

Water Security Risk – Part Five

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Practical, Localized, and Generalizable Solutions at the National Level (Part Two)

Given the serious challenges of water scarcity and the increasing pressure on the country's water resources, smart and multi-dimensional management of water resources is essential. In this regard, the use of modern technologies, the development of water treatment and recycling infrastructure, supporting industries and various sectors in reducing consumption and optimizing water use, as well as coherent and coordinated policymaking, can play an effective role in preserving water resources and ensuring the country's economic and environmental sustainability. In the present article, we will examine practical solutions and executive policies in various sectors, including industries, wastewater treatment, urban and rural water resource management, and the role of laws and multi-level management structures.

Smart Conservation of Natural and Artificial Water Resources: A Solution for a Sustainable Future

Dams, natural and artificial reservoirs, wetlands, marshes, and rivers are vital water resources of the country that must be managed carefully and efficiently. Given the high rate of evaporation and water leakage in these resources, the use of evaporation-reduction technologies, such as anti-evaporation covers and the installation of smart meters, can save 20 to 30 percent of water consumption.

Alongside these measures, the protection and restoration of wetlands and marshes contribute to preserving water quality and biodiversity and play an important role in combating drought. Rivers, as vital arteries for water transmission, also require special attention; planting trees along rivers and around natural and artificial water reservoirs should be prioritized. In addition

to meeting their own water needs, these trees significantly reduce water evaporation by providing shade and reducing the intensity of sunlight and wind.

These measures not only help preserve and conserve water resources, but also contribute to increasing ecosystem sustainability and improving agricultural and environmental conditions.

Legal Requirement for Mechanizing Water Consumption: A Vital Step toward Optimal Water Resource Management

One of the simple and effective ways to conserve water is to require the mechanization of water consumption in all properties that use water. This could be established as a legal requirement for obtaining or transferring a property deed. Accordingly, any property seeking to obtain a new deed or transfer ownership would be required to install and operate mechanized water-consumption systems, such as smart meters and consumption-management systems.

In addition to facilitating the monitoring and control of water consumption, this law would reduce waste of water resources and contribute to more efficient use of resources. Furthermore, facilitating the issuance of deeds for undocumented agricultural land—approximately 50 percent of agricultural land lacks deeds—combined with the requirement to mechanize water consumption, could provide a strong incentive for resource conservation and sustainable agricultural development.

Implementing this legal requirement, with the cooperation of relevant authorities and the provision of financial and educational incentives to property owners, could rapidly become widespread nationwide and constitute an important step toward the smart management of water resources.

Conservation of Drinking Water in Homes: From Traditional Methods to Mandatory Mechanization upon Completion of Construction

Conserving drinking water in homes is highly important and can be optimized through traditional and mechanized methods. Traditional methods such as using water-efficient faucets and fixtures, collecting and reusing rainwater,

preventing leaks and dripping faucets, and using water efficiently for washing can have a significant impact on reducing water consumption.

On the other hand, installing smart meters and water-consumption control systems makes it possible to accurately monitor consumption and detect water losses. These systems can automatically manage consumption and issue necessary warnings.

An effective practical solution for achieving this objective is to require the installation of water-saving equipment and the mechanization of water consumption as a condition for issuing the building completion certificate. Accordingly, without a certificate confirming the installation of water-saving systems, the completion certificate would not be issued. This would lead to widespread and universal compliance with water-conservation measures during building construction.

Smart Water Management and Sustainable Industrial Development: A Solution for Preserving Resources and Generating Wealth

Proper water circulation and optimal water management in industries are key to sustainable development and wealth creation. Following the enactment of the law requiring a geographic annex for water management, all new projects are required to comply with the country's water maps so that water consumption is planned in accordance with regional capacities.

One important solution is to prioritize support for housing development in water-rich provinces and provide financial support and facilities to water-intensive industries so that, by relocating their activities from water-scarce areas to provinces with sustainable water resources, pressure on water resources can be reduced and balance in the country's water consumption can be maintained.

In addition to conserving water resources, this approach can significantly contribute to balanced economic development across different regions of the country and create sustainable employment opportunities.

Wastewater Treatment: An Effective Solution for Water Conservation and Environmental Protection

Wastewater treatment is one of the most important solutions for reducing the extraction of surface and groundwater. By reusing treated water in agriculture, industry, and green spaces, the consumption of freshwater can be significantly reduced, thereby helping to preserve water resources.

In addition to conserving water, wastewater treatment prevents pollution of natural resources and contributes to improving environmental quality and public health.

Prioritizing wastewater treatment in each region ensures that the treated water is used in the same area, thereby preventing pollution, optimizing the water-use cycle, and reducing pressure on water resources.

