previous member of the same collective farm. The size may vary between 30 – 120 ha based on the number of farmers; and
3. Reorganization of the former state and collective farms into structures such as Joint Stock Companies, Lease Enterprises, Dehkan Associations or Collective Farms with large amount of land in possession. The size may vary between 1,000 – 1,500 ha, based on the number of farmers.

After the first land reforms, people with different backgrounds and limited farming knowledge started practicing farming. There has been little effort to explain the new landholders their rights and roles in the agricultural sector. In the case of water management, little care has been taken to arrange the maintenance and operation of the existent irrigation and drainage systems. On-farm irrigation and drainage infrastructure, formerly operated by collective farms, were gradually abandoned without clearly delegating a management body. Also, the lack of funding from the state and the nominal revenues of farmers could not support the rehabilitation of irrigation and drainage systems. Subsequently, the agricultural sector was deteriorating and issues like water use efficiency decrease, lower crop productivity and land degradation were in the spotlight.

Many agricultural reforms have attempted to revamp the sector and underpin subsistence farming after independence. The water sector has gone through several stages of reform, initially starting in 2006 when the government of Tajikistan launched the implementation of a “Strategy for State Administrative Reform” through the Presidential Decree No. 1713 (GOT, 2006b). Also, in August 2012, as part of the Agrarian Reform, the Government of Tajikistan approved the “Agriculture Reform Programme” of the Republic of Tajikistan for 2012-2020, which included the reform of the water sector and transition to integrated water resource management approaches (IWRM) based on river basin planning (GOT, 2012a).

The following year, on November 19, 2013, the Decree “On the improvement of the management structure of the executive bodies of the Republic of Tajikistan” was issued. In accordance with this Decree, the former Ministry of Land Reclamation and Water Resources (MWRM) was abolished, and the Ministry of Energy and Water Resources (MEWR) was created to oversee and implement policies and regulations in the field of water management in the country.

The important role of water for the agricultural sector was commended. Issues related to land reclamation and irrigation in accordance with the same decree in 2014 were transferred to the newly created Agency for Land Reclamation and Irrigation under the Government of the Republic of Tajikistan (ALRI). ALRI also controls shore protection and other measures to prevent mudflows and floods.

In 2015, the Water Sector Reform Programme was put into practice by developing a water strategy for 2016-2025 based on a river basin approach. The water sector reform also aimed at laying the foundation for the application of IWRM in Tajikistan, decentralizing tasks to different basins and assign responsibilities between different governmental agencies. In the frame of Water Sector Reform, four (4) major basins and some sub-basins were created as noted in Section 1.1 The basins and sub-basins shall be managed by the newly introduced River Basin Organizations (RBOs) while also the new institution of River Basin Councils (RBCs) will have a consulting role in the management processes (GOT, 2015a).

For the successful implementation of the Water Sector Reforms, it is necessary to revise the relevant existing and develop new laws. In this regard, the ALRI recently finalized a draft law on irrigation and on land improvement and irrigation to regulate this sector of agricultural land within the specified basins. Furthermore, the revision of the operation of Water User Associations (WUAs) is currently on-going for updating the issues related to determination of WUA rights; service fees and fee collection processes; taxation and property rights and compliance with the river basin management approach.

The implementation of the Water Sector Reform Programme requests significant support from development partners and donor organizations, in addition to the support of the Government of the Republic of Tajikistan. The following development partners are currently highly engaged in the reform process as the World Bank (WB), Asian Development Bank (ADB), European Union (EU), Swiss Agency for Development and Cooperation (SDC); European Bank for Reconstruction and Development (EBRD), United Nations Development Programme (UNDP) and the Development Coordination Council (DCC).

The institutions such as the RBOs and RBs will be initially funded by the development partners for the period 2016-2018 in the form of Working Groups. From 2019 and onwards the Tajik state shall provide financing for the four (4) RBOs and five (5) sub-basin organization from the central budget allocations under the supervision of MEWR.

2.3 Food security

Tajikistan is a highly agrarian country with an estimated 75% of Tajik workers employed in the agricultural sector. Agriculture contributes to 21% of the national GDP (USAID, 2014). Achieving food security by developing the agricultural sector is a priority for Tajikistan. Sufficient agricultural output is furthermore crucial to sustain rural livelihoods.

Agriculture in Tajikistan was modernized in the Soviet period and continues to be growing as one of the most important sectors in the country. During the Soviet era, Central Asia was transformed into an agricultural supplier for the whole Soviet Union mainly providing wheat and cotton crops. Due to massive modernization, the agricultural output in Tajikistan tripled between 1960 and 1988. After independence, however, liberalization of the agricultural sector caused a large decline in agricultural output, dropping productivity by 55% between 1991 and 1997.

Since the beginning of the twenty-first century, agricultural production has shown remarkable recovery and has surpassed the level of 1991 once again. While cotton used to be the most important crop for Tajikistan in the first decade after independence, it has since 2011 been surpassed by crops as potatoes, wheat, fruit, onions and cotton (USAID, 2014). The Khatlon province in the southeast of the country provides most of the production and is considered to be the ''bread basket'' of Tajikistan. In Table 5 below, the agricultural significance in the regions of Tajikistan presented:

Table 5. Agricultural significance of regions of Tajikistan in 2009 (%)

	Khatlon	Sughd	DRS	GBAO
Gross agriculture output	45	29	26	4
Agricultural land (crops)	33	24	26	17
Agricultural land (livestock)	49	32	18	1
Cattle	40	27	26	7
Sheep/goats	39	31	21	9

Explanatory Note: DRS = Districts of Republican Subordination; GBAO = Gorno-Badakhshan Autonomous Region. (USAID, 2014)

Nevertheless, domestic food production is still insufficient to meet the national demand. The nutrition of many poor households solely consists of staple foods (wheat, maize). Many of these households lack dietary diversity which causes high rates of malnutrition. Although undernourishment has improved significantly since the 1990s, it still affected 20% of the population by 2007 (Swinnen & Van Herck, 2013). In rural areas this is worse, where an estimated 32% of the population suffered from food shortages in 2009, with 9% of the rural households severely affected (WFP, 2009).[iii] Children are particularly impacted: almost 25% of children suffered from malnutrition in 2012.

Photo 3: Isolated mountain village in the northern Sughd region. Subsistence farmers in mountain communities rely on agriculture for their livelihoods (Photo: Ronan Shenhav, 2016)

Tajikistan has to import approximately 60% of its food due to insufficient domestic food production. Imports of wheat and barley mainly come from Kazakhstan and the Russian Federation. Imports accounted for 58% of Tajikistan's domestic wheat requirements and 81% of overall food consumption for 2012-2013 (USAID, 2014). Without significant investments, the lack of arable land, a growing population and an insufficient domestic supply Tajikistan's dependence on food imports is likely to rise. High food prices in the last years have affected rural communities in Tajikistan significantly.

Many poor households are vulnerable to world food price fluctuations. Although the food security situation has improved since 2009, global food price spikes led the government of Tajikistan to introduce price controls in Dushanbe in 2010 and 2011. The Tajik government sees food security and nutrition as a high priority to sustain national socioeconomic stability as specified in the National Development Strategy of the country until 2030 (NDS-2030). Analysts argue that is essential for Tajikistan to reach domestic demand by making substantial investments in the agro-food industry (Swinnen & Van Herck, 2013). Trends in agricultural production of main crops in Tajikistan are presented in Figure 5 below.

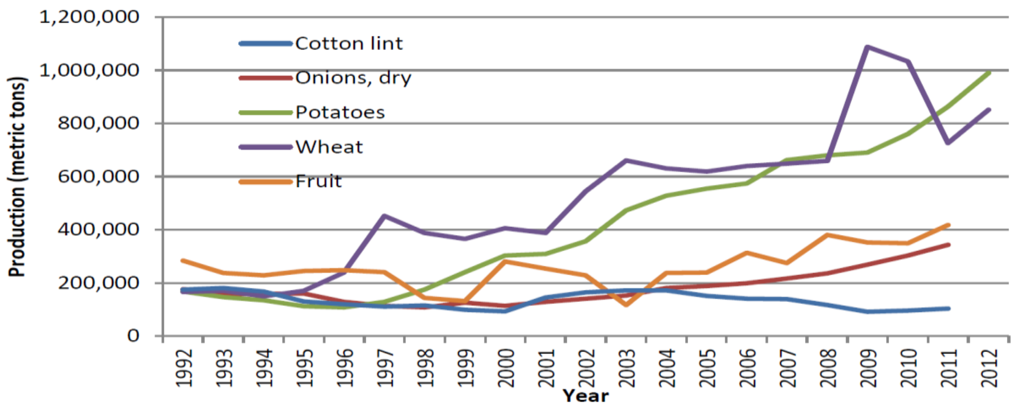

Figure 5. Trends in Tajikistan agricultural production developed based on statistic data, 1992-2011 (USAID, 2014)

Food security in Tajikistan depends on two key aspects: irrigated agriculture and land productivity. This is highly linked with sustainable irrigation methods. The yield of wheat crops in irrigated lands of valleys in Tajikistan (Khatlon, Sughd and DRS) for instance, is averagely 4-6 times higher than the wheat produced in rain fed areas. As a result, almost 80% of the agricultural output in Tajikistan is cultivated in irrigated areas of small scale farming. In order to supply these lands with sufficient water, more than 90% of Tajikistan's total annual runoff of fresh and groundwater sources is diverted to agriculture (GOT, 2015a). The total volume of water abstracted from all sources for irrigation is averagely 8.0-10.0 km^3 per year. Irrigated water is often diverted from rivers by gravitation canals. However, in many cases, the river water level is in lower elevation than the agricultural land, which makes it necessary for water to be lifted by large pumping stations into main canals. There are also many instances where boreholes are drilled from aquifers from higher than 150m depth. Table 6 shows the pumping irrigation by height in the regions of Tajikistan as provided from ALRI agency to a World Bank report (2017) for the year 2015.

