

Water Security Risk – Part Six

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

The Secrets of Water Management Over Time: From Complex Challenges to New Horizons

Water is a vital source of life and the foundation of sustainable development for every country. However, its management has always faced numerous challenges. Over the past decades, water-management policymaking in our country has followed a complex and winding path, influenced by climatic, economic, social, and technological factors. Examining this trajectory not only reveals the problems and weaknesses of the past, but also presents promising prospects and unique opportunities for improvement and innovation in water-resource management. In this analysis, we will take an in-depth look at the influential factors and the key role of managers in shaping water policies, while presenting ways to move toward a sustainable and hopeful future.

The Impact of Dredging on Water Conservation

The Impact of Failing to Dredge Rivers and Dams on Water Loss in Iran

Failure to dredge rivers and dams causes sediment to accumulate in their beds and reduces the effective storage capacity of reservoirs. As a result, during heavy rainfall, part of the water flows over the spillways instead of being stored in dams and is consequently lost. Studies indicate that in Iran, due to sedimentation resulting from insufficient dredging, approximately **0.5% to 0.75% of the effective storage capacity of dams is lost annually**. This figure becomes highly significant over the long term. For example, the capacity of the Dez Dam has reportedly declined by nearly 20% over approximately 40 years of operation, rendering a portion of its capacity unusable. In addition, estimates by the World Bank indicate that approximately **236 million cubic meters of the country's water-storage capacity are lost annually** during the rainy season as excess water overflows from reservoirs for this reason.

This reduction in capacity causes dams to fill more quickly during the rainy season, resulting in a significant volume of runoff being wasted. To reduce this problem, regular dredging of reservoirs and riverbeds, erosion control in upstream areas, and sediment monitoring are essential. Implementing these measures can prevent the loss of millions of cubic meters of water every year and extend the useful life of dams.

Simple Solutions for Dredging and Preventing Water Loss, with Priority Given to Community Investment

1. Periodic Manual and Mechanical Dredging

In small areas and shallow rivers, manual dredging can be carried out with the assistance of local communities and volunteers. This approach is relatively low-cost and can help preserve reservoir capacity and maintain the free flow of water.

2. Controlling Soil Erosion Upstream

Planting trees and vegetation in watersheds, preventing inappropriate agricultural practices, and stabilizing soil can reduce the amount of sediment entering rivers. Local residents and farmers can participate in these efforts.

3. Establishing Local Funds for Maintenance and Dredging

Establishing community-based funds to finance dredging and water-resource maintenance can be an effective way to attract local investment and encourage participation in resource protection.

4. Use of Nanobubble Technology

Nanobubble technology, which generates extremely small air bubbles in water, can contribute to water treatment and quality improvement and may help reduce suspended sediments. This technology has recently been adopted in some countries and has the potential to reduce sedimentation and improve reservoir efficiency. In Iran, however, although it has been implemented in certain areas, it is still at an experimental stage in this particular context and requires greater support and investment.

Economic Benefits of Using Materials Extracted Through Dredging

1. Supplying Construction and Infrastructure Materials

Sediments and sands extracted from riverbeds and reservoirs can, after screening and treatment, be used as sand, gravel, and clay in construction projects, road building, brick manufacturing, and cement production.

Result: Reduced costs associated with extracting materials from new mines and conservation of natural resources.

2. A Source of Income for Local Communities

By establishing community cooperatives or local companies to collect, sort, and sell dredged materials, sustainable employment opportunities can be created for rural and coastal communities.

Result: Strengthening the local economy and increasing people's motivation to participate in dredging activities.

3. Reducing Waste-Disposal Costs

If sedimentary materials are properly recycled, there will be less need to transport and dispose of them at distant sites. This can reduce the costs of transporting and landfilling dredged sediments.

4. Use in the Rehabilitation of Agricultural Land

Fine-grained sediments, particularly those removed from dam reservoirs, often contain useful organic and mineral materials that can be used to improve the structure of poor and degraded soils.

Result: Reduced expenditure on chemical fertilizers and increased soil fertility.

Environmental Benefits of Using Dredged Materials

1. Preventing Excessive Extraction from Natural Resources

Using dredged materials instead of extracting sand and gravel from rivers and mountains can reduce environmental degradation and soil erosion.