Water Management Solutions Tailored to the Geographical Characteristics of Each Region

Desert and Arid Regions

In these regions, the main priority is the use of water-efficient agricultural methods and drought-resistant plants. The application of drip irrigation, mulching to preserve soil moisture, and the rehabilitation of qanats can significantly reduce water consumption. In addition, the use of treated wastewater in green spaces and agriculture, as well as the utilization of solar desalination plants, can provide new and sustainable water resources.

Mountainous Regions (such as the Alborz and Zagros)

Protecting groundwater resources and springs is of great importance in these areas. The development of mechanized qanats for transferring water to plains, the construction of small local dams to control runoff, and the storage of rainwater are among the key solutions. The main water resources in these regions include springs, rainfall, and runoff, which must be managed sustainably.

Forested and Humid Regions

In these areas, protecting vegetation and forests is highly important because vegetation plays an effective role in maintaining soil moisture and preventing erosion. Managing runoff and preventing pollution of water resources are

among the measures that should be implemented. In addition, the use of modern technologies to improve water-use efficiency in agriculture and industry is recommended in these regions.

Coastal and Marine Regions

In these regions, exploiting saline water through solar desalination technologies and wave energy can provide suitable water resources for agriculture and industries. Protecting wetlands and coastal ecosystems is essential for maintaining environmental balance.

Legal Framework and Multi-Level Management System for Improving Water Consumption and Management

For water management in the country to be effective and sustainable, we need a coherent legal framework and a multi-level management system that can be implemented at all levels and pave the way for facilitation and cooperation among government agencies and the public.

National Level

At this level, legislation should be clear and binding. Enacting laws such as the “requirement to mechanize irrigation systems in agriculture and industry,” the “condition for issuing and transferring property deeds subject to compliance with water-consumption management regulations,” and the “requirement to include a geographical water-management annex in industrial and development projects” would provide legal facilitation. In addition, a clearly defined organizational structure, such as a Supreme Water Council, should be established to assume responsibility for macro-level coordination among ministries, organizations, and relevant institutions.

Provincial and Regional Level

At this stage, water-resource management is organized according to geographical characteristics and regional needs. Provinces should have water-resource management offices that serve as facilitators for implementing macro-level policies and coordinating among local institutions and the private sector. Financial and technical support for mechanizing irrigation systems and water recycling in industries should also be pursued at this level.

Local Level and Water Users

Ultimately, farmers, industries, and the public should be directly involved in managing water consumption. Education, awareness-building, and the provision of affordable tools such as smart meters and low-loss irrigation systems are part of this process. In addition, establishing local professional associations of water users for monitoring and cooperation can contribute to sustainable water management.

This multi-level system will not only ensure that laws are implemented more accurately and practically, but will also enable faster monitoring and corrective action, ultimately ensuring optimal and sustainable water consumption.

Diverse Financing Methods for Water and Agricultural Projects

Private Sector Investment (PPP)

Establishing public-private partnership models for implementing projects such as water treatment plants, mechanized irrigation, and renewable energy in agriculture.

Local and Provincial Funds

Establishing agricultural and water development funds in the provinces using combined resources from the government, municipalities, the private sector, and public participation.

Targeted Bank Financing

Allocating low-interest or subsidized loans to priority projects, such as modern irrigation, qanats, and wastewater treatment, with long-term repayment periods.

Issuance of Participation Bonds and Sukuk

Using Islamic financial instruments for water and agricultural infrastructure projects, backed by the government or non-governmental public institutions.

International Financing and Development Loans

Utilizing resources from the Islamic Development Bank, the World Bank, or regional institutions for projects with environmental or economic returns.

Sustainable Revenue from Water and Environmental Services

Charging reasonable tariffs to water users, selling treated wastewater, or imposing environmental fees to finance maintenance and development costs...

Role of Public Institutions such as Municipalities and Free Zones

Municipalities, particularly in urban and water-scarce areas, can participate in implementing water recycling projects, irrigating green spaces with treated wastewater, and constructing wastewater treatment plants.

Support for the Production of Mechanized Water-Saving Equipment

Domestic Production Incentives

Providing production and research and development (R&D) subsidies to knowledge-based companies and domestic manufacturers of water-saving equipment, such as:

- Drip and tape irrigation systems
- Smart water meters
- Water recycling and treatment systems
- Domestic and industrial wastewater treatment equipment

Bank Facilities and Tax Exemptions

Providing low-cost financing to manufacturers of water-saving equipment and multi-year tax exemptions for high-efficiency and optimized-consumption equipment.

Support for the Mechanization of Qanat Excavation and Rehabilitation

- Designing and manufacturing mechanized qanat excavation equipment with the support of the Ministry of Industry, Mine and Trade and the Ministry of Agricultural Jihad.
- Facilitating the import of the technology and machinery required for qanat rehabilitation and transferring the technology domestically.

