# THE NECESSITY OF MULTI-PURPOSE MONITORING OF THE REPUBLIC OF AZERBAIJAN'S WATER RESOURCES

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**Abstract**

*The Republic of Azerbaijan's climate is changing, and the signs of shortcomings with the water resources are everywhere, and predominantly associated problems are getting increasingly severe. In turn, the synoptic weather systems leading to decreasing low precipitation levels due to climate change have aggravated the country's water scarcity in recent years, as all other environmental relational parts frequencies are meaningfully changing. Most frequently, the reduction in rainfalls persistently affects agriculture, infrastructure, the environment, and ecosystems in many ways. We do not yet know where, when, and how much water sources are lost from water reserves, for instance, the Caspian Sea storage.*

*Consequently, the country's vulnerable water resources must be carefully monitored in different ways and scales precisely and wisely. It seems that according to the possibilities of technologies, software, and expert forces, it is now time to take executive measures to solve this critical problem of the country comprehensively. Accordingly, multi-platform and multi-purpose monitoring systems are almost immediately required to construct a relevant applied-based nationwide wide-ranging water resources database. Major watersheds must be watchfully experimented with by employing advanced integrated and fused real, near real-time, and intelligent smart monitoring systems directed to advanced machine-deep-learning approaches.*

**Keywords:** multi-purpose monitoring, real monitoring, near-real monitoring, smart monitoring, water resources

## I. Introduction

The water crisis in the Republic of Azerbaijan is entering a new pattern where its impacts are becoming visible in the daily lives of millions of people (Safarov et al., 2018). Several strong signs are showing significant changes in the process of reducing water resources, particularly in the semiarid and drought-prone parts of the country with increasing vulnerability to this natural hazard (Safarov et al., 2017). Water scarcity and drought issues are among the biggest challenges facing the country. This phenomenon can be due to the appearance of changes in the frequency of atmospheric systems and less precipitated clouds associated with the precipitation potential in these systems (Rasouli, 2011). The water source of the country is related to the arrival of moist air masses from outside the country, especially from the west, northwest, and occasionally from the southwest (Mammadov et al., 2009; Bayramov, 2020). Clearly, during the past decades, the frequency of occurrence of these systems has decreased, and sometimes, with destructive floods, whenever large amounts of water resources are out of reach of the country. In addition, the river network in Azerbaijan is unevenly distributed over the territory, and, drinking water in Azerbaijan is mainly sourced from such distributed rivers.

The bad news is that the Caspian Sea- the largest landlocked water body worldwide- has been facing a decrease in water and its consequences such as changes in the coastal environment and ecology of the coasts (Rasouli and Imrani, 2023). Various reports indicate that the water level of the Caspian Sea has decreased by 2 meters in recent years and could drop by 9 to 18 meters by the end of the 21st century (Lahijani et al., 2023). If we count the effects of climate change and the current water consumption policies to this category, we will witness exponential crises in the country's water resources (Safarov et al., 2020). Water scarcity in Azerbaijan could lead to a complex social-ecological challenge, and various factors contribute to it differently, including agriculture, urbanization, climate change, population growth, land-use change, and an ineffective water management system (Chen et al., 2017).

In such a situation, policymakers and experts in the fields related to water resources science should take fundamental steps for the country's vulnerable water consumption. One of the most important is obtaining accurate information through multipurpose and multimeter monitoring methods. Nowadays, we can refer to real-time, near real-time, and smart-monitoring systems as intelligent measurements of related parameters (Rasouli and Mammadov, 2021). After a detailed knowledge of the quantitative and qualitative characteristics of the water resources, it is possible to witness positive consequences with optimal water consumption policies. Hence, with the aim of systematic access to comprehensive and accurate information and in the category of resources in crisis of the country, it is possible to use modern methods of remote sensing, especially of the types of receiving all data related to water resources at the time having the following:

- ✓ Observation and detection of water data types from natural and non-natural environments of the country,
- ✓ Operating special tools with high technology in the accurate detection of water elements,
- ✓ Recognition of water resources at different temporal and spatial scales,
- ✓ An accurate understanding of water surface changes in the country water basin contexts,