Result: Preservation of natural ecosystems and reduction of the adverse impacts of open-pit mining.

2. Recycling Natural Materials within the Environmental Cycle

Using dredged materials in wetland restoration projects, soil stabilization, or the creation of green belts can help return mineral materials to natural ecosystems.

3. Improving Water Quality and Aquatic Habitats

Removing contaminated sediments from riverbeds can reduce heavy-metal pollution and suspended contaminants in the water and improve ecological conditions for aquatic organisms.

4. Rehabilitation of Degraded and Desertified Lands

Combining dredged materials with compost or organic matter can be used in desertification-control projects and the rehabilitation of saline or low-productivity lands.

Practical Proposals for the Utilization of Dredged Materials

- Establishing local processing workshops for sorting and preparing extracted materials.
- Developing environmental and health standards for the safe use of sediments.
- Government support for job-creation projects and private-sector investment in this field.
- Using environmental monitoring methods to ensure that recycled materials are free from contamination.

As a result, dredged materials, if properly managed, are not merely waste; rather, they can become a valuable economic and environmental resource.

Their intelligent utilization can lead to lower costs, increased local income, protection of natural resources, and environmental restoration.

This represents an effective step toward the sustainable management of the country's water and natural resources.

Methods for Directing Excess Reservoir Water and Seasonal Rainfall to Qanats, and Various Water-Storage Methods

1. Directing Excess Water to Qanats:

Direct Channeling: Constructing dedicated channels to transfer excess water from reservoirs or rivers to qanat openings.

Construction of Interconnecting Wells: Creating wells to transfer surface water into underground aquifers that supply qanats.

Flow-Control Systems: Installing water-control structures to regulate and more accurately distribute water between reservoirs and qanats during periods of high water availability.

2. Types of Water-Storage Methods:

Underground Dams: Storing water in underground aquifers through infiltration into the soil (recharge), which helps reduce evaporation and water loss.

Storage Basins: Constructing small- and medium-sized basins to collect and store water near the point of use.

Earth Reservoirs and Embankments: Using soil and vegetation to construct low-cost reservoirs for storing rainwater and surface runoff.

Aquifer Recharge and Watershed Management: An engineering approach to strengthening groundwater storage by controlling the entry of excess water into underground aquifers.

Tanks and Storage Reservoirs: Used at household and rural scales for storing water for consumption.

Benefits of Earthen Ponds for Water Conservation and Their Applications

Earthen ponds are water-storage facilities constructed using soil and natural materials. Due to their low cost and ease of construction, they are widely used in rural and agricultural areas of Iran.

Advantages:

Reducing Water Loss: Earthen ponds can help improve the storage of rainwater and surface runoff by controlling rapid infiltration and excessive water loss.

Increasing Local Water Storage: These ponds increase local water-storage capacity and reduce dependence on distant water resources.

Supplying Agricultural Water: Particularly during dry seasons, stored water can serve as a reliable source for irrigating agricultural fields.

Supporting Groundwater Recharge: Water stored in earthen ponds can gradually infiltrate into underground aquifers and contribute to the restoration of groundwater resources.

Applications:

- Irrigation of small and medium-sized farms and orchards
- Providing water for livestock in water-scarce areas
- Storing rainwater and surface runoff in rural areas
- Use in water-resource restoration and soil-conservation projects

The Impact of External Factors on Water Scarcity in Iran and Possible Responses

Various factors originating from neighboring and regional countries, particularly in shared transboundary water basins, have been cited as contributing to the intensification of water scarcity in Iran.

Improper Water Management and Construction of Transboundary Dams: Neighboring countries such as Turkey, Iraq, and Afghanistan have constructed major dams on some shared rivers, including the Tigris, Euphrates, and Helmand, which can reduce water flows reaching Iran. This has contributed to significant reductions in Iran's surface-water resources.

Regional Climate Change: Some countries are also experiencing lower precipitation as a result of climate change, which can have regional effects on the flow of shared rivers and consequently affect Iran.

Reduced International Cooperation: The absence of effective agreements and cooperation among countries for the management of shared water resources can increase tensions and reduce access to water resources.

Possible Responses:

1. Strengthening Water Diplomacy: Expanding negotiations and bilateral or multilateral agreements for the equitable management of shared water resources.

