United Nations
Educational, Scientific and
Cultural Organization

Regional Centre
on Urban Water Management
(under the auspices of UNESCO)

IDI
International Drought Initiative

Water Security in Human Settlements

Best Practices and Lessons Learned in Arid and Semi-Arid Areas

Regional Centre on Urban Water Management (RCUWM)

A Contribution to UNESCO Intergovernmental Hydrological Programme (IHP)

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The Role of Education in Water Security: Case Study from Uzbekistan

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Abstract

Water security of Uzbekistan, located between two main rivers, Syrdarya and Amudarya, faces challenges of global, regional and local levels. Since 1960's through 2010, the global climate change has caused the depletion of the third part of glaciers in the upstream of the rivers. It is projected further reduction of the glacier extent in average by 50% to 2050 as compared to 2010, which may result in reducing the river flow by 20-45% during summer months (Punkari et al., 2014). The unmet water demand to 2050 may amount 50% of total demand in Amudarya River basin and 33% in Syrdarya River basin. This may be followed by significant cut off the crop production and increase of the unmet food demand. Water and energy nexus are the major challenges for developing the basin-scale water cooperation in Central Asia. While the upstream states facing shortage of fossil energy resources make steps forward developing the hydropower, the downstream states, prioritizing food crop production, try to preserve the irrigation-based basin water management. Recently, Uzbekistan, the downstream country and Tajikistan, the upstream state, made first steps forward for developing the upstream hydropower for mutual benefits and managing its potential negative consequences to the downstream crop production and the environment. At the local level, subsidizing energy and water, and conventional irrigation practices are among constrains for efficient use of available water resources. While overall irrigation application amounts are in line with crop evapotranspiration rates, the irrigation schedules do not fully coincide with crop water requirements. As the consequence, unutilized water losses recharge groundwater and form drainage flow. Increasing the productivity of available water resources is considered to be the way to meet growing water demand and the adaptation strategy to new environment.

The government, aimed to meet indicated challenges, adopted institutional changes which are as follows: water management shifted from the administrative approach to basin management; basin' administrations of irrigation systems are created considering the hydrographic boundaries; the next level is irrigation system administrations (ISA), and; then district level water administrations (DLWA) deliver water to water consumer associations. In 2017, to simplify the process of water governance, the level of the ISAs was removed and their responsibilities were transferred to DLWAs. This caused complications in water distribution in summer 2018 between the districts, and between the water consumer associations. While DLWAs have to play advisory role for farmers on water saving technologies, they did not have qualified staff to deliver the consultancy services.

At farm-level, the government adopted the program of wide scale introducing the drip irrigation. The area under drip irrigation is projected to increase from 28,000 ha in 2018 to about 500,000 ha in 3 to 5 years. The key role in shifting to drip irrigation is given to clusters, representing contractually linked cotton lint processing factories and farmers. The

government removed custom taxes for importing any equipment to produce the drip systems and guaranteed low percentage credits for purchasing and installing drip irrigation. The lack of the qualified local consultants able to deliver the training services to farmers for operation and maintenance of drip systems may become one of the main constrains for accelerating the program.

Given above examples indicate the importance of high education/ universities role in sustainable and more productive water use at all levels. The report describes several alternatives which can contribute to building the capacities of the water institutions to meet water security challenges.

Keywords: Water security, Capacity building, Integrated Water Resources Management

Introduction

Water security of Uzbekistan, located between two main rivers, Syrdarya and Amudarya, faces challenges of global, regional and local levels. Climate change impact, increasing demand and competition for water between different water uses are among them. The objective of this paper is to determine the role of education in the process of transforming the water management. This study summarizes the current and potential impacts of the challenges on human activities and environment. The institutional and technical measures taken by the government to adapt water management to new environment are highlighted. Two of them, introducing integrated water resources management (IWRM) in Fergana Valley and wide scale adoption of drip irrigation are discussed in detail. Introducing IWRM principles in the Fergana Valley followed by the extensive capacity building programs clearly showed the way of achieving the goal. The program of wide adoption of drip irrigation technology recently taken by the Government indicates the needs for diversifying and revisiting the education process.