Table 6. Pump irrigation areas by height of water lifting

Location	Pump irrigation areas by height of water pumping, ha					Total, ha
	Up to 100m	100–150m	150-200m	200-250m	250- 300m	
Sughd	109,051	24,415	26,040	1,627	1,627	162,760
Khatlon	90,562	11,320	1,029	-	-	102,911
RRS	7,995	2,112	3,922	754	302	15,085
Badakhshan	92	-	-	-	-	92
National	207,700	37,847	30,991	2,381	1,929	280,850

World Bank (2017)

To this end, 44% of irrigated agriculture is dependent on pump stations to supply agricultural land. Around 35% of agricultural produce depends on pumping irrigation. However, there is great variety in the dependence on pumped irrigation across the country, due to differences in terrain and altitude: agricultural land in some areas of Tajikistan is only for 21% supplied by pumps (Rasht Valley), while other areas rely up to 85% on pumped irrigation (Sughd region). Currently the operational pumping infrastructure is estimated to irrigate 280,850 ha.

2.4 Agricultural energy consumption

Agriculture and energy are intimately connected in Tajikistan. The agricultural sector in Tajikistan still accounts for a significant proportion of the total national electricity bill and in 2015 was the third largest energy consumer in the country, accounting for 15% of the total energy consumption (see Table 7). Total agricultural energy consumption has been variable from 2005 to 2015 with fluctuations from 10% to nearly 14 %. However, the share of pumping irrigation has slowly decreased throughout the last decade, from 10-11% to 8-9%, with a fall of electricity consumption from 1,546 million kWh in 2005 to 1,246 kWh in 2015. It is noted that there has been a decrease of industrial electricity consumption since 2005. This can be largely attributed to the decreasing productivity of Tajikistan's largest aluminum plant, the Tajikistan Aluminum Company (TALCO), which used to account for around 40% of Tajikistan's total energy consumption (ADB, 2011).

Table 7. Consumption of electricity per sector 2005-2015 (in million kWh)

YEARS		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1. Industry	kWh	7187	8113	8109	7729	6804	7435	6565	6421	5592	4421	4610
	%	48%	51%	47%	48%	42%	46%	41%	39%	34%	31%	30%
2. Residences	kWh	3941	3352	3045	2818	3618	3967	3881	3611	4369	4447	4914
	%	26%	21%	18%	18%	22%	24%	24%	22%	27%	29%	30%
3. Agriculture	kWh	1546	1677	2222	1967	1962	1757	2189	2266	2167	1832	1977
	%	10%	11%	12%	12%	12%	11%	13%	13%	14%	14%	13%
Irrigation pumps	kWh	1546	1677	1648	1512	1497	1307	1676	1585	1434	1227	1246
	%	10%	11%	10%	9%	9%	8%	10%	10%	9%	9%	8%
Farm-houses, offices	kWh	0	0	31	23	10	8	7	4	4	3	3
	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Livestock	kWh	0	0	5	5	6	7	11	13	11	10	7
farms	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Drinking water pumps	kWh	0	0	538	427	449	435	495	664	718	592	721
	%	0%	0%	3%	3%	3%	3%	3%	4%	4%	4%	5%
4. Other	kWh	438	423	1179	1141	1453	992	1119	1573	1536	1423	1481
	%	3%	3%	7%	7%	9%	6%	7%	9%	9%	10%	10%
5. Public sector	kWh	426	410	478	480	420	308	360	422	410	457	556
	%	3%	3%	3%	3%	3%	2%	2%	3%	3%	3%	4%
TOTAL	kWh	**15084**	**15652**	**17255**	**16102**	**16219**	**16216**	**16303**	**16559**	**16241**	**14412**	**15515**

(GOT, 2011; Barqi Tojik, 2016d)

The share of pumping irrigation is higher during the summer months and varies annually depending on climatic conditions (ADB, 2011). In Figure 6, the mean monthly electricity consumption in agriculture is estimated for the period 2012-2016 as part of the total energy produced.

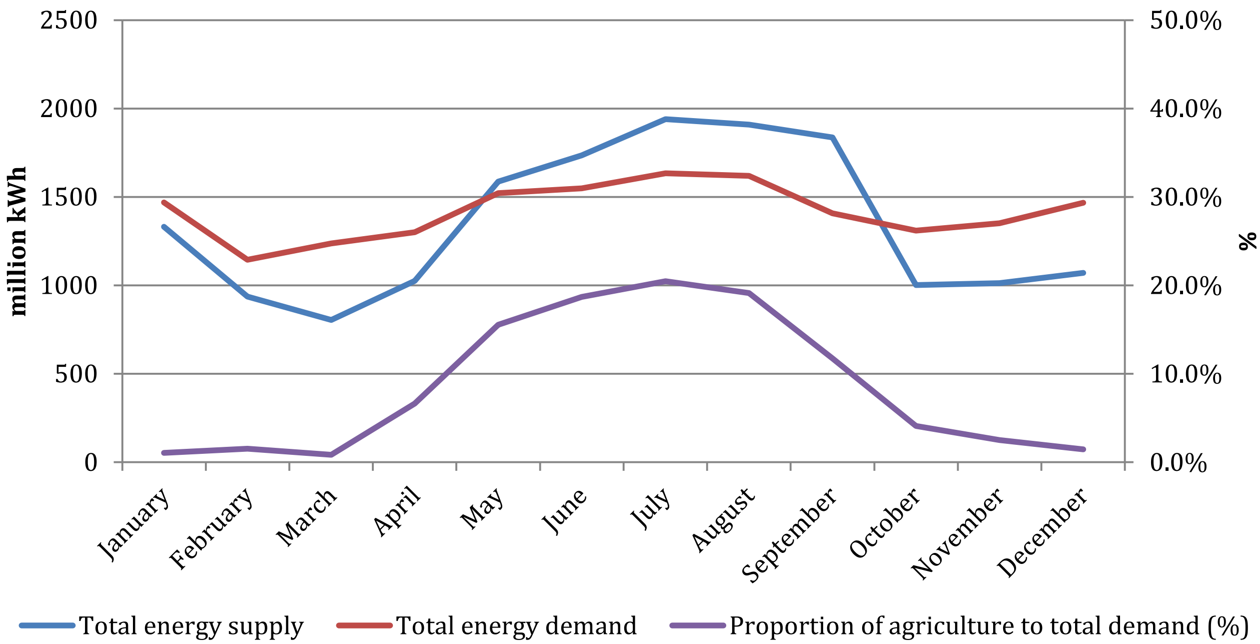

Figure 6. Mean monthly agricultural electricity consumption for the period 2012-2016 in million kWh (World Bank, 2017)

As shown in Figure 6, agricultural energy consumption accounts for about only 1% of the national energy supply in winter but in summer months this increases to 20.5%. The increased summer demand is supplied by the excessive summer hydropower production. However, the summer energy surplus (when hydropower generation rises above energy consumption between May to September), can be significantly reduced by the higher share of agricultural consumption. As a result, the energy export opportunities described in previous chapters, maybe mitigated due to the need of water supply in agricultural sector.

Restrictions on the reliability of irrigation energy supply strongly affect agricultural production and further increase the inefficient use of energy, which adversely affects the country's food security. Due to the deterioration of the power system connecting the HPPs to the pump-compressor stations, there is a power outage without warning, which causes pump damage to many pumps that do not work. These interruptions create serious problems when working with pumping station operators as well as with farmers and have a significant impact on the production of their crops.

Photo 4: The gates on Lower Kostakoz canal in the B. Ghafurov district (Photo: Daler Domullodzhanov, 2016)

According to the Energy Charter Secretariat, the average annual loss of agricultural products caused by energy supply limitations was estimated at 30% per year (Energy Charter Secretariat, 2013).