Requirement to Use Domestic Equipment in Projects

Giving priority to domestically manufactured equipment in all government projects and agricultural, industrial, and drinking-water projects in order to increase demand and stabilize the market for domestic manufacturers.

Establishment of Specialized Industrial Parks

Establishing industrial parks or clusters for the production of water-saving equipment with complete infrastructure, export support, and access to regional markets.

Promoting the Use of Water-Saving Equipment through Media and Education

- Providing information and training to users and farmers to familiarize them with the benefits of using such equipment, in cooperation with the Ministry of Agricultural Jihad, the Islamic Republic of Iran Broadcasting (IRIB), and mass and professional media.
- Providing support and incentives for participation in specialized exhibitions.

Successful Experiences that Can Serve as Models for Water Conservation

Use of Treated Wastewater in Agriculture – Tunisia

Tunisia is a dry and water-scarce country in North Africa with a Mediterranean and desert climate similar to Iran's. Tunisia has managed, through investment in urban wastewater treatment, to meet nearly 30% of its agricultural water needs with recycled water. This approach has both reduced groundwater extraction and transformed the wastewater problem into a source of water supply while maintaining environmental protection. This model can be implemented in many Iranian cities, such as Yazd, Kerman, and Mashhad.

Modern Greenhouse Cultivation – Turkey

Over the past decade, Turkey has made significant investments in smart greenhouses. By using controlled systems, water consumption has been reduced by up to 90% compared with traditional agriculture. At the same time, economic productivity has increased and exports of greenhouse products have grown substantially. Iran can also follow this path in water-constrained areas, particularly in southern Kerman, Fars, Isfahan, and Khorasan.

Qanats Rehabilitated with New Technology – Iran

In Razavi Khorasan and some parts of Yazd, projects have been carried out to rehabilitate traditional qanats using mechanized technology. These projects have provided a sustainable supply of water for agriculture over distances of tens of kilometers, with minimal cost and energy consumption. This successful Iranian experience can be implemented in many foothill areas of the country within the Zagros and Alborz mountain ranges.

Subsurface Irrigation – Australia

In states such as New South Wales, farmers have been able to irrigate plant roots directly without evaporation by installing subsurface irrigation systems. By reducing evaporation by up to 70%, this method has significantly reduced water consumption while also increasing plant growth. In Iran, it can also be used in hot and low-rainfall areas such as Sistan, Bushehr, and Ahvaz.

Hydroponic Cultivation (Soilless) – The Netherlands

The Netherlands, despite limited water and soil resources, is one of the world's major agricultural exporters. The key to this success is the use of hydroponic cultivation, which does not require soil and significantly reduces water consumption. This method has strong economic justification in areas of Iran with poor soil and limited water, such as the southern coasts or desert regions.

Rainwater Harvesting Projects – India

In states such as Rajasthan, local projects for storing rainwater in homes, schools, and agricultural centers have provided a significant portion of the required water. These projects have been implemented with the participation of local communities and institutions. In Iran, they can also be implemented in mountainous areas or regions with concentrated rainfall, such as the northwest, Kurdistan, and Kermanshah.

Iran, with its high climatic diversity, can implement a combination of these experiences regionally and in accordance with the geographical conditions of each province. The most important point is to pay attention to economic feasibility, localize the technology, and facilitate regulations for implementation so that the projects reach the implementation stage rather than remaining merely on paper.

Cloud Seeding Technology and Optimal Management of Heavy Precipitation

Cloud seeding is one of the scientific and economically viable methods for increasing precipitation in dry and low-rainfall regions. In this method, specific particles such as silver iodide or natural salts are introduced into suitable clouds to enhance and intensify the precipitation process. In our country, this technology has also been tested and used on a limited scale in provinces such as Yazd, Kerman, and Khorasan, while its basic infrastructure is currently being developed.

Alongside increasing precipitation, one of the important advantages of this technology is the possibility of managing heavy and flood-producing rainfall. Through proper planning and cooperation among meteorological organizations, water-resource authorities, crisis-management agencies, and passive-defense institutions, heavy rainfall can be utilized for groundwater recharge, reservoir filling, wetland restoration, and controlled flood routing, so that instead of causing damage, it can become a resource for restoring the country's water resources.

The role of towers installed at high elevations and strategic locations is very important in this technology. These towers introduce cloud-seeding materials at locations with the highest probability of precipitation formation and adjust the route and intensity of operations precisely according to atmospheric data.

In addition to China, which has invested \$1.5 billion in this field in recent years, the United States, Russia, and the United Arab Emirates can also be mentioned as countries active in this area. Each has made significant investments and developed advanced infrastructure and has reported positive experiences with this technology in the management of its water resources.