Water Management

Available water resources of Uzbekistan are at 51 km^3/yr in average, of which 46.8 km^3/yr, or about 90%, is allocated for agriculture. Because of 80% of available water resources originate in the upstream states and belong to transboundary water courses, the operation regime of the upstream reservoirs plays important role in securing the water supply. In addition to the upstream reservoirs, Uzbekistan has 31 in-bed and 27 off-bed reservoirs with net capacity of 16 km^3. The water management infrastructure in Uzbekistan is represented by 180,000 km of canals, 140,000 km of drainage, 1620 pump stations with annual power requirements of 8.2 billion kWh, 4100 wells for irrigation and 4300 wells for drainage purposes. Over 41,000 staff is involved in water management.

Global Challenges

Since water resources of Uzbekistan are mainly transboundary, the impact of global climate change is given for water resources at the regional scale.

At current, about one-third of the river flow originates from mountain glaciers that are quickly losing their volume due to global climate warming. Glaciers cover 18,128 square kilometers (km^2) in the Aral Sea Basin, and they have an important hydrological role because they release melt-water, especially during the dry summer months. During the past decades the rivers received a significant amount of excessive water from glacial melt, but in the future this source may be lost as a consequence of vanishing glaciers. In the future, water shortages are expected to be a serious problem for the national economy and the environment. Demand for water will increase at the same time as the river flow diminish (Punkari M. et al., 2014).

The ADB made projections, until 2050, indicate that mean temperatures will rise throughout the years in the Central Asian region, with an annual mean temperature rise of about 3o C. The projected changes in annual precipitation were relatively small until the year 2050 and varied from model to model. The already-dry southwestern parts of the region were projected to become even drier, especially during summer time. Uzbekistan climate is predicted to become more arid. Since, Uzbekistan uses substantial amounts of water from the Amudarya River for agriculture, the foreseen decrease of these water resources can have a severe impact on the country's economy (Schlüter et al., 2013). The large-scale irrigation systems are already suffering from water shortages, and higher temperatures will increase the volume of water required by the irrigated crops.

Based on the future melting rates of glaciers in the Aral Sea Basin, predicted using Global Climate Model Projections and hydrologic modeling, the glacier extent in the Aral Sea Basin is projected to reduce to 2050 by 50% as compared to 2010 (Punkari et al., 2014). Table 9.1 shows the contribution of the different sources to the total river flow. In the Amudarya River basin, glacial melt is an important contributor to the entire flow, especially in the smaller streams at higher elevations. Total water resources generated in the upstream parts of the Aral Sea Basin indicate that for the upstream Amudarya almost 40% of the total flow is generated by glacial melt, while for the upstream Syrdarya this figure is just over 10%.

Table 9.1: The relative flow contribution of the four components for the upstream Syrdarya and upstream Amudarya rivers, 2001-2010 (%) hydrological component Syrdarya River and Amudarya River (Punkari M. et al., 2014)

Hydrological Component	Syrdarya River	Amudarya River
Direct runoff[1]	31	16
Base flow[2]	23	19
Snow melt[3]	35	27
Glacial melt[4]	11	38

1- Rainfall flowing overland directly into the streams;
2- Rainfall infiltrating into the soil and flowing through the soil into the streams, or available as groundwater;
3- Precipitation falling as snow and flowing into the streams when it melts;
4- Precipitation feeding glaciers and that eventually melt and flow into the streams.

The data given in Table 9.1 indicates that the glacial recession caused by climate change will have a major impact on total flow and the timing of flows. The analysis shows that inflow into the downstream areas will decrease by 22%–28% for the Syrdarya River and 26%–35% for the Amudarya River by 2050. The range of the projected decreases reflects the uncertainty in the climate projections.