2. Increasing the Use of Modern Technologies: Improving water-use efficiency through modern agricultural methods, water treatment, and water recycling within the country.

3. Developing Groundwater Resources and Water Storage: Strengthening aquifer-recharge, watershed-management, and water-storage projects in order to reduce dependence on shared surface-water resources.

4. Comprehensive Monitoring and Management of River Basins: Using satellite data and advanced technologies for more accurate management of water resources.

5. Strengthening Regional Cooperation: Participating in joint projects such as flood management and environmental protection.

6. Shared Basins: The Potential Impact of Cloud Seeding in Neighboring Countries on Water Scarcity in Iran and Possible Responses

Cloud seeding is a method used by some countries to increase precipitation or influence weather conditions. In recent years, concerns have been raised that cloud-seeding activities in neighboring countries, such as Turkey or Saudi Arabia, might reduce precipitation and contribute to water scarcity in Iran.

Factors Affecting:

Targeted Cloud Seeding: Some countries seed clouds to increase precipitation in their own regions, using chemicals such as silver iodide. This may alter precipitation patterns and potentially reduce rainfall in neighboring areas.

Redirecting Cloud Flows: Changing the movement of rain-bearing clouds toward specific areas may potentially reduce precipitation in Iran's river basins.

Lack of Regional Coordination: The absence of agreements or cooperation regarding the joint management of clouds and water resources can lead to tensions and environmental problems.

Measures to Address the Issue:

1. Strengthening Regional Diplomacy and Joint Cooperation: Establishing regional mechanisms for the joint management of water resources and cloud seeding, with the aim of preventing negative impacts on neighboring countries.

2. Scientific Research and Monitoring: Establishing precipitation-monitoring stations and using remote-sensing technologies to accurately monitor changes in precipitation and the effects of cloud seeding.

3. Developing Domestic Technologies: Investing in domestic cloud-seeding technologies to optimize water-resource management and reduce dependence on natural precipitation.

4. Education and Public Awareness: Increasing public and decision-makers' awareness of the effects of cloud seeding and the need for regional cooperation.

Facilitating Laws and Regulations for Water Resource Management with Public Participation

For optimal water-resource management and addressing water scarcity, laws and regulations play a key role, particularly when public participation is prioritized. The following are among the effective laws and policies:

1. Establishing and Strengthening Local and Community-Based Institutions:

Adopting laws to establish cooperatives and community-based water-management funds, such as dredging, soil-conservation, and water-protection funds, with financial and managerial independence.

Defining the legal role of village and local councils in water-resource management and granting them participatory decision-making rights.

2. Financial and Incentive-Based Support for Public Participation:

Allocating government funding and banking facilities to community-participation projects involving dredging, erosion control, and water storage.

Providing tax exemptions or grants to encourage environmental activities and water-resource conservation by local communities.

3. Strengthening Transparency and Accountability:

Requiring government agencies to publish water-resource management performance reports and budget allocations in a transparent and publicly accessible manner.

Establishing community-based monitoring mechanisms to follow up on project implementation and ensure the efficient use of resources.

4. Developing Public Participation Laws for Water Projects:

Adopting legislation that facilitates the participation of the private sector and local communities in water-related projects, including dredging, construction of small reservoirs, desertification control, and modern technologies.

Simplifying permits and reducing bureaucracy for implementing local and community-based water projects.

5. Legal Education and Awareness Building:

Requiring public education programs on the importance of water-resource management and the role of citizens under relevant laws.

These measures can encourage people to become active partners in water protection and management, while enabling the government to better manage the costs and challenges associated with water scarcity through public participation.

Successful Domestic Models

1. Participatory Water Resource Management in Khuzestan Province (Hot and Dry Areas):

In this region, farmers and local communities have formed water cooperatives and assumed responsibility for maintaining qanats, dredging rivers, and managing small dams. This model has contributed to increased water-use efficiency and reduced water losses.

2. Aquifer Recharge and Watershed Management Projects in Kerman Province (Semi-Arid Areas):

With the participation of local communities and institutions, surface water is controlled and directed toward underground aquifers. These projects have resulted in increased groundwater storage and helped reduce water scarcity.