## II. Result and Discussion

**Real-Time Monitoring Systems (RTMS).**

One of the main aims of remote sensing is the observation and detection of dissimilar data types from physical and non-physical environments of the water surfaces (Sharma et al., 2021). Based on the RTMS, special tools with superior technology in water resource elements are vital for our country's current water crises. Each RTMS provides new raw data or higher levels for other information-producing systems. Some scientists believe that any RTMS can be considered the driver of Spatial Information Science (SIS) with the goal of sustainable water resources management policy (Rasouli et al., 2021). An RTMS acts to detect the physical characteristics of an area covered by water by measuring its reflected and emitted radiation at a distance (typically from active or non-active sensors). Since Apollo 17 captured the famous Blue Marble photograph of the earth in 1972, we have had a good idea of "what our planet looks like." Such shots show satellite imagery, real-time cloud cover, precipitation, and many other water-related layers worldwide. Meanwell, the modern remote sensing technique is widely used to delineate surface water bodies, estimate meteorological variables like precipitation, calculate hydrological state variables like soil moisture and land surface characteristics, and estimate fluxes such as evapotranspiration.

In the same way, it is vital to accurately measure the critical conditions of our country's water resources. An example of this type of real-time remote sensing is the NASA meteorology satellite systems. Such systems can monitor not only the atmospheric conditions (for example, cloud characters) covering the country for every 30-minute interval but also check the conditions of the land surface and water resources, for instance, the Caspian Sea changes. Among other real-time sensors of the active type, we can mention the meteorological Doppler Radar, which measures different rainfall parameters as it can estimate the intensity and accumulation of daily rainfall with suitable spatial and diurnal resolutions (Rasouli et al., 2014). In the same way, surface precipitation rate, daily rainfall resolution, and intensity can be produced in 15 minutes. To watch the country's water surface context and changes accurately real-time remote sensing detection is needed (Rasouli et al., 2010). Compared with the traditional methods, the proposed framework is an adaptable remote sensing detection framework for most of the country's water surface observation. Despite the existence of real-time measurement devices, we have the possibility and ability to use the existing real-time systems in a way to solve the water crisis in the declaration.

***Near Real-Time Water Sources Monitoring (NRTWSM).***

An NRTWSM system could be defined as the observation of water bodies such as lakes, oceans, and rivers from a distance to describe their surface, color, state of ecosystem health, and productivity timely. This kind of remote sensing technology assists in monitoring water quality by detecting parameters such as turbidity, chlorophyll concentration, and temperature. The sensors can identify pollutants and harmful algal blooms in water bodies, helping authorities take timely actions to safeguard water quality and public health, evolving rapidly. Many sensors, for example, most Sentinel (1-6) satellites incorporating applied algorithms, are making significant advancements in water resources applications (EU's Copernicus Programme, 2021). Thus, a broad range of applications of remote sensing in water resources can be summarized under three classes water resources mapping, estimation of the hydro-meteorological state variables and fluxes, and applications of the remote sensing data in water resources management. Under each section, details of the sources of the country's remote sensing data products that could addressed, if any, are also included.

For many years, NRTWSM has been increasingly used as a complementary source of information in water networks and, in many cases, is the only feasible source. Satellite-based sensors are making direct and indirect measurements of nearly all components of the hydrological cycle (Han et al., 2017). These include precipitation, evaporation, lake and river levels, surface water, soil moisture, snow, total water storage, and subsurface water. Accordingly, these sensors currently provide critical information in monitoring the evolution of hazards and their impacts. Although some of these satellite remote sensing products are in their initial stages, there are some advantages and positive signs in their use for NRTWSM. Large spatial coverage and high temporal resolution (sub-daily for geostationary and equatorial orbiting satellites) means they can provide near-nationwide information in near real-time (Liu et al., 2020). These data can be processed and transformed the raw data collected by the sensors into meaningful information for water resources researchers and managers. It may include pre-processing, which involves correcting errors, distortions, and noise caused by the sensors, the atmosphere, and the terrain. NRTWSM allows scientists to record the quantity and qualities of water bodies around the country, which provides information on the presence and abundance of optically active natural water components. Despite the many views and different sensors and methods of applying NRTWSM, users can refer to Sentinel-1 & 6 (active), Sentinel-2, Sentinel-3, and Landsat 8 and 9 as non-passive imagery. NASA's atmosphere section is another example of a near real-time capability that supports interested users in monitoring a wide variety of water-based-created data and parameters (NASA, 2013). These data are made available much quicker than routine image processing allows (Rasouli et al., 2021). Most data products are available within three hours of satellite observation, with imagery generally available 3-5 hours after the observation stage. To access these valuable data in monitoring water resources, researchers only need the specific cases usable for most geographic regions of the country.