The major user of fresh water in Uzbekistan is irrigated agriculture. About 94% (48 km^3/yr) of water resources is consumed by irrigated agriculture, while other sectors such as households and industry consume about 3 km^3/yr (Ahmadjanov, 2017). Climate change will reduce available water resources and increase the demand of crops since higher temperatures lead to elevated evaporation rates. The total water demand in the Syrdarya Basin is projected to increase by about 3%–4% by 2050, while demand in the Amudarya Basin will increase by about 4%–5%. It is expected that water shortages will be higher in the downstream of the rivers where located major irrigation systems of the region. These data show needs for actions to secure sustainable water use in Uzbekistan.

Regional Challenges

At the regional/country level the water challenges are associated with growing population and increasing demand. From 1980 to 2010 the population of Uzbekistan doubled which accordingly increased demand for water, energy and food, and reduced water availability per capita from 3200 to 1500 m^3/yr. Water and energy nexus associated with competition for water between the upstream hydropower and the downstream agriculture complicates the situation. Limited fossil energy resources induce the upstream states to change the operation regime of the key upstream reservoirs from agriculture to hydropower generation mode. As the consequence, this may change the river flow regime in the downstream — more water may come in winter and less in summer. The downstream human activity, which one at present is mainly irrigated farming, may face increasing water shortages. Uncertainties, such as climate change, scarcity and sharp fluctuation in water resources availability, may increase the competition for water between human and environmental needs.

Local Challenges

At the local level, conventional furrow irrigation practices cause high infiltration losses. Often, irrigation applications depend on water supply regime rather than crop water requirements. This results in groundwater table rise and secondary salinization of the irrigated land. About 31% of the irrigated land is prone to salinization. Other barriers for efficient use of available water resources are as follows:

- High number of farmers complicating water distribution process
- Most of water consumer associations (WCA) created on administrative base
- Poor financial status of WCAs
- Aged infrastructure
- Lack of flow monitoring infrastructure
- Coarse land leveling practices

In water short environments farmers widely apply alternate furrow irrigation and/or plastic sheets to cover furrow beds. At WCA and DLWA levels time-based water rotation is in practice between WCAs and farmers, accordingly. Unfortunately, these measures are not sufficient to cover water shortages, especially in the tail ends of the irrigation systems.

Actions taken to meet water challenges

The government has introduced the combination of the institutional and technical measures, such as:

- introducing limit-based water use permits;
- water administrations shifted from administrative approach to basin approach;
- basin management administrations of irrigation systems are created at the small river basin level > following level is irrigation system administrations > district level water administrations > water consumer associations> farmers;
- replacing high water consumptive crops. Cotton/alfalfa crop rotation is replaced by cotton/winter wheat cropping sequence;
- modernizing water infrastructure;
- strengthening legal basis of water management and use;
- wide adoption of water saving (with focus on drip irrigation) is on the way;
- strengthening of formal and informal institutions;
- prioritizing measures for amelioration of salt affected land.

The water administration at current represents the mixture of basin and administrative approaches. The water management above district level takes into consideration the hydrographic boundaries, while DLWAs and WCAs are created on the administrative base. During water short years/periods the water allocation is according to the limited water use rule, which applies the equal cut of water permits based on the availability of water. The advantage of this rule is simple practical solution, while the shortage is that the rule does not consider the growth phase of crops.

Having water shortages and prioritizing food independence policy since 1993 the state shifted from cotton/alfalfa crop rotation to cotton/winter wheat cropping sequence and increased grain production on the irrigated land. Main infrastructure, installed in 1970-1985s is aged and requires renovation. The state one by one reinstalls water intake and other structures while WCA and farm levels require financial inflows. Two initiatives described below to highlight the role of education in meeting the water challenges are integrated water resources management (IWRM) and wide scale adoption of drip irrigation.