Indicatively, in 2011 the potential electricity consumption to be saved, summing up the potential of newer machinery, efficient water use and introduction better crop patterns, was at least 50% of the current electricity consumption in agriculture (ADB, 2011).

2.5 Agricultural energy tariffs

The electricity for the agricultural sector is provided with subsidized rate to the farmers. The subsidization rate may vary between agricultural activities depending on the use as presented in Table 8. For instance, the tariff for pumping systems is still distinctively lower than for all other sectors. It should be mentioned that there is tariff differentiation on pumping systems between winter and summer period in order to limit electricity consumption in winter when power shortages are present. In practice, the tariff on pumping irrigation for 2016 was 0.0028 US$/kWh for the period 1 April-30 September while in winter period (1 October-31st March) was increased to 0.12 US$/kWh.

The tariffs presented in Table 8 and Figure 7, demonstrate the charges per kWh as defined by Barqi Tojik utility. As can be seen, tariffs of all types of agricultural use have fluctuated in the last decade. However, while costs for offices and farmhouses, as well as livestock farms, have been steadily increased since 2006, the costs for irrigation pumps and rural drinking water pumps still remain low. Nevertheless, according to Barqi Tojik, this price has increased again by 16.2% in 2017 according to the new tariff system approved until 2020 (see Section 1.5).

Table 8. Electricity tariffs to the agricultural sector 2006-2016 (cents US$ and diram TJS per kWh)[iv]

		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Offices and farmhouses	**USD**	0.0018	0.0162	0.0288	0.0367	0.0484	0.0058	0.0620	0.0647	0.0673	0.0583	0.0461
	TJS	0.6	5.58	9.87	15.26	21.2	2.68	29.51	30.81	33.27	36.11	36.2
Livestock farming	**USD**	0.0081	0.0114	0.0237	0.0356	0.0486	0.0544	0.0616	0.0659	0.0679	0.0583	0.0461
	TJS	2.66	3.91	8.12	14.8	21.29	25.12	29.33	31.41	33.59	36.11	36.15
Irrigation pumping	**USD**	0.0016	0.0023	0.0083	0.0082	0.0040	0.0040	0.0048	0.0048	0.0046	0.0054	0.0030
	TJS	0.54	0.8	2.84	3.42	1.75	1.87	2.31	2.29	2.25	3.33	2.34
Drinking water pumping	**USD**	0.0020	0.0028	0.0081	0.0082	0.0059	0.0064	0.0067	0.0071	0.0063	0.0038	0.0041
	TJS	0.65	0.95	2.77	3.43	2.58	2.96	3.19	3.4	3.1	2.38	3.19

(Barqi Tojik, 2016e)

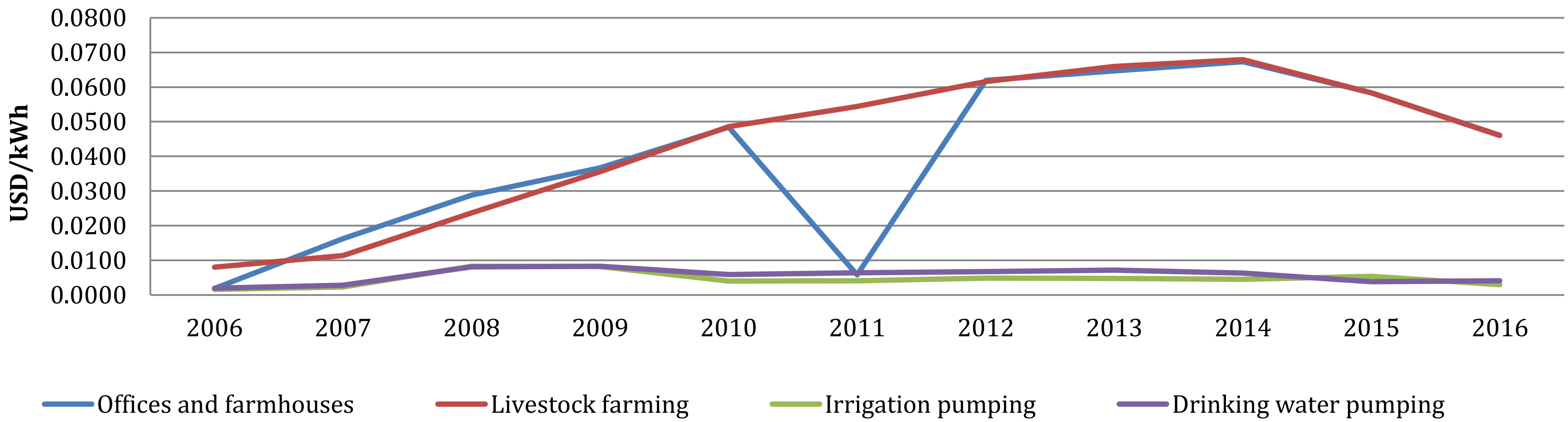

Figure 7. Agricultural tariffs 2006-2016 (USD per kWh)

However, some problems have arisen within the current tariff system. Many farmers claim that these tariffs do not mirror the actual costs paid by their side for the water supply services. The farmers are initially requested to pay Irrigation Service Fees (ISF) for the water supplied to the plots by WUA. The ISF encompass the costs associated with the water provision from the main canal or pumping stations to farms within on-farm irrigation system. The ISF is paid by farmers through collection in their respective WUA to cover operational cost and reparation expenditures of on-farm irrigation and drainage system.

Photo 5: Irrigation canal near Voce' in the Khatlon region (Photo: Ronan Shenhav, 2016)

Table 9. Water abstraction costs per m³ in all region of Tajikistan[v]

Regions	Prime cost of extraction for one cubic meter (Dirams/ m³)	Prime cost of extraction for one cubic meter (USD/ m³)
Kurgan-Tube	3.15	0.0040
Kulob	9.93	0.0127
Khatlon	6.55	0.0083
DRS	9.38	0.0119
Sughd	6.45	0.0082
Averagely in national level	7.09	0.0090

(ALRI, 2016)

Chapter 3. Water User Associations: emergence and capacity

3.1 Introduction of WUAs to Central Asia and Tajikistan

The need to effectively manage water systems in Central Asia led to the introduction of Water User Associations (WUAs) in the late 1990s and early 2000s (Abdullaev et al. 2006; 2008). In all Central Asian countries, WUAs have been established through top-down approaches. Various international organizations supported the introduction of WUAs by aiming at improving the efficiency of agricultural water use and underpinning agricultural reforms. WUAs were introduced as non-profit organizations operated by a group of water users who withdraw their irrigational water from an area covered by one or more distributary canals. Water users include ordinary cultivators of land, individual members of lease-holding farms, cooperatives, owners of private land and owners of home garden plots.

The first WUAs in Central Asia were established in Kyrgyzstan in the mid-1990s. This was a pilot project initiated by the Asian Development Bank, World Bank, UN Food and Agricultural Organization (FAO) and the government of Japan. According to the 1997 Statute on Water Users Associations in Rural Areas of Kyrgyzstan, existing on-farm water infrastructures were transferred to WUAs. Associations were granted the right to trade water, define fees and impose sanctions in case of a breach of regulations. The Water Code stipulated that the bulk of water suppliers should enter into agreements with WUAs and could not provide water directly to individuals without negotiating with the respective WUA. Similar provisions were included in Uzbekistan with the Decree of the Uzbekistan Cabinet of Ministers of July 21, 2003. The Decree changed water management from an administrative and territorial system to a basin approach and consolidated water management through the establishment of WUAs (Wegerich, 2000).

The governments have issued decrees on formation of WUAs that resulted in the establishment of thousands of WUAs within a very short time. However, most of them existed only in theory but in practice they did not have a proper functional and administrative role (Zavgordnyaya, 2006; Wegerich, 2006). Although Central Asian states, including Tajikistan, have taken active steps for the initial establishment of WUAs, there was insufficient support for its further development into full-fledged organizations. At present, many WUAs in Tajikistan are not able to mobilize both in-kind and cash contributions, and face difficulties on managing water within their boundaries. They suffer from weak governance structures mostly attributed to the top down approaches applied for the establishment of these entities.

The introduction of WUAs in Tajikistan started in the 1990s following the implementation of the first phase of Land Reforms in 1998-2000 through the support of different non-governmental organizations (NGOs) and projects. One of the main purposes was to operate, maintain and use on-farm irrigation systems through adequate and reliable water supply. The Regulation of the Government of Tajikistan #281 from June 25, 1996, on “Assertion of Regulation on order of fee collection for water delivery service to water users from state water management systems” was decreed for this purpose (Rahmatilloev, 2002). WUAs were responsible to ensure the optimal operation of the water sources within its jurisdiction for the benefit of the members. A WUA should exercise fair, effective, and timely distribution of water between farms, collect payments for the water supply and settle disputes related to the distribution and use of water.