***Smart Water Resources Monitoring Systems (SWRMS).***

In recent years, SWRMS systems have emerged as powerful tools in this endeavor, providing real-time data and actionable insights to promote sustainable water usage and reduce waste (Saqib et al., 2015). Water demand in urban and rural areas countrywide has increased due to population growth and climate change. In today's situation, SWRMS could integrate sensors, meters, and advanced analytics to continuously monitor and analyze water usage patterns within a particular area. Technically, all SWRMS tools can be connected to a central hub and mobile application by providing users with real-time insights into their water resources under the study. By introducing SWRMS, it is possible to leverage the capabilities of the Internet of Things (IoT) to collect and analyze real-time data on water consumption. These systems comprise sensors, meters, and intelligent software that work together to provide a comprehensive view of water usage in the agricultural and residential sectors. SWRMS has many key features and advantages of real-time data, leak detection, usage analytics, remote control, and integration with other IoT devices.

At a controllable SWRMS approach, incorporating into a society-used water consumption offers numerous benefits for homeowners, water utilities, environment water usage, leak prevention, cost savings, and Environmental impacts. At a glance, conserving water through SWMS minimizes the strain on local water resources and reduces energy consumption associated with water treatment and distribution (Palermo et al., 2022). These systems contribute to a more sustainable future by preserving precious water supplies for the next generations. Given these issues, water utilities need a well-planned SWRMS to monitor remotely every part of the water cycle—from sourcing to treatment to delivery to consumption—to respond faster to changing conditions, minimize disruptions, and operate more efficiently. Participants can explore the following areas of interest in this challenge:

- Monitoring of water level and condition (through advanced telemetric devices, drones, or pressure sensors, among others)
- Demand forecasting or monitoring consumption to help manage the pressure and speed of water
- Asset management, detecting leaks, and predictive maintenance
- Staff safety and operational performance; including status reporting like workforce capacity and activities
- Tailored customer service, for example, real-time updates on closures and disruptions, hourly consumption, leak detection, and customer feedback,

In the recent years, several innovations have been made in the field of communications that are transitioning to the Internet of Things with the progression of advancements in technology. In water domain sections, Wireless Sensor Networks (WSN) are one of those independent sensing devices to monitor physical and environmental conditions along with thousands of applications in other fields (Taheria et al., 2020).

## III. Conclusion

All water sources in the Republic of Azerbaijan are undergoing significant changes, as the signs of environmental damage can be seen everywhere in our beloved homeland. There are extensive changes in water territories that seem unavoidable in large dimensions. Such changes in water environments could affect industrial sections, agriculture activities, people's health, and the national economy in many ways. To access these aims, meteorologists, climatologists, water scientists, and managers have to watch and get accurate information about the water resources through one unique applicable policy to reduce the disastrous consequences of unintelligent use of limited and vulnerable water resources.

It is now possible to introduce a modern multi-platform, and with dissimilar purposes suited to the country's water resources sections with reasonable time, energy, and costs. Applying advanced image processing methods and informed interpretation of the ending results can lead to the applied pure sciences. The design of timely, purposeful, and multi-purpose decision-making databases can be of considerable help to researchers and managers of water fields.

If truth be told, most water resources are ever-changing meaningfully throughout the country. We have lost some of the lakes during the last few years. The Caspian Sea coastal areas are changing meaningfully and may seriously affect infrastructure, the environment, and ecosystems in many ways:

- In most parts of the country, particularly in Aran County, water resources are declining sharply.
- The Azerbaijan geo-environment must be watchfully monitored employing modern remote sensing technology.
- Advanced image processing is a better way to reach practical and accurate knowledge of water topics and associated environmental matters.
- Some advanced image processing, such as OBIA, Fuzzy, and Machine-Learning / Deep learning, could provide essential water databases for management plans.
- A combination of multi-platforms such as real-time, near-real-time, and smart-monitoring systems is almost immediately required if it is not too late.

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