Integrated Water Resources Management in Fergana Valley

IWRM principles were tested in Southern Fergana Canal command area in the Fergana Valley, the Syrdarya River basin. The canal takes water from the Andijan reservoir on the Karadarya River. The total length of the canal is 120 km. The command area of 83844 ha belongs to Andijan and Fergana provinces of Uzbekistan, except about 2500 ha belonging to Osh province of Kyrgyz Republic. This irrigation transfer action was funded by SDC and implemented in the cooperation by the Scientific Information Center of the Interstate Coordination Water Commission and the International Water Management Institute. The project was implemented step-wise during 2002-2012.

During its inception phase, 2002, the project analyzed the existing water management issues in Central Asia, selected and justified the project sites, made initial contacts with key stakeholders and specified the IWRM principles to the local context. The key findings of the inception study were as follows: declining the state funding to maintain the base level of the irrigation systems; increasing number of farmers, after collapse of the 'kolhoz' system, led to the institutional gap in the water management below the district level; the inefficiencies in the water management practices cause low water productivities (IWRM in Fergana Valley project, 2009).

During the implementation phase, 2003-2004, the project initiated major institutional reforms, such as the establishment of unified canal management organization along hydrographic boundaries, involving water users in the canal governance, creating hydrographic water consumer associations (WCA) using bottom-up social mobilization approach. Along with the institutional measures, actions were taken to increase water productivity and adopt irrigation schedules meeting crop water requirements (Dukhovny and Stulina, 2012).

The phase III (2005 - 2008) concentrated on strengthening both vertical and horizontal linkages. Public participation was integrated at all levels of the water management hierarchy. Aiming the inter-sectoral integration, emphasis was given on consultation efforts. At national level the project established multidisciplinary and inter-ministerial groups. Transboundary small river component was added to the project's agenda (SIC ICWC/ IWMI, 2008).

The capacity building activities became the main component of the project. Over 100 training events were conducted under the project with over 8000 participants (Fig.8.1). Main attention was given to training of WUAs staff, canal administrations and farmers.

The phase IV of the project focused on improving the water productivity and strengthening water management in small river basins. Institutional innovations supported by technical interventions and the intensive training program guarantied the success of the project (Fig.8.2). Forty-seven WCAs were shifted from administrative to hydrographic boundaries during the project life in 2004 through 2007. Irrigation applications were reduced from 12700 m^3/ha to 6700 m^3/ha in average. Significant reduction of number of infection illnesses, such as Hepatitis A, Diaries, Dysenteries, also would be not possible without the intensive capacity activities.

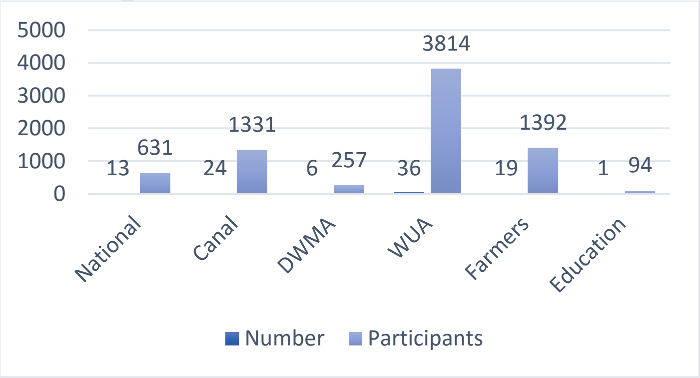

Figure 9.1 Number of Events and Participants of the Training Programs During the Third Phase of the Project (2005-2008) (After Mirzaev, 2011)

