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Innovative Tools for Automated Water Metering in Uzbekistan

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Abstract

This policy brief gives the analysis of the current state, key aspects, principles and prospects of water metering automation for unbiased and timely accounting of water resources in the Republic of Uzbekistan.

The Decree of the President of Uzbekistan on measures for the efficient organization of water management sets the tasks for wider adoption of ICT in the sector and for achievement of transparent water accounting. In this context, through the automation of water management processes it is planned to organize remote control of large water infrastructure, limit water losses to 10%, and reduce human interventions in these processes [1].

Water accounting underpins the operation of irrigation systems and, thus, is essential for water use planning. Therefore, for the improvement of irrigation performance, it is first necessary to automate water metering. Herewith, the automation principles and scheme are chosen depending on type, design, and operating features of a water metering site, i.e. whether water discharge is measured directly or derived from other measured parameters.

Water metering is automated at outlets and control sections of irrigation canals, helping to improve performance and decrease irrigation water wastes without additional costs.

Introduction

One of priority tasks in the Water Sector Development Concept [2] and the Water Management and Irrigation Development Strategy of the Republic of Uzbekistan [3] is the modernization and development of water infrastructure, the automation of water management processes, and the wider adoption of up-to-date innovative technologies in the national water sector.

Currently, poor water accounting at regional and national levels leads to over-use, wastage and inefficient distribution of water resources in transboundary and small rivers, This, in turn, causes additional energy and labor inputs and, finally, lower crop yields.

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In this context, water accounting can be considered as a tool of water conservation, and automation of water accounting will help distributing water among water users and consumers in required quantities and in due time.

Unbiased and timely water accounting is an important precondition for the efficient performance of irrigation systems. It helps to manage and regulate field water regime, conduct observation and control over operation of individual structures, systems, sites, etc. [4]. Water accounting is needed for effective organization of water use and distribution. In turn, automation of water accounting at the on-farm canals, including the collector-drainage network, will provide timely and reliable information on quantities of irrigation and drainage water and its distribution.

Analysis of the current state

The National Hydrometeorological Service (UzHydromet) is responsible for surface water accounting along all rivers and large collecting drains in Uzbekistan, while Basin Irrigation System Authorities (BISA) and regional divisions of the national Ministry for Water Management measure water flowing through water intake facilities and other hydraulic structures. As to transboundary rivers, UzHydromet, based on agreements and by request, receives relevant information from national hydrometeorological services in other countries.

Recently, due to the lack of automated water accounting at the sections, where transboundary rivers cross the national boundaries of riparian states in Central Asia, it is complicated to monitor water resources along the transboundary rivers, but, thanks to joint efforts of ICWC executive bodies, the countries of Central Asia have managed to avoid acute conflicts when allocating transboundary water both in drought and flood conditions.

The automation of water accounting in Uzbekistan has started in the early 2000s. Thus, as part of the regional project "Automation of Canals in the Ferghana Valley", Phases I and II [5], head and key structures were equipped with SCADA system, and gate position sensors and ultrasonic level sensors Prosonic FMU230E were installed at all regulators (Fig. 1).

Figure 1. Automated water accounting at the structures of BWO Syr Darya

This enabled the effective regulation of water resources, while the automated online gate control under variable flow from the Toktogul reservoir helped to reduce water withdrawals. The modern water metering and accounting facilities have improved the accuracy of water level and salinity measurements, leading to the reduction of measurement error from 5-10% to 2-3%.

However, water discharge was not measured directly. Moreover, water level meters were not calibrated by metrological centers or UzHydromet's bodies, although their calibration intervals are not more than 2 years. The accuracy of their readings is checked by sea gauges or gauging rods installed in parallel.

The analysis of current water accounting in the Syr Darya River basin showed that in Uzbekistan the water discharge in the river's upper and middle reaches is measured through gauging rods. Additionally, after junction of the Naryn River and the Karadarya River, 27 km downstream the Syr Darya River, the UzHydromet's gauging station "Kal" is equipped with the Valdai water-level recorder and also with a sea gauge for duplicate measurements.