It should be underlined that the on-farm irrigation and drainage networks of some former collective (Sovkhoz/Kolkhoz) farms were not transferred to the State (ALRI) but remained property of the farm. Following the restructuring of the collective farms, they were planned to be transferred to ALRI, but due to lack of financial means for operation and maintenance these assets could not be transferred. Similar to other former Soviet countries such systems were assigned to local or regional authorities but with no clear legal basis. In practice, they remained under the full management of the former collective farm members.

In 1999, specialists of the National Center for Farms Privatization Support project (NSFPSP), financed by the World Bank together with specialists from the Ministry of Land Reclamation and Water Management, developed an exemplary WUA Charter, which was reviewed and approved by the Government of Tajikistan (GOT, 1999). To speed up the process of establishing WUAs in Tajikistan, the government requested the Ministry of Land Reclamation and Water Resources to disseminate the Model of WUA Charter on the areas of the country. A joint decree (№ 86/34) was issued "On approval of the Model of the WUA Charter” by the Ministry of Land Reclamation and Water Resources of the Republic of Tajikistan and the Ministry of Agriculture of the Republic of Tajikistan in April 20, 2000 (GOT, 2000).

Experts from the NSFPSP have focused on the legislative context to authorize WUAs’ existence in the country. The experience of the WB, ADB, USAID, EU and UN financed projects in Central Asia and were used in the preparation of the WUA Law. The “Water Users Association” Law was eventually adopted on November 8, 2006 and laid the foundation for establishment, operation and management of WUAs as “non-commercial organizations providing services for operation & maintenance of irrigation systems for the benefit of water users” (GOT, 2006a). By the end of 2015 around 409 WUAs have been established with total service area of 380,425 ha, including 48,725 ha of house gardens and involvement of nearly 51,000 private (dehkan) Farms. The WUAs were supported by local and central governments, local communities and NGOs through a series of projects on water resource management. Some of the milestone projects where the following:

- World Bank on Private Farms Privatization (1999 - 2008)
- Asian Development Bank (ADB) Irrigation Rehabilitation Project (2005 – 2011)
- GTZ on Sustainable Water Use and Management (2003 – 2008)
- U.S. Agency for International Development (USAID) on WUA Support Program (2004-2010), Family Farming Program for Tajikistan (2010-2015) and the Feed the Future Tajikistan Agriculture and Water Activity (2015-2018)
- Swiss Development Cooperation (SDC) on IWRM in Fergana Valley (2001-2010) (IWRM-FV)
- European Bank for Reconstruction Development (EBRD) on Southern Tajikistan Water Rehabilitation Project (2010 – 2011) (WUASP).

3.2 Administrative profile of WUAs in Tajikistan

Water User Associations (WUAs) in Tajikistan are the only entities to be responsible for the maintenance and operation of irrigation and other water supply systems on the local level. The legal basis for WUA operation in Tajikistan is ensured by the following laws, codes and regulations:

- Regulation of Government of Tajikistan #281 on "Assertion of Regulation on order of fee collection for water delivery service to water users from state water management systems" – which dictates the economic relationships between water management organizations and water users. This regulation portrays Antimonopoly Service as the main regulatory agency to supervise the tariff systems of different sectors in Tajikistan (GOT, 1996b).
- The "Civil Code" of Republic of Tajikistan – which supervises the creation of non-governmental public organizations. Customarily, WUAs are acknowledged as public organizations created in the framework of this code (GOT, 1999).
- The "Water Code" of the Republic of Tajikistan – which regulates water relations in order to ensure rational use of water for the needs of the population, protection from pollution, set up of proactive measures for efficient water use, protecting the rights of individuals on equal water use. The law expanded the legal basis of creation of WUA, the regulatory relationships among ALRI and WUAs and formally recognized WUAs as the main entity to handle water supply services in local level (GOT, 2000).
- The "Water Users Association" #387 Law of the Republic of Tajikistan consists of the legal basis of formation, operation and management of WUAs as non-commercial organizations with the aim of operation and maintenance of irrigation systems for serving to meet the social interests (GOT, 2006a).
- The new law of Land reclamation and Irrigation is under preparation – to stipulate the relationships of the main stakeholders, users and ensure proper irrigation water usage and land reclamation policies.

Based on the request of the Government of the Republic of Tajikistan the World Bank has recently (2016) financed a project on reviewing the existent the Water Code and the Law on WUAs are in line with integrated water resources management and river basin management approaches. The drafted updated options of both documents have been submitted to MEWR and ALRI for feedback and comments and are under discussion (GOT, 2016b).

According to the existent WUA law the Association have the following rights:

- Sign contracts with state water management departments and water users;
- Acquire the necessary funds for the timely preparation of irrigation schedules;
- Collect Irrigation Services Fee (ISF) and other prescribed payments;
- Construct canals, drains and roads when necessary;
- Import goods and properties needed to implement its activities;
- Enroll in the Federation of WUAs which operates in accordance with the approved articles of association;
- Carry out other activities that do not contradict the legislation of the Republic of Tajikistan (GOT, 2006).

The WUA duties include:

- Maintaining irrigation facilities and, if necessary, build new assets;
- Ensure fair distribution and control of water in accordance with the national agronomic and reclamation standards;
- Take measures to protect the natural environment, prevent salinity and water logging;
- Pay attention to the opinions and suggestions of its members;
- Deliver ISF to ALRI in accordance to the amount of water supplied;
- Resolve disputes and conflicts arising between members on water use issues;
- Improve water supply and land reclamation in its service area.

The organizational structure of WUAs reflects the governance and management aspects of the entity (Rahmatilloev, Kamoliddinov, & Azizov, 2001). Specific responsibilities and duties are defined in such a manner to ensure that all activities, particularly financial, are conducted transparently and are available to all members. The diagram below shows the organizational structure used in Tajikistan.

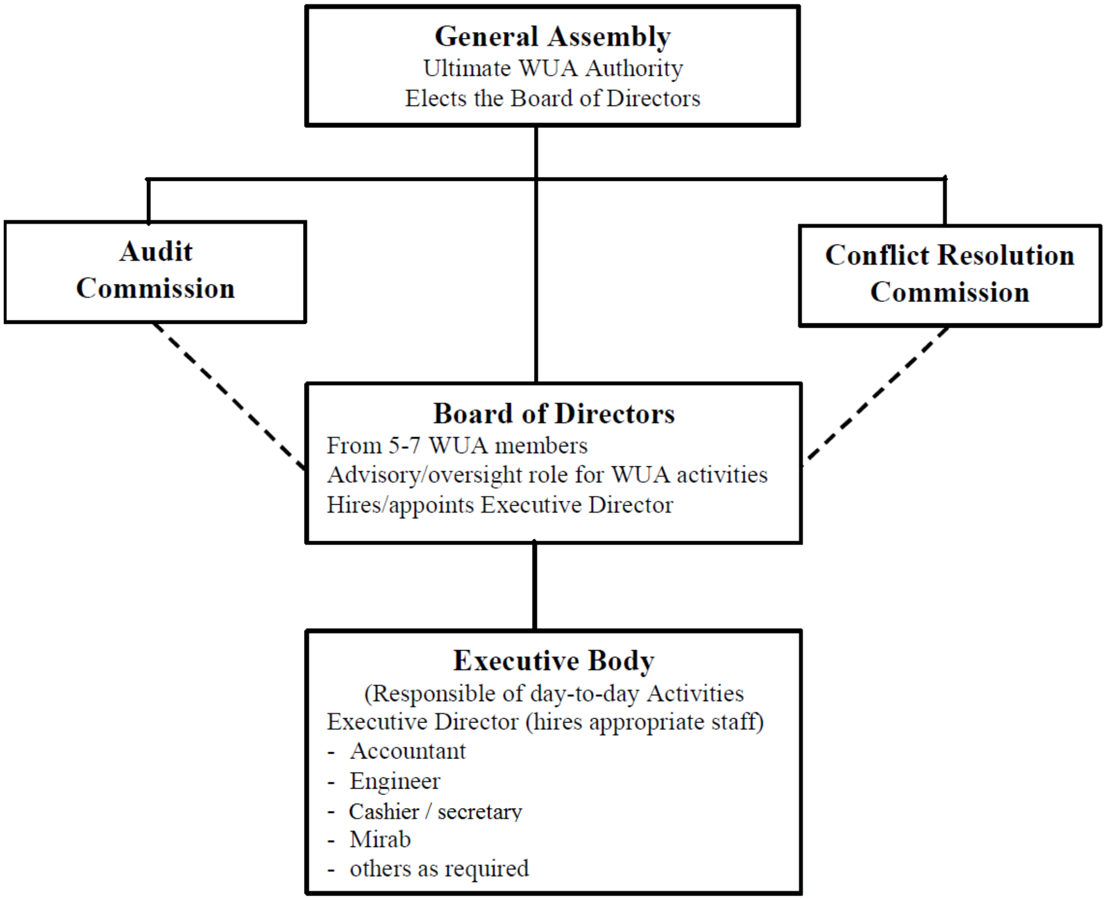

Figure 2. Organizational structure of WUAs in Tajikistan (IWRM-FV & WUASP, 2009)

The General Assembly is the supreme governing body of WUAs that is supervising the following:

- Adoption and amendment of articles of the WUA Charter;
- Admission and expulsion of members of the WUA;
- Determination of the procedures of voting and election of members of Board of Directors (BoD), chairman of the WUA, members of the Audit Commission and the Conflict Resolution Commission;
- Approval of the BoD's, the Audit Commission's and the Conflict Resolution Commission's decisions;
- Definition of membership fees;
- Establishment of wages to employees of the WUA;
- Approval of Annual Plans and Budgets of the WUA;
- Organization of the WUA's management structure and termination of its powers;
- Approval of the annual report and balance sheet of the WUA;
- Consideration and adoption of the report of the BoD, the Commissions and Committees of the WUA;

- Adoption and approval of the regulations, instructions and internal rules of the WUA;
- Establishment of Representatives Meetings;
- Decisions on the establishment and liquidation of WUAs.