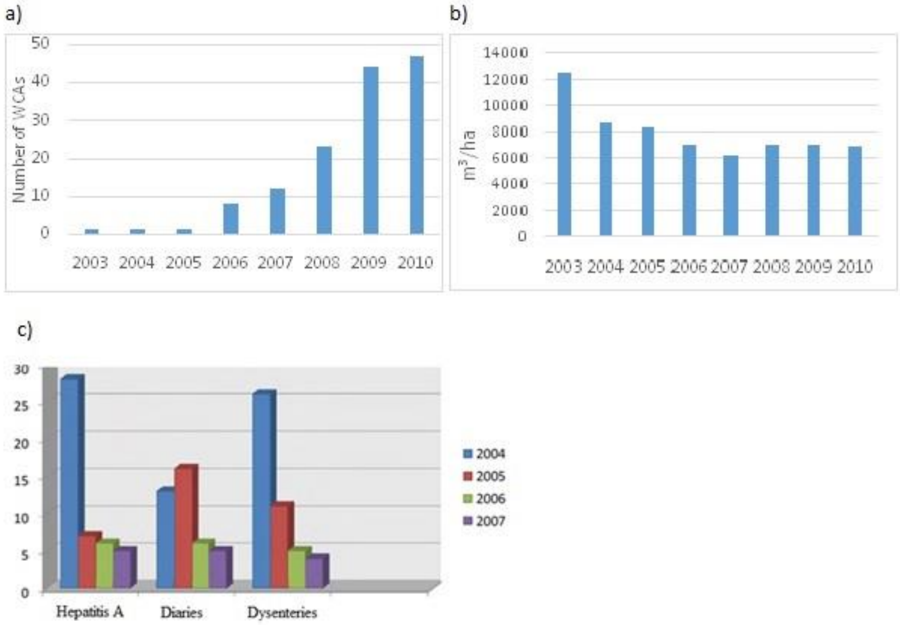

Figure 9.2 Number of WCAs established on hydrographic base (a), changes in irrigation applications (b) and number of infection illnesses among the population (c). (IWRM, 2008)

Issues Identified in Introduced Water Management Principles

Along with the successes, some issues identified were as follows:

- Unclear sharing responsibilities between different levels, especially between irrigation system administrations, canal administrations and district level water administrations (DLWA). DLWAs had similar responsibilities with ISAs but at the district level;
- Incentives for water savings were not introduced. Water was delivered to WCA gates free of charge. Farmers paid fees only for WCA's services;
- Capacities of DLWAs to lead the WCAs and water users forward adapting water saving technologies and improving water productivity under the growing water shortages were not strengthened;
- Capacity building program did not cover high education (University level);
- Capacities of district level water administrations were not in place to deal with the facing challenges;
- Financial situation of WCAs did not reach the level to maintain/ modernize infrastructure.

These issues require consideration and actions. The project outcomes indicate that the development through institutional and technical interventions is to be supported by the strong capacity building programs insuring the successful reaching the aims.

Wide Scale Adoption of Drip Irrigation

This is another example demonstrating the role of education in the development. The company Shortages, specializing on exploring natural gas and producing plastic material, such as polyethylene and PVC, has taken the initiative of demonstrating the advantages of drip irrigation in Uzbekistan. Aiming increasing the market for plastic materials, which the company produces, in 2010, the company purchased the equipment for making drip lines and hired the staff. Starting from 2011 through 2013 the company installed demonstration sites of drip irrigation of cotton on 150 ha area total in 2011 in Bukhara, Navoi and Kashkadarya provinces and 100 ha in 2012, and for irrigation of 11 ha orchards in 2013 (Fig. 8.3). Except highly salt affected areas, the yield of cotton exceeded 4 t/ha against 2.5-3 t/ha under furrow irrigation (Karshiev, 2018). This significant increase in crop yield was demonstrated to the farming communities, and then the demonstration sites were transferred free of charge to farmers. Impressed by the cotton yields on the fields belong to the company, in 2014, neighboring farmers took credits for purchasing and installing drip systems for orchards, vegetables and cotton. However, gradually the interest of farmers to drip irrigation is reduced due to several issues, including high maintenance costs, the lack of incentives to save water and the lack of knowledge to maintain and operate the drip system.