The checking of sensor performance has proven their reliability but, due to long service, all the earlier installed angular position transducers are virtually out of order because of wear and tear.

Upon initiative of the Uzbek Ministry for Water Management, the Korean International Cooperation Agency (KOICA) has been actively engaged in the irrigation canal automation process in recent years. Many gauging stations along the main canals were equipped with autonomous Korean level sensors capable of transmitting the data wirelessly. All electronic equipment is installed in blocks protected from rainfall and unauthorized access. The system contains the values of water discharge depending on water level in a canal: Q=f(H). The water level is measured by a highly-precise level sensor placed just over the water surface (Fig. 2). Measurements of level (H) and discharge (Q) are conducted continuously and transmitted online to a control station.

Figure 2. Automated Smart Water level sensors along irrigation canals

The Water Management and Irrigation Development Strategy of the Republic of Uzbekistan for 2021-2023 sets the task to increase water accounting sites equipped with Smart Water technology to 18,576 and transfer 60 large waterworks facilities to automated control.

In fact, over implementation, Smart Water was introduced only at 7,759 sites, i.e. 10,817 less than planned (Fig. 3), and 56 large waterworks facilities have been automated (Fig. 4).

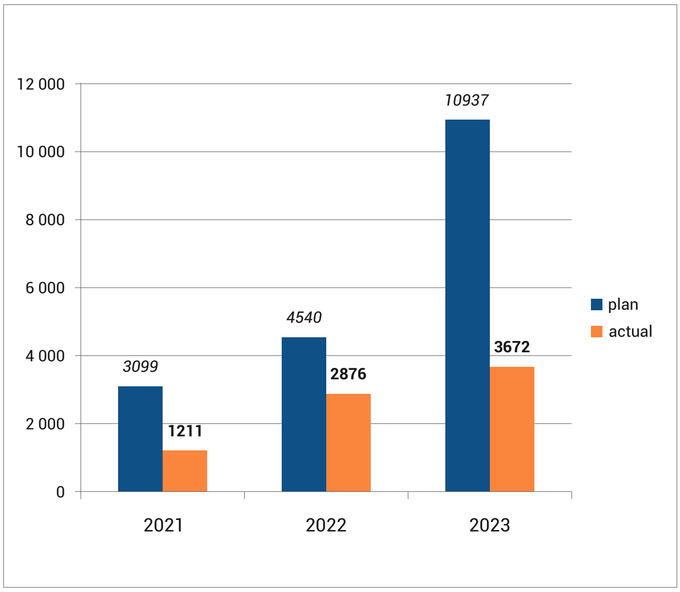

Figure. 3. Introduction of Smart Water technology in 2021-2023

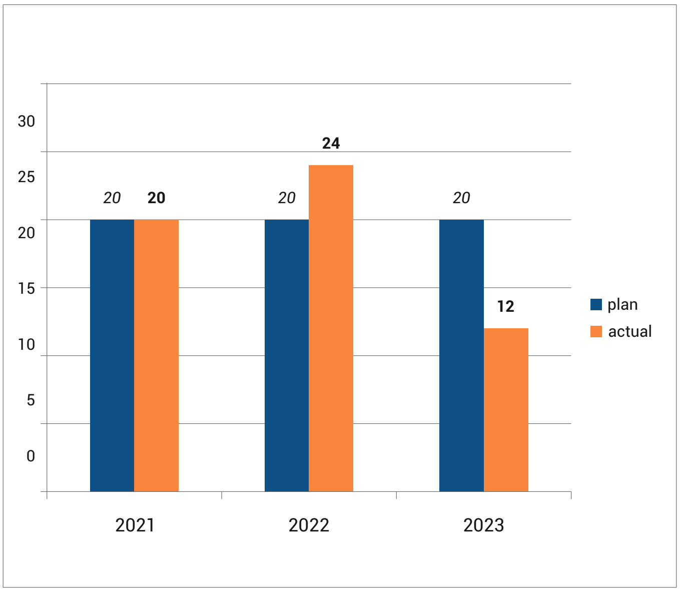

Figure 4. Automation of large waterworks facilities in 2021-2023

In 2021-2023, 56.7 billion UZS (47 percent) out of the required 121.1 billion UZS were allocated for installation of Smart Water devices and 9.04 billion UZS (53 percent) out of the required 17.2 billion UZS, for automation of large waterworks facilities.