According to the existent WUA Law the General Assembly needs a minimum of two-thirds of the WUA members to take decisions while each member shall have one vote. The procedure of convening and holding regular and extraordinary meetings of General Assembly is determined by the WUA Charter.

The Board of Directors (BoD) shall implement day-to-day management of the WUA. The BoD Chairman as well the members are elected by the General Assembly. BoD meetings are held in accordance with the Charter of WUA. The Chairman of the BoD has the following authorities:

- Acts on behalf of WUA without power of attorney;
- Chairing in the General Assembly;
- Manages the property of the WUAs and on behalf of issues powers of attorney;
- Opens accounts in banks and other credit institutions;
- Sign the decisions of the BoD;
- Upon the decision the BoD can hire and dismiss employees;
- Issue orders within the limits of its powers;
- Establish a Conflict Resolution Commission if necessary.

The Conflict Resolution Commission appointed by BoD is responsible to resolve disputes arising between members of the WUA and other water users in the distribution and use of water. If the Commission cannot resolve the dispute, then their case will be brought to court. To control the financial and economic activity of the WUA, the General Assembly elects the Audit Committee consisting of at least three people. The Audit Committee checks the financial states of the WUA based on results of the fiscal year (USAID, 2010).

The relation between WUA and water users is formulated through the signing of a contractual agreement on water supply services. The agreement stipulates the responsibilities of both the member and WUA, requested amount of water volume, renting of services and penalties in case of not implementing responsibilities of both sides.

3.3 WUAs and financial mechanisms

WUAs have a set of options to generate income and acquire property such as membership fees, getting dividends from bank deposits, receiving charity from legal entities and individuals and other sources. The membership fee is supposed to be the major source of income for a WUA to sustain its operation. However, in practice, the membership fee can cover the operational expenditures of WUAs only to a limited extent.

In addition to the membership fee, an irrigation service fee (ISF) is collected to compensate for the volume of water provided to each member. The ISF is based on the amount of delivered water and is measured with water meters. If no water measuring facilities are available, then fixed rated are rates are set according to the type of crop cultivated per ha which are supervised by the Antimonopoly Agency.

The payment realization procedure follows a complicated order for the avoidance of double taxation hindrances. In particular, the ISF charges are coming with an additional Value Added Tax (VAT) which is delivered to the central government. However, there is another payment for the sustenance of main canals and pumping stations as mentioned already. For the avoidance of additional VAT in this payment, the farmers are paying ISF together with this amount in one order. It is nevertheless clear that the amount paid by farmers corresponds to two different agencies (WUAs and regional ALRI offices).

Water Users Associations have no right to sell or rent fixed assets to other organizations. In the case of liquidation of the WUA, the reserves and any other belongings return to its members. The budget of WUAs covers the salaries of hired workers, repairing of irrigation systems and land reclamation, payment of taxes and unplanned expenses in the command areas. It is noted that WUAs as a non-commercial organizations attribute taxes as stipulated by the Tax Code of the Republic of Tajikistan (GOT, 2012b). An indicative breakdown of a WUA's annual operational expense is presented in Table 10 below:

Table 1. Calculation of Annual Operational Costs

#	List of expenses	Unit	Quantity
1.	Annual wage of workers	US$	
	Social tax 25%	US$	
	Total:	US$	
2.	Used electricity for irrigation and land reclamation	kWh	
	Used electricity for WUA Office	kWh	
	Expenditures for used electricity for irrigation and land reclamation	US$	
	Expenditures for used electricity for WUA Office	US$	
3.	POL (petroleum, oil, lubricants)	US$	
4.	Stationary	US$	
5.	Expenses for the maintenance of administrative building or renting	US$	
6.	Communication cost	US$	
7.	Utilities	US$	
	Total:	**US$**	

(Rahmatilloev & Salihbaeva, 2014)

It is important to note that the electricity costs used for the operation of pump stations and other purposes are calculated separately. As a rule of thumb, WUAs use electricity for two purposes: to supply offices (light, heating) and to operate irrigation or drainage pumps. If a WUA has a vehicle or excavator under its balance sheet, the cost of petroleum, oil and lubricants is estimated accordingly as presented in Annex 1.

To identify the volume of technical maintenance works and the relevant expenditures, the BoD assigns a Technical Commission from experienced and knowledgeable members. The Commission screens all the irrigation and drainage facilities and develops a Defect Log report as presented in Annex 2 (Akramov, Rahmatilloev& Salihbaeva, 2012). The annual expenditures for technical maintenance of the WUA's command area encompass the removal of sediments from canals and drainage systems and the operation of hydro-technical structures.

3.4 Technical capacity of WUAs

Each WUA has to develop an annual plan of the command area and the crops to be irrigated under its jurisdiction. This plan encompasses a monthly water service schedule based on the requests of each member. For the identification of the total irrigated area of each member, the following data needs to be collected and filled in as presented in Table 11:

Table 2. Irrigation plan for each member in WUA

Primary/Secondary Canal	Farm	Hydromodule zone	Irrigated Crops		Irrigation in non-cultivated period	
			First crop	Second crop	Washing	Prior to sowing
Total:						

Notes: Hydromodule zone: The average water consumption per hectare for a certain period by calculating the relevant case-specific parameters (e.g. evapotranspiration, root zone etc.); Washing: The amount of water use to wash away the soil salinity; Prior to sowing: watering just before planting of seeds to bring soil humidity to the optimal level for plant development.

(Akramov, Rahmatilloev, & Salihbaeva, 2012)

In turn, each WUA shall estimate the water use to be delivered in each farm based on the efficiency or the potential water loss from water source until the farm. The efficiency rate is calculated through different parameters like the irrigation technique, the canal type, the evaporation volume, the seepage into the soil deep layers, among others. Table 12 presents the template used by WUAs for the estimation of the efficiency rate on a farm level:

Table 3. Efficiency rate of irrigation services on farm level

#	Crops	Irrigated area (ha)	Efficiency Rate		Water required(m³/ha)		Irrigation volume (m³)
			Irrigation Technique	On-farm canals	Net	Gross	
1	Cotton						
2	Cereals						
3	Vegetables						
4	Melons						
5	Potato						
6	Alfa-alfa						
7	Rice						
8	Others (added)						
Total:							

(Akramov, Rahmatilloev, & Salihbaeva, 2012)

The annual net irrigation water requirements per farm shall be made on the basis of the already prepared irrigation schedules for each crop while some coefficients shall be introduced. Once the irrigation volume to be appointed for each crop is arranged, a schedule of the water delivery dates is prepared as presented in Table 13 below:

Table 4. Calendar plan of the irrigation request on a farm level

#	List irrigation objects	Irr.area, (ha)	Indicators	January			February			Added months		
				1	2	3	1	2	3	1	2	3
1	Total irrigated volume		ω, ha									
			Q, L/sec									
1.1	Total irrigation of crops:		ω, ha									
			Q, L/sec									
1.2	Each Crop (e.g cotton)		ω, ha									
			Q, L/sec									
1.3	Winter watering		ω, ha									
			Q, L/sec									
1.4	Prior to planting second crop		ω, ha									
			Q, L/sec									
1.5	Washing		ω, ha									
			Q, L/sec									
1.6	Other uses (e.g.livestock)		ω, ha									
			Q, L/sec									

Explanatory Notes: Irr. area (ha)= Irrigated area; Winter watering=watering of land in winter months mainly for the prevention of pests and plant diseases. Through the winter watering the top soil is frozen by eliminating the spread of pests; Prior to sowing= watering just before planting of seeds to bring soil humidity to the optimal level for plant development; ω, ha= Is the irrigation volume needed on hectare basis; L/sec= is the requested flow needed in liters per second. (Akramov, Rahmatilloev, & Salihbaeva, 2012)

Unfortunately, in many cases the limited capacity of the WUA's technical staff and the lack of water measuring facilities restrict the even realization of the above tasks as it will be presented in the following chapter.