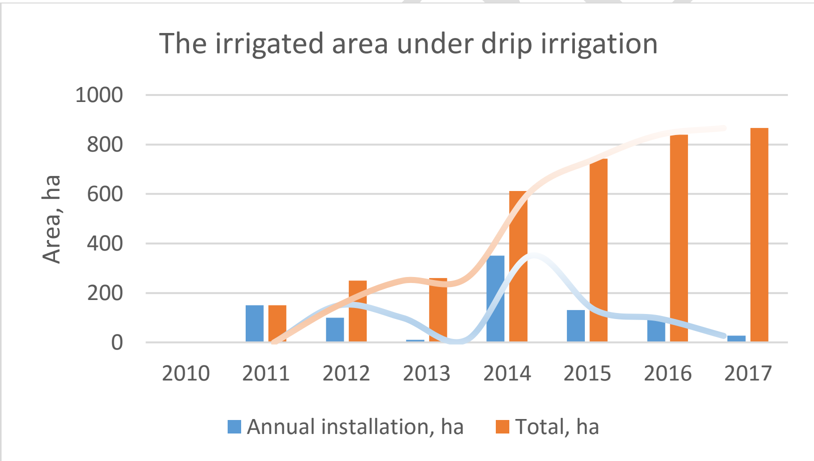

Figure 9.3 Installing Drip Systems at Farm Fields by Shurtangas Company (modified from Karshiev, 2018)

Facing the water shortages, the government declared the program of wide scale adoption of drip irrigation. It is planned increasing the area under drip irrigation from 28,000 ha in 2018 to 500,000 ha in the nearest future. The key role in shifting from furrow to drip irrigation is given to clusters, representing linkage between farmers and cotton lint (or fruits/vegetables) processing enterprises (Fig. 8.6).

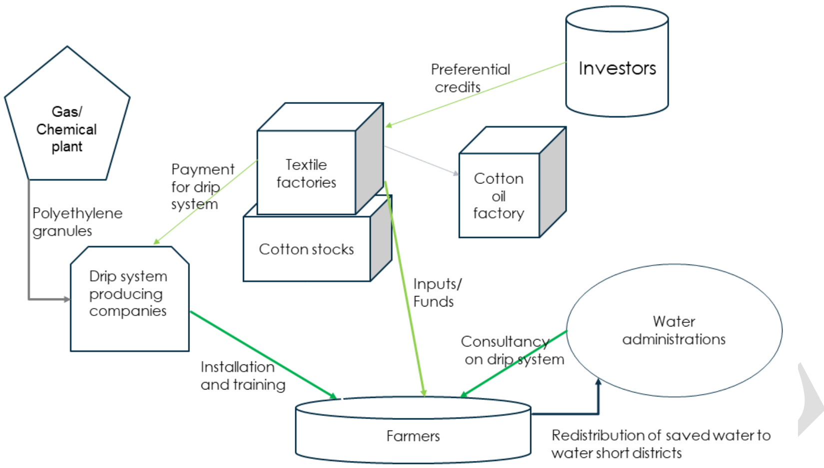

Figure 9.4 Cluster Approach to Wide Adoption of Drip Irrigation

The cluster linkages indicate needs for quite different skilled developers who can understand win-win situations along the resource use>crop production> processing line. From one side, it requires specialists in narrow fields, such as drip system – in design, installation, maintenance and operation. From the other side, specialists of new areas are required such as value chain analyses. According to this scheme, District Level Water Administration's advisory support for farmers is important in successful maintenance and operation of drip systems. The implementation of the approach requires skilled staff of the water administrations/WCAs and farmers' advisory services.

Conclusions

Given two examples indicate, that along with the institutional and technical interventions, the importance of revisiting education and capacity building programs, including water management courses for securing water resources in Uzbekistan. Introducing innovations and advances in water management requires narrow oriented rather than wide profile specialists. At the same time, specialists required in new areas such as water diplomacy, value chain analyses, high technologies, including GIS and remote sensing. Cooperation in education is another efficient way in capacity building of new water generation.

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