In addition, the approved Roadmap for further deepening of water sector reforms provides for the implementation of a modern automated water system developed by Rubicon Water Pty. Ltd. along the Mirishkor-Kamashi Canal in Kashkadarya province [6]. The Project was implemented upon initiative of the Ministry of Agriculture through the EU's grant. As a result of 18.2 billion UZS-worth design and construction work, 26 gates along the Mirishkor-Kamashi Canal, from the headwork to the end outlet, have been automated (Fig.5).

Figure 5. The Mirishkor-Kamashi Canal automated by Rubikon Water Pty. Ltd.

As a result, water supply of more than 6,500 ha of irrigated land has been improved, and water management and distribution processes have been also improved (30-40% reduction of water losses) [7]. In 2022, 11.5 million m^3 of water (25% of the average annual flow) was saved through the remote and timely water control.

Modern international automated water accounting methods and technologies

It is critical to monitor river water level. There are many places where remote monitoring of water level is required. Real-time monitoring is also an important part of water conservation, river management, flood control, disaster risk reduction and other projects.

The analysis of international practices has shown that water level and discharge measurements on such transboundary rivers as Colorado and Columbia in North America, Tigris-Euphrates and Helmand in the Middle East, and Indus in South Asia are taken with the use of modern innovation methods and technologies [8-10]. Doppler, radar, and ultrasonic water accounting methods have been used there for many years.

At present, the below devices and equipment have proven to be most effective in automated water accounting:

Level sensor is a device that measures the water level in contact or noncontact manner. The level sensors include magnetostrictive gages, guided-wave radars, level transmitter radars, ultrasonic sensors, hydrostatic pressure transducers, etc.

Radar level sensor. Electromagnetic waves form the basis of level measurement with the radar. A radar sensor emits a focused electromagnetic wave that is reflected by objects as an echo and is then evaluated by the sensor (Fig. 6). In addition to free-radiating radar sensors, the radar category also includes those based on guided microwave technology, which are referred to as guided radar, TDR (time domain reflectometry) or also GWR (guided wave radar) sensors.

Ultrasonic sensors. The ultrasonic level sensor (Fig.7) and monitoring system allow controlling remotely the

Figure 6. Radar level sensor

Figure 7. Ultrasonic sensor

water level in a river or any other water body. The monitoring system transmits the current, measured water level in the river directly to PC located distantly in the control station through the wireless cell communication network.

Additionally, it can be equipped with autonomous uninterruptable power supply so that this system can be used in places that have no connection to fixed networks.

Float sensors. The float sensors (Fig. 8) are designed for simple monitoring of the water level. These are effective in cases, when the use of other (conductivity, ultrasonic, etc.) sensors is not technically or economically feasible.

The float sensors (switchers) may be combined with other devices or work autonomously by controlling actuators through the relay or contactor.