Chapter 4. Challenges and interventions in WUAs and irrigation

4.1 Challenges in irrigation systems of Tajikistan

In 2015, 409 WUAs have been established with a total service area of 380,425 ha, including 48,725 ha of kitchen gardens and the participation of nearly 51,000 private (dehkan) farms. The irrigated land with pumping infrastructure covered by WUAs is estimated at around 280,850 ha. Undoubtedly, many positive changes have been achieved within the last decades for the improvement of WUAs' performance in Tajikistan. Many projects are currently being implemented to rehabilitate water infrastructure while numerous trainings for WUA personnel are realized. However, WUAs still face major legal, management, operational and budget constraints which threaten their existence. We may synopsize the current hindrances in two major groups: the institutional and socio-economic constraints on one hand (Table 14) and the technical on the other (Table 15).

Table 5. Institutional and Socio-Economic problems

Problem	Engaged Partners	Level	Explanatory Note
Outdated legislation	MEWR, ALRI	National	In context of the Water Sector Reforms, the existent legislation on WUAs does fully reflect their increased responsibilities to maintain and operate irrigation systems and to collect fees
Weak coordination	ALRI, Regional authority, WUA	Regional, National	There is lacking of coordination between ALRI, the regional authorities and WUAs, resulting in over- or underpricing, limited maintenance and a diffusion of responsibilities
Two fees for water services	Regional ALRI, WUA	Regional, National	The attribution of double fees to the regional ALRI and WUAs provokes protest by farmers
No tier tariff system	ALRI, Antimonopoly Agency, WUA	National, Local	There is lack of a multiple tier tariff system where tariff rates are increased proportionally with consumption preventing large water abstractions
Fees evasion	WUA	Local	There is not yet strong legal framework to

			penalize WUA members when evading fees
Not clear WUA boundaries	WUA	Local	There is unclear land demarcation of WUA areas and many illegal activities are overlooked like water abstraction, sand extraction, etc.
Few farmers in WUAs	WUA	Local	The non-compulsory inclusion of all farmers in WUAs allows free-riders in water supply

Respectively, the technical and administrative problems are shown in Table 15:

Table 6. Technical and Administrative problems

Problem	Engaged Partners	Level	Explanatory Note
Aged and Damaged Assets	ALRI HQ Regional ALRI, WUA	National, Regional, Local	Most of the facilities are old with poor maintenance and operational performance
Poor flood protection	ALRI, WUA	National, Local	There is inefficient flooding protection in most of the agricultural land
Aged drainage systems	ALRI, WUA	National, Local	The drainage canals are mostly damaged resulting in water-logging, salinization, etc.
Lack of inventory	ALRI, Regional Authorities, WUA	Regional, National	There is no inventory on the irrigation and drainage assets and facilities in the country
Lack of water metering	WUA	Local	Many water meters are damaged or absent and volumes are estimated imprecisely
Frequent power cuts	Barqi Tojik, WUA	National, Local	There are frequent and unscheduled power cuts that severely reduce water supply
Water - demanding crops and poor patterns	Ministry of Agriculture, WUA, Farmers	National, Local	Farmers grow water demanding crops and/or the cropping patterns that do not support water savings
Weak knowledge capacity of WUA	WUA	Local	WUA personnel have limited knowledge capacity to estimate major issues like water distribution plans, calculation of crop water requirements etc.

4.2 Interventions for improving irrigation systems in Tajikistan

As mentioned in the previous chapters, there is a need to structurally reform irrigation and drainage systems in Tajikistan in order to sustain the agricultural sector. The improvement of "hard components" dealing with the restoration and repair of machinery and infrastructure is a huge undertaking demanding vast funding reserves. However, the development of "soft components" dealing with managerial and administrative aspects may also offer significant improvements with low or no-cost implications.

A recent study conducted by the World Bank has tested different institutional measures for energy savings and cost recovery in pumped irrigation such as better technical capacity of WUA personnel, improved collection of ISF and better collaboration between state agencies. Different combinations of the institutional interventions could improve 5-15% of the efficiency rate of water pumping by attributing different cost savings in each case (World Bank, 2017).

Three scenarios were developed on which the energy saved and the costs recovered from the institutional measures could be diverted to different purposes. The first scenario assumed the increase of the irrigated volume, the second the expansion of the irrigated areas and the third the release of energy savings for export purposes. In effect, while the first and second scenarios were investing the energy savings and the recovered costs on more irrigation volume and land expansion, the third one was investing in lucrative energy trading. The revenues raised from the energy trading in the third scenario were in turn returned to the agricultural sector for the rehabilitation of the most deficient assets. The rehabilitation could substantially improve the irrigation and drainage in the country and reduce the operational and maintenance expenditures. Indicatively, by reallocating the revenues from exporting 5-15% of the agricultural energy consumption that is saved, the study has deduced that the third scenario could decrease irrigation and drainage costs in Tajikistan from US$31.09 million to US$11.70 million (62%) on an annual basis (World Bank, 2017). The World Bank suggests a limited amount of methods to achieve these energy savings.

In our study, we acknowledge that the Water User Association is the main institutional body at on-farm irrigation system that can well influence the effectiveness of water delivery in the field. To this end we suggest different interventions by mainly focusing on institutional and socio-economic aspects or else the ''soft components'' that could improve the performance of WUAs and promote energy savings.

It is noted that the detailed data collection on the exact energy savings to be recovered through the introduction of different interventions was beyond the capacity of this study. We however argue on imminent restructuring of WUAs in Tajikistan as a prerequisite for the sustainability of the agricultural sector in the country. By assessing the institutional and socio-economic interventions, it can be noticed that many state initiatives are already moving toward this direction. In particular, in 2016 the MEWR has already started developing a draft of new Water Code and WUA Law within the Water Sector Reform framework.

The new legislative components will address the need of WUAs to administer its area in alignment with a river basin approach. The improved coordination between ALRI, regional authorities and WUAs is also dictated in the new legislation by also adding the RBOs as a main coordinator of water management on a basin level. In effect, the RBOs will supervise the proper performance of all water facilities on each basin and hence a close cooperation with WUAs is foreseen.

Photo 6: The water regulating facilities on Khodjabakirgan canal in B. Ghafurov district (Photo: Daler Domullodzhanov, 2016)

We further underline the need to enhance the capacity of WUAs to sustainably administer main assets like pumping stations, canals, drainage systems etc., in on-farm irrigation system and ensure proper operation and maintenance of all infrastructure within their boundaries. The transition from a centralized (ALRI) to decentralized management status (WUAs) should be cautiously arranged. Care should be given on the preparedness of WUA to manage and maintain infrastructural facilities (e.g. pumps, canals, gates etc.) currently managed by ALRI. Most of the WUAs are nowadays lacking the economic and technical capacity to maintain major irrigation assets as well to be endowed with the management of new hardware equipment (e.g. excavators). The notion of WUA federations proposed by different water management projects seems to require some further refining and readiness from local WUAs to get into effect. More emphasis should be probably given on the administrative duties between local and regional irrigation authorities as well the future role of RBO on the facilitation of these administrative entities.

The transition aspect is also related with the demarcation of WUA boundaries and the avoidance of free-riders in its territory. Once all the facilities and assets will be undertaken by WUAs the command areas to supervise will be expanded. The WUAs shall be clearly authorized to control and intervene in any situation that might disturb its function. The farmlands located within the boundaries of WUAs shall be compulsory provided water by the association while the farmers shall become members to avoid free-riding cases.

The current economic weakness of WUAs to improve cost recovery from ISF and convince its members to pay annual fees is also interlinked with the transition aspect. Most of the farmers complain about the dual fees to be paid in regional ALRIs and WUAs and the poor services offered (Abdullaev et al. 2010). A unified fee should be established for all water supply services to the farmers based on the actual costs incurred for the delivery duties and the operation of drainage systems.

A two or multi-tier tariff system should be also introduced to restrain farmers from overconsumption practices. As already established in many WUAs in Europe and US, farmers are asked to pay a higher price per cubic meter if they consume above a certain amount of water volume. The pricing may be divided in two (two-tier) or multiple levels depending on the structural schedule of the tariff system. The technical capacity building of WUAs can play a significant role in the cost minimization of reparation works in canals and drainages networks.