Successful International Models

1. Participatory Water Resource Management in Spain (Dry Mediterranean Regions):

Farmers in Spanish villages participate in irrigation cooperatives and manage efficient water use and the maintenance of irrigation canals. This historic system has increased water-use efficiency and helped manage water scarcity.

2. Aquifer Recharge and Rainwater Harvesting in Australia (Arid and Semi-Arid Areas):

Australia has used aquifer-recharge techniques, rainwater harvesting, and community participation in water-resource management to improve water storage and reduce water losses.

3. Water Resource Management Cooperatives in India (Rural and Arid Areas):

In rural parts of India, local cooperatives have been established to construct and maintain earthen ponds and drip-irrigation systems. These initiatives have helped improve access to water and promote sustainable agriculture.

These examples demonstrate that public participation, local cooperatives, and simple technologies can be used effectively in water-resource management, particularly in areas with challenging climatic conditions.

Academic and Scientific Research in Iran

1. Evaporation Modeling Using Climatic Data

A study conducted in Iran has developed models for simulating evaporation using data on temperature, relative humidity, sunshine duration, and wind speed. These models can be useful for water-resources management and for predicting crop water requirements.

2. Integrated Management of Surface and Groundwater Resources Under Drought Conditions

A study conducted in Hormozgan Province indicates that, under drought conditions, the simultaneous use of surface-water and groundwater resources can contribute to improved water-resources management.

International Research

1. Groundwater-Level Modeling Using Evolutionary Optimization Algorithms

A study conducted in Iran has developed models for predicting groundwater levels by combining evolutionary optimization algorithms with artificial neural networks, adaptive neuro-fuzzy inference systems, and support vector machines.

2. Assessing the Compatibility of Water-Resources Governance Systems Using Statistical Mechanics Methods

A study in Iran indicates that aligning water-resources governance structures with hydrological characteristics can contribute to improving the efficiency of water-resources management.

Proposed Strategies for Implementing Research

Development of Water-Resources Prediction Models: The use of predictive models can contribute to the optimal management of water resources.

Integrated Water-Resources Management: The simultaneous use of surface-water and groundwater resources can be beneficial under drought conditions.

Alignment of Governance Structures with Hydrological Characteristics: Such alignment can contribute to improving the efficiency of water-resources management.

Management Analysis of Water-Management Policymaking Across Different Periods

Water-resources management policies in the country have been influenced by various factors during different periods. Some of the most important include:

Climatic Conditions and Natural Resources: Precipitation levels, climate change, and geographical conditions have played a determining role in water-management decisions.

Population and Economic Needs: Population growth, agricultural and industrial development, and the need to provide water for domestic and industrial uses have increased complexity and changed priorities.

Technology and Scientific Knowledge: Access to modern technologies, technical expertise, and accurate data has contributed to improving policies during different periods.

Organizational and Legal Structures: The existence or absence of coherent institutional structures and codified laws has had a significant impact on the implementation of water policies.

Social and Cultural Participation: The level of public participation and public awareness has also influenced the success of policies.

The Role of Managers and Critical Assessment of Their Facilitation Role

Water-resources managers play a vital role in facilitation, coordination among different sectors, and monitoring the implementation of programs. However, in some cases:

- Lack of coordination among different institutions and sectors has slowed decision-making and policy implementation.
- Weak transparency and accountability have reduced public trust and limited public participation.
- A short-term approach to problems and insufficient use of scientific data and modern technologies have reduced efficiency.

Hope for Improvement

Given scientific advances, increasing public awareness, and the necessity of sustainable resource management, today's managers can achieve significant improvements in water management by adopting interactive approaches, using modern technologies, and encouraging public participation. Strengthening legal and organizational structures, education and awareness-building, and increasing transparency are also key pathways toward future success.

Conclusion

Water-resources management is a complex and multidimensional issue whose success requires intelligent interaction among climatic, social, economic, and technological factors. Past experiences have demonstrated that the role of managers in facilitation, transparency, coordination, and the use of modern knowledge is crucial. By increasing public participation, employing advanced technologies, and strengthening legal structures, it is possible to achieve a promising vision for sustainable water management. Although this path is challenging, with determination and comprehensive cooperation, improving water management and preserving this valuable resource for future generations is entirely possible and achievable.