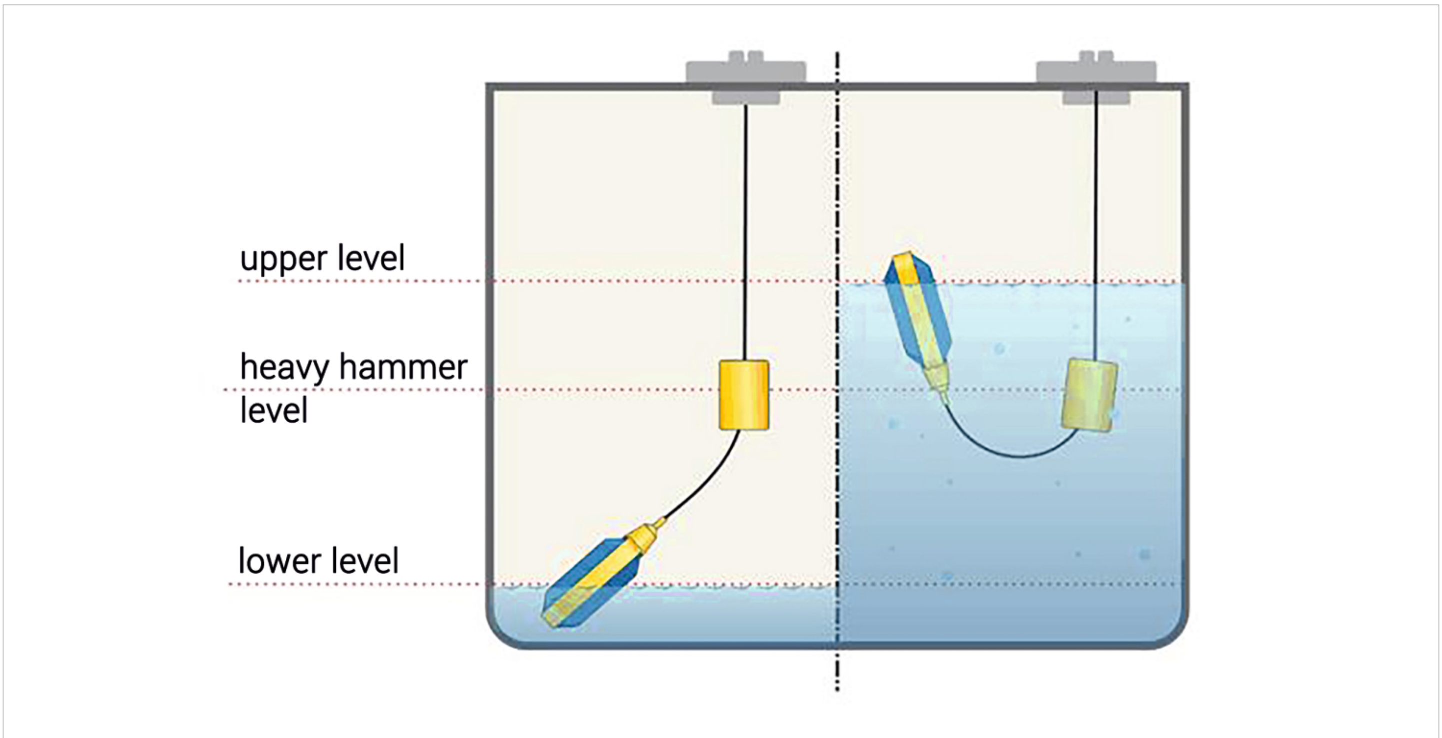

Figure 8. Float sensor

Water discharge measuring devices (flow meters). A flow meter is a device used to measure the volume or mass of water, i.e. the quantity of water (volume, mass) that flows through a cross-section per unit time.

Flow meters are designed to measure water discharge in open channels and rivers (up to 300 m wide mainly) using the velocity-area method, while drawing a flow profile.