The technical and administrative interventions to be adopted by WUAs could be initially spotted on the knowledge enhancement of WUA personnel of various aspects. There are already a number of courses and trainings organized by various donors in cooperation with state agencies on the capacity building of WUAs in the country. Indicatively, a noticeable effort has been conducted by the Feed for Future Programme funded by USAID which was partly implemented by Chemonics, an organization focusing on increasing capacity of WUAs in South Tajikistan (Chemonics, 2016). The capacity increase is sought through institutional and technical trainings. The institutional trainings are based on the creation of community organized methods on water resources management; organizational and leadership development; conflict management and WUA Financial Management and audit procedures for WUAs. The technical trainings are focused on water use planning for agricultural and general water distribution concepts; irrigation water record keeping; operation and maintenance (O&M) of farm-irrigation and drainage systems and methods of cleaning drainage and collector systems of the WUAs. Such initiatives could help improving water use efficiency by encouraging energy savings and costs recovery in pumping irrigation. The trainings could also well introduce agronomic courses for the introduction of more water-resistant crops and better cropping patterns to enhance water savings and subsequently less energy usage. To ensure proper operation of the on-farm water system, delivery of service oriented management and increasing water use efficiency preparation of young specialists with higher education is very important.

The installation of water meter devices and small reservoirs have been already prioritized as relatively low-costs interventions to substantially improve water savings on farm level. Indicatively, agricultural electricity consumption in farmhouses, workshops and lighting has been declined after 2006 when electricity metering was introduced. Although the water volume decrease in irrigation may not be of similar scale, however, the accurate measuring of the water consumed is anticipated to offer more savings on water consumption.

The uninterrupted provision of energy supply in irrigation cannot be easily resolved in the short run. However, as proposed by the World Bank study on the cost recovery of pumped irrigation (2017), the construction of buffer reservoirs could mitigate the problem. In practice, the reservoirs may be constructed next to the pumping discharge points and filled in when the pumps operate. They shall be on slightly higher elevation than the farmlands so that the water can flow with gravitational force to the plots. When power cuts occur, WUAs can release the reserved water, distribute according to the allocation plan and refill reservoirs once electricity recovers.

The above interventions are some of the low or no-costs measures to be gradually adopted by WUAs nationwide. The water and energy savings to be earned by each intervention is yet hard to define due to poor and outdated data and contradictory information from different agencies. However, the current study has attempted to point out opportunities of rehabilitating pumping irrigation and agriculture in Tajikistan by also improving the energy balance in the country.

A recent study prepared for PAMP II project on the ''Institutional Strengthening for Integrated Water Resources Management'' in Tajik Ferghana Valley has accentuated similar interventions (PAMP II, 2017). In particular, the study has also recommended that the irrigation service shall correspond to the beneficiaries' (farmers) needs through rehabilitation of water supply services and trainings. Attention was also given on the full reflection of the actual costs in the Irrigation Service Fee (ISF) and noted that only then WUAs shall be able to operate and maintain farm and inter-farm infrastructures in a sustainable manner. When WUAs are well established with economic and technical capacity then the facilities and premises (e.g. pumps, canals) currently managed by ALRI could be gradually handed over to WUAs or federation schemes that could represent many WUAs in one region. The report highlighted the need for a river basin management principle in consultation with RBOs as we have also mentioned above.

Concluding remarks

Tajikistan is rich in water resources and has a large potential for hydropower development. In recent decades, energy consumption has changed to less energy being used by industry, more consumption by urbanization and with a stable or slightly decreasing agricultural energy demand. In this study, we made an effort to identify the agricultural water management and related energy consumption in Tajikistan, a country in transition with changing energy consumption. In Tajikistan, agriculture consume 10 % of the total energy consumed on annual basis and 20 % in the summer. Energy export from Tajikistan is a promising and secure manner to generate high revenues in a relatively short-term period. The energy demand from the neighboring countries to the south of Tajikistan (Afghanistan and Pakistan) is predicted to increase in the near future. Improving energy use and agricultural water management plans is essential to prepare for future decisions where the share of agricultural energy demand compared to other users might increase.

From our assessment the following preliminary recommendations were made:

- We encourage the energy trading with neighbouring countries by also recommending interventions for the improvement of agricultural water supply through WUAs on a local level.
- If the future land use changes occur with more agricultural water and energy demand,

we argue that the suggested interventions could result in considerable energy savings, providing more energy for export.

- The introduction of “soft components’’ with low or even no installation costs in WUAs could offer significant energy savings of pumping irrigation and improve agricultural water supply.

Currently many interventions are taking place Tajikistan already. For instance, presently new legislations are in process, the irrigation inventory in southern Tajikistan is near completion, network rehabilitation is taking places mainly in north and south Tajikistan while WUA trainings are being conducted all over the country. It is difficult to currently estimate the exact benefits emanating from simultaneous interventions. However, these improvements will distinctively enhance energy and economic savings in the irrigation sector.

This study presented a baseline assessment and preliminary analysis on the energy and agricultural water management perspectives in Tajikistan. Further studies are needed for more in-depth analysis of energy savings and cost recovery stemming from the suggested interventions. The challenges faced in Tajikistan on agricultural energy efficiency and WUAs herein may also provide some insight to neighboring counties.

References

Aalto J, Kämäräinen M, Shodmonov M, Rajabov N, Venalainen (2017) Features of Tajikistan's past and future climate, *International Journal of Climatology*. 37, 14, p. 4949-4961 13 p.

Abdullaev I, Hassan UI, Manthrithilake M (2006). *The Reliability Improvement in Irrigation Services: Application of Rotational Water Distribution to Tertiary Canals in Central Asia.* Tashkent: IWMI Research Report

Abdullaev I (2008) Water User Groups in Central Asia: Emerging Form of Collective Action in Irrigation Water Management. *Water Resources Management, 24*, 1030.

Abdullaev I, Kazbekov J, Manthritilake H, Jumaboev K (2010) Water user groups in Central Asia: emerging form of collective action in irrigation water management. *Water Resour Manage* 24:1030

Agency for Land Reclamation and Irrigation under the Republic of Tajikistan (2016, October 28). First Meeting of National Commission on Irrigation and Drainage Dushanbe, Tajikistan

Akhroroval A, Mukimova N, Razykov, R (2013) *The energy security of the Republic of Tajikistan*, Dushanbe, Tajikistan.

Akramov A, Rahmatilloev R, Salihbaeva G(2012). *Organization of measurement, planning and distribution of water in WUA and farms*. IWRM-FV, Dushanbe, Tajikistan

Asian Development Bank (2011). *Central Asia Regional Economic Cooperation Power Sector Master Plan.* Retrieved October 19, 2016, https://www.adb.org/projects/43549-012/main Accessed 04.10.2017

Barqi Tojik (2016a) *Electricity consumption by consumer group in 2015.* [Written communication].

—. (2016b) *Energy Sector in Tajikistan.* [Written communication].

—. (2016c) *Import and export of electricity 2005-2016.* [Written communication].

—. (2016d) *Electricity consumers by sector 2006-2016.* [Written communication].

—. (2016e) *Tariffs 2009-2016.* [Written communication].

CAWA-Regional Research Network "Water in Central Asia http://www.cawater-info.net, Accessed on 12.08.2016

Chemonics (2016) Assisting Farmers in Tajikistan, https://www.chemonics.com/projects/assisting-farmers-tajikistan/ , Accessed on 22.11.2016

Energy Charter Secretariat (2013) *In-Depth Energy Efficiency Review: Tajikistan.* http://www.energycharter.org/fileadmin/DocumentsMedia/IDEER/IDEER-Tajikistan_2013_en.pdf, Accessed on 19.10.2016

FAO- Food and Agriculture Organization (2009) *FAO Crop and Food Security Assessment Mission to Tajikistan* http://www.fao.org/docrep/012/ak339e/ak339e00.htm Accessed on 08.03.2017

—. (2012) *Irrigation in Central Asia in figures - FAO AQUASTAT Survey.* http://www.fao.org/giews/countrybrief/country.jsp?code=TJK Accessed on 08.03.2017

Hydromet (2016) Material provided by Muzaffar Shodmonov from the Tajikistan National Agency for Hydrometeorology through a contractual agreement in the year 2016 with the OSCE Office in Tajikistan

Government of Tajikistan (1996a) *Regulation of Government of Tajikistan #281 'Assertion of Regulation on order of fee collection for water delivery service to water users from state water management systems'.*