The most important factor in the successful implementation of this technology is its potentially significant economic and environmental benefits, which can create opportunities for attracting private-sector investment. To realize this potential, it is necessary to facilitate the legal framework and establish clear and transparent rules for investors so that capital can be directed toward these projects and their implementation can be carried out systematically and efficiently.

With proper policy and regulatory frameworks and support for private-sector participation, including agricultural and agro-industrial enterprises, cloud-seeding technology can play an effective role in improving the management of the country's water resources and constitute one component of broader efforts to address drought and water scarcity.

Stakeholder Participation Through Private Investment: The Key to Sustainable Water Management

The more professional associations, local and community organizations, civil-society groups, and private investors become partners and beneficiaries in water-saving projects, the stronger their motivation and demand will be for the continued, expanded, and sustainable implementation of such projects.

From investment in smart irrigation equipment to wastewater treatment, mechanized qanat development, and water recycling in industry and agriculture, if long-term economic benefits are created for the private sector, these projects can move beyond being temporary government-led initiatives and become genuinely sustainable and community-supported programs.

Legal Requirement for Mechanizing Water Consumption in Governmental and Semi-Governmental Organizations

The government can formally require all governmental and quasi-governmental organizations, endowment institutions, and municipalities that use water in agriculture, industry, drinking-water supply, and other sectors to adopt mechanized and efficient water-consumption systems.

This process should be accompanied by the approval and supervision of water and wastewater experts, agricultural authorities, and other relevant technical bodies so that water consumption is optimized while creating a practical model for the private and public sectors.

Such a measure would encourage large organizations to move away from inefficient water consumption and take a leading role in smart water management and conservation, thereby supporting the implementation of broader national water-management policies.

Innovative Water-Saving Solutions with an Emphasis on Domestic Technologies and Nanotechnology

The use of nanotechnology in the water sector, particularly domestically developed technologies, offers numerous opportunities to reduce consumption and improve water quality. Nanoparticles and nanobubbles can potentially reduce evaporation, optimize treatment processes, and enable smarter control of water distribution.

For example, nanobubbles in water and wastewater treatment can increase the efficiency of pollutant removal and reduce energy consumption. In agricultural irrigation, the use of nanobubbles may improve water uptake by plant roots and reduce evaporation, potentially resulting in significant water savings.

In addition to nanotechnology, domestic technologies such as smart drip-irrigation systems, smart meters, and soil-moisture sensors enable more precise and efficient management of water resources. These technologies can reduce water losses and increase water-use efficiency in agriculture, industry, and household consumption.

Overall, integrating domestic nanotechnology with other advanced technologies can provide an appropriate pathway toward sustainable water-resource management, while simultaneously protecting the environment and significantly improving efficiency.

Silver nanoparticles have applications in water treatment and possess strong antibacterial properties, which can potentially reduce the use of chemicals and energy in treatment processes.

For example, titanium dioxide nanoparticles are used as catalysts in wastewater treatment through photocatalytic processes, where pollutants can be degraded without relying on large quantities of harsh chemicals, potentially reducing the demand for freshwater.

Porous silica nanoparticles can increase moisture retention in agricultural soils and reduce irrigation requirements.

Nanobubbles in drip irrigation can improve water uptake by plants and reduce surface evaporation, with some studies and applications reporting improvements in water-use efficiency of up to 30 percent.

Desertification Control: A Path Toward Land Restoration and Strengthening the National Economy

Combating desertification is one of the important approaches to protecting natural resources and increasing economic productivity. By using modern technologies such as drone-based seed dispersal, vegetation cover can potentially be restored rapidly in arid and desert regions through rainfed methods. Such measures can contribute to the restoration of rangelands and public lands and reduce dependence on imported livestock feed, potentially contributing to lower meat prices and stronger food security.

A global example often cited in this context is the Great Green Wall initiative in Africa, which began in 2005. Such initiatives demonstrate that with careful planning and the use of modern technologies, land restoration and desertification-control programs can be advanced more effectively and contribute to sustainable development.

Conclusion of Part Two: Modern Technologies and Strategic Water-Resource Management

It has become clear that the use of modern technologies such as cloud seeding, intelligent flood management, and advanced infrastructure can play an important role not only in increasing water-use efficiency but also as part of a broader strategy for managing the country's natural resources and strengthening water security at the geopolitical level.

Countries active in this field have demonstrated that targeted investment and an appropriate legal and regulatory environment are important factors in the sustainable utilization of water resources. By facilitating private-sector participation and developing domestic technologies, it is possible to move toward smarter water-resource management and make more effective use of the country's natural capacities.

This approach can contribute to strengthening the country's strategic position in the region and enhancing food security, environmental sustainability, and economic resilience.