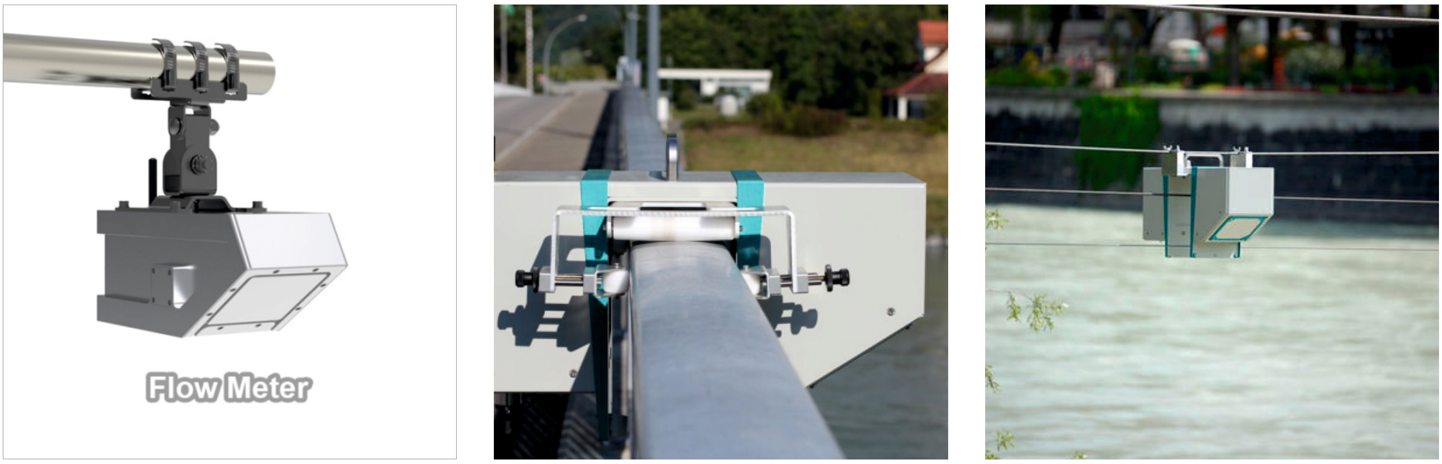

Figure 9. Water discharge measuring devices (flow meters)

The flow meters usually use the online digital signal processing technology (digital filtration and adjustment of ultrasonic pulses) for correct measurement of an echo signal (continuous dual-directional measurement method).

The flow meters can also be used in emergency warning systems (floods, droughts, backwater situations), thus guaranteeing accurate, stable and reliable results even in extreme operating conditions.

However, the maintenance and operation of large gauging stations is becoming more and more cost ineffective. For example, every year more than 100 USGS streamgaging stations with record lengths are being discontinued even in such developed country as the US [11].

Those are replaced by satellite altimetry and remote sensing images [12]. Recently, satellites have been used in measurements of the river water level and discharge (Fig.10).

For example, Envisat launched at an altitude of 800 km orbits the Earth in about 101 minutes and, thus, allows having the accurate data every 2 hours. This method is good for getting accurate online data on the remote water sites.