—. (1996b) *The Land Code of the Republic of Tajikistan.*

—. (1999) *Project Appraisal Document, Farm Privatization Support Project.*

—. (2000) *The Water Code of the Republic of Tajikistan.*
—. (2001) *Concept on the Rational Use and Protection of Water Resources in the Republic of Tajikistan.*
—. (2004) *Decree No. 86 'The program of economic development of the Republic of Tajikistan for the period until 2015'.*
—. (2006a) *"Water Users Association" Law of the Republic of Tajikistan # 387.*
—. (2006b) *Presidential Decree No. 1713 'Strategy for State Administrative Reform'.*
—. (2007) *Resolution 500 of the Government of Tajikistan 'Concept of Transition of the Republic of Tajikistan to Sustainable Development'.*
—. (2010) *Public Employment for Sustainable Agriculture and Water Management Project: Environmental Assessment and Generic Environmental Management Plan.*
—. (2011a) *Resolution 551 of the Government of Tajikistan 'Programme for the efficient use of hydropower resources and energy 2012-2016'.*
—. (2011b) *Order of Antimonopoly Committee under Government of Tajikistan #45 'Tariff of Service Fee in State Irrigation Systems'.*
—. (2012a) *'Agriculture Reform Programme' of the Republic of Tajikistan for 2012-2020.*
—. (2012b) *The Tax Code of the Republic of Tajikistan.*
—. (2014) *Sustainable Energy for All: Tajikistan, Rapid Assessment and Gap Analysis.*
—. (2015a) *Water Sector Reforms Programme of the Republic of Tajikistan for 2016-2025.* Dushanbe.
—. (2015b) *Order # RP-594 of the President of the Republic of Tajikistan.*
—. (2016a) *Minutes of the Fourth Meeting of the Coordination Unit for implementation of the Water Sector Reform Programme for the period 2016-2025.*
—. (2016b) *Land use data of State Committee on Land Management and Geodesy of the Republic of Tajikistan.*
IWRM-FV & WUASP (2009) *An Approach to Water User Associations in Tajikistan.* Retrieved from http://publications.iwmi.org/pdf/H042571.pdf
McCarthy O, Ahamed I, Kulaeva F, et al. (2018) A randomized controlled trial of an intervention delivered by mobile phone app instant messaging to increase the acceptability of effective contraception among young people in Tajikistan. *Reproductive Health*. 2018;15:28. doi:10.1186/s12978-018-0473-z.
PAMP II (2017) *Consulting Services for Institutional Strengthening for Integrated Water Resources Management (Package-A),* Final Report, Volume 2, Dushanbe, Tajikistan
Rahmatilloev, R. (2002). *Organizational aspects of improvement of water management at the on-farm level in the transition to a market economy in irrigated agriculture in Tajikistan,* Dushanbe, Tajikistan
Rahmatilloev R, Kamoliddinov A, Azizov N (2001) *Recommendation on formation of WUA in Tajikistan, 1st edition.* Dushanbe, Tajikistan
Rahmatilloev R, Kudratov R & Salihbaeva G (2012) *Development and introduction of WUA budget.* Dushanbe: IWRM-FV, Dushanbe, Tajikistan
Rahmatilloev R, Salihbaeva G (2014) *WUA budget preparation.* Dushanbe: IWRM-FV, Dushanbe, Tajikistan
SNC-Lavalin (2011) *Central Asia - South Asia Electricity Transmission and Trade (CASA-1000) Project Feasibility Study Update.* Retrieved October 19, 2016, from http://www.casa-1000.org/1)Techno-EconomicFeasbilityStudy_MainRep_English.pdf

Swinnen J, Van Herck K (2013). Food Security and Sociopolitical Stability in Eastern Europe and Central Asia. (C. B. Barrett, Ed.) *Food Security and Sociopolitical Stability*, Oxford Publ, UK

USAID (2010) *Report on Assessment of Water User Association Support Program (WUASP).* Retrieved from http://pdf.usaid.gov/pdf_docs/pdacx191.pdf

USAID (2014) *Tajikistan Fact Sheet.* Retrieved March 8, 2017, from https://feedthefuture.gov/sites/default/files/resource/files/ftf_factsheet_tajikistan.pdf

Wegerich K (2000) Water user associations in Uzbekistan and Kyrgyzstan: study on conditions for sustainable development. *Occasional Paper, 32*.

—. (2006). *'Illicit' water: un-accounted, but paid for: observations on rent-seeking as causes of drainage floods in the lower Amu Darya. http://www.ceres.wur.nl/ Activities/2006_Wegerich_illicit_water.pdf*

World Bank (2013) *Winter Energy Crisis: Electricity Supply and Demand Alternatives.* Retrieved September 21, 2016, from http://documents.worldbank.org/curated/en/500811468116363418/pdf/796160PUB0REPL00Box377374B00PUBLIC0.pdf

—. (2017a) *The Costs of Irrigation Inefficiency in Tajikistan* http://documents.worldbank.org/curated/en/116581486551262816/pdf/ACS21200-WP-P129682-PUBLIC-TheCostsofIrrigationInefficiencyinTajikistan.pdf Accessed on 11.03.2017

—.(2017b) *GDP per capita in Tajikistan* http://data.worldbank.org/indicator/NY.GDP.PCAP.CD?contextual=default&locations=TJ-RU, Accessed on 14.07.2017

WFP- World Food Programme. (2009) *Food Security Bulletin Tajikistan.* http://documents.wfp.org/stellent/groups/public/documents/ena/wfp208031.pdf?_ga=1.181901351.1218971891.1489280143. Accessed on 12.08.2017

Zavgordnyaya, D. (2006). *WUAs in Uzbekistan: theory and practice.* Bonn, Germany

Annex 1. Example of calculating costs of mobile assets in WUAs

Table 7. Niva Chevrolet annual operation and maintenance expenses calculation

Items	Unit	Quantity
Quantity	pcs	1
Monthly millage	km	1,100
Annual millage	km	13,200
Type and name of fuel	Petrol A92	
Norm of fuel consumption	Liter per 100 km	13
Monthly fuel usage	Liter	139
Annual fuel usage	Liter	1663
Unit cost of fuel	TJS per liter	5
Monthly cost of fuel	TJS	679
Annual cost of fuel	TJS	8150
Norm of oil consumption	Liter per 5,000 km	4
Annual oil usage	Liter	10.6
Unit cost of oil	TJS per liter	20
Annual cost of oil	TJS	221
Transportation tax	TJS	700
Totally:	**TJS**	**9,061**

(Rahmatilloev, Kudratov, & Salihbaeva, 2012)

Table 8. MTZ-80 excavator's annual operation and maintenance expenses calculation

Items	Unit	Quantity
Quantity	pcs	1
Monthly operation	hour	160
Annual operation	hour	1280
Type and name of fuel	Solar oil	
Norm of fuel consumption	Liter per hour	7.3
Monthly fuel usage	Liter	1,168
Annual fuel usage	Liter	9,344
Unit cost of fuel	TJS per liter	5
Monthly cost of fuel	TJS	5,840
Annual cost of fuel	TJS	46,720
Norm of oil consumption	Liter per 100 liter of fuel	1.3
Annual oil usage	Liter	121
Unit cost of oil	TJS per liter	10
Annual cost of oil	TJS	1,215
Transportation tax	TJS	1,000
Totally:	**TJS**	**48,935**

(Rahmatilloev & Salihbaeva, 2014)

Annex 2. Defect Log Template of Commission for WUA

____

(name of canals, facilities, equipment)

____

(date, month, year)

Type of facility	**Identified defects**	**List of reparation works**	**Unit**	**Quantity**	**Cost of unit, TJS**	**Total cost, TJS**
Totally:						
Including works implemented with WUA equipment:						
Including expenditures covered be membership fee:						

(Rahmatilloev & Salihbaeva, 2014)

Endnotes

[i] The mean exchange rate of 1 USD was 7,8496 Tajik Somoni (TJS) in 2016 according to official statistics by Deutsche Bank, https://www.bundesbank.de/Navigation/EN/Statistics/Time_series_databases/Macro_economic_time_series/its_details_value_node.html?nsc=true&https=1&https=1&https=1&https=1&tsId=BBEX3.A.TJS.USD.CA.AC.A04.

[ii] According to European Environmental Agency (2017), water stress occurs when the demand for water exceeds the available amount during a certain period or when poor quality restricts its use. Water stress causes deterioration of fresh water resources in terms of quantity (aquifer over-exploitation, dry rivers, etc.) and quality (eutrophication, organic matter pollution, saline intrusion, etc.).

[iii] According to the government of Tajikistan, in 2009 there were 1.4 million people suffering from food insecurity, including 390,000 people who were severely affected.

[iv] As calculated by average annual exchange rates in respective years: 1 USD was valued 3.302
TJK for 2006, 3.443 for 2007, 3.428 for 2008, 4.159 for 2009, 4.379 for 2010, 4.618 for 2011, 4.763 for 2102, 4.764 for 2013, 4.943 for 2014, 6.193 for 2015 and 7.849 for 2016 according to Deutsche Bank, https://www.bundesbank.de/Navigation/EN/Statistics/Time_series_databases/Macro_economic_time_series/its_details_value_node.html?nsc=true&https=1&https=1&https=1&https=1&tsId=BBEX3.A.TJS.USD.CA.AC.A04.

[v] The GBAO region is included due to limited irrigated area of the territory.