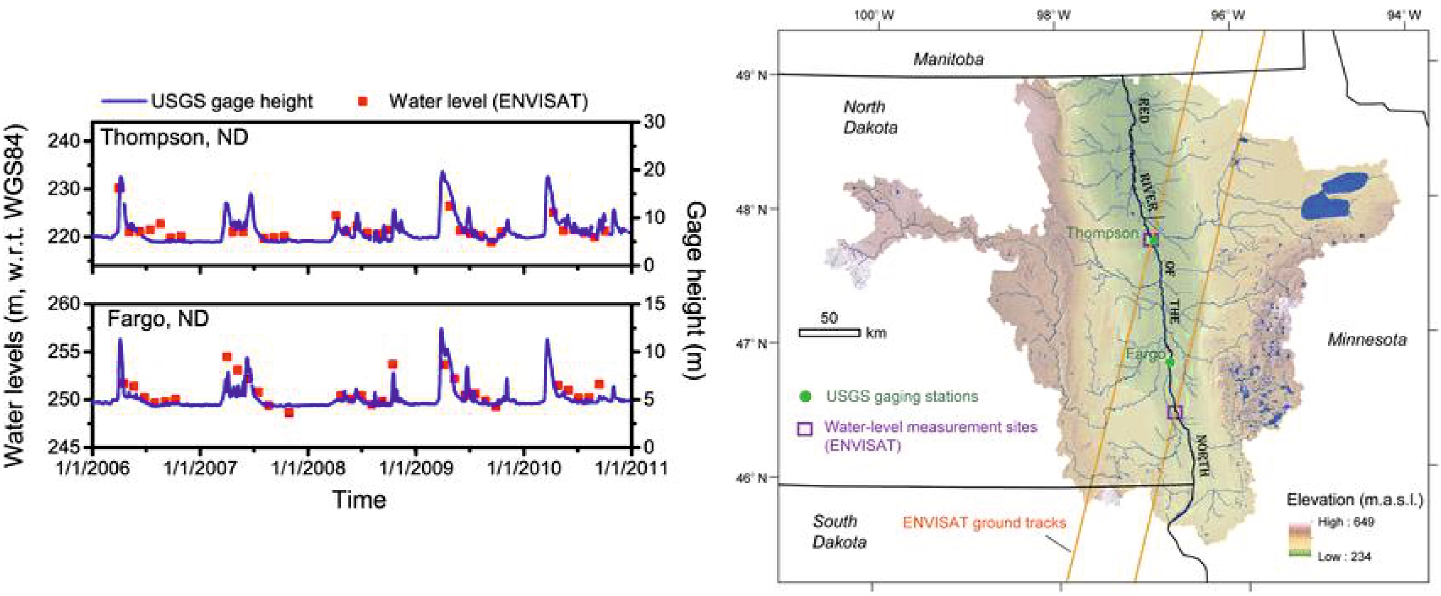

Figure 10. Measuring water levels using satellite altimetry and remote sensing by the ENVISAT [13]

Also, we should not forget that even many developed countries still use sea gauges or gauging rods, various types of weirs, current meters and other devices for measuring the water level and discharge. However, through the modern innovative approaches, engineering solutions and coordinated joint efforts, it is possible to achieve high, and most importantly, sustainable results in the water accounting automation.

Comparative table of water accounting devices

Name	Advantages	Disadvantages	Notes
Gauging rod	Simple and reliable use, low cost, no power inputs or additional equipment	Continuous visual collection of readings, dependence on human factor, no timely/online data collection	Used in parallel with electronic meters
Volumetric method	Resistant to eddies and other disturbances of flow velocity, no need for calibration of flow profile, low power inputs, potential for automatic regulation of water level and discharge	Needs heavy grading and assembly operations	Measures volume of water
Radar method	Provides online data, can be equipped with autonomous uninterrupted power supply, digital signal processing	Needs continuous access to electricity, high cost, not resistant to bad weather conditions, measures only water level, needs regular calibration of flow profile	Working principle: emission of focused electromagnetic wave
Ultrasonic method	Provides online data, can be equipped with autonomous uninterrupted power supply, digital signal processing	Needs continuous access to electricity, high cost, not resistant to bad weather conditions, measures only water level, needs regular calibration of flow profile	Working principle: emission of ultrasonic wave
Doppler method	Provides online data, no need for calibration of flow profile, measures velocity in different flow layers	Needs continuous access to electricity, high cost	Measures water discharge by the velocity-area method
Float method	Simple use, relatively cheap	Lacks high accuracy	Compatible with other meters
Satellite altimetry and remote sensing	Provides online data on remotely located sites, no power inputs	Needs additional equipment and access to satellite images, GIS and RS knowledge	Relatively new and understudied method

**all metering devices must be calibrated in due time by specialized metrological centers or the Agency for Standardization and Metrology*

Conclusions and recommendations

In the process of automation of water accounting, one should proceed from the following: whether water discharge is measured directly or derived from other measured parameters. Moreover, the automation principles and scheme are to be chosen depending on type, design, and operating features of a water metering site. In this context, only automation of all processes in the irrigation system can give the maximum technical and economic effect from water accounting.

It was found that:

- gauging rods are the simplest and reliable devices for measuring water level in rivers, canals, and reservoirs;

- due to long record length (over 20 years), most automatic water accounting devices cannot be used because of wear and tear and even have not been checked by metrological centers;

- the allocated funds are not sufficient for automation of gauging stations (cover only 50% of needs).

In this context, it is recommended to:

- attract donors for investments in the water sector;

- study the feasibility of applying the international practices of satellite altimetry and remote sensing in transboundary water accounting;

- before implementation of the planned automation projects, start modernizing the earlier installed automatic water metering devices;

- equip existing gauging stations with radar level sensors and ultrasonic discharge meters working by the velocity-area method, while in case of more than 300-m wide rivers, where the flow velocity is not uniform over the cross-section and variable, use radar sensors, with one master sensor and several slave sensors.

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