Reviving Indigenous Irrigation Systems in Arid and Semi-Arid Ecosystems of Iran: A Pathway to Sustainable Water Management

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- **Water supply is a major global challenge (SDG 6).**
- **By 2030 (UN & SDG Projections):**
  - 2 billion people without safe drinking water
  - 3.2 billion facing severe water stress
  - Global freshwater demand may exceed supply by up to 40%
  - Up to 700 million people displaced due to water scarcity

- **Water = Human & National Security Issue**
  - Water and food insecurity can trigger social tensions and conflicts

Lake Urmia: Shrinking Ecosystem & Vanishing Biodiversity

Key Facts:

- **Second largest hypersaline lake**; once ~5,000 km²
- Lost **>96% of water volume** over the last 20 years
- April 2024 water level still **lower than 2010**

Biodiversity & Ecosystem Services:

- Endemic species: **Artemia urmiana** (brine shrimp)
- Habitat for **migratory birds**: Greater Flamingo, Pelican, Redshank, Heron, Gulls, Lapwings
- Provided **climate regulation, recreation, mud therapy, tourism**

Lake Urmia: Shrinking Ecosystem & Vanishing Biodiversity

- **55–75% of lakebed turned to salt flats**

Consequences of Drying:

- **Decline in biodiversity**
- **Salt storms & disease spread**
- Collapse of **tourism & agriculture**, rising **unemployment & migration**

Lake Orumieh in August 1998 and 2011

(Source: NASA Earth Observatory: https://earthobservatory.nasa.gov/images/76327/lake-orumiyeh-iran)

Human vs. Climate Factors:

- Studies show that **65–84% of the lake's water loss is due to human activities**, while only 16–35% is related to climatic changes.

2. Dam Construction and Mismanagement of Water:

- **23 dams** have been built in the lake's watershed, with **15 of them primarily for agricultural use**.
- Dams have reduced water inflow to the lake and increased evaporation, leading to severe water shortages.

3. Water-Intensive and Unsustainable Agriculture:

- The irrigated area expanded from 200,000 hectares to 500,000 hectares, with cultivation of **alfalfa, corn, sugar beet, and apple orchards**, which require large amounts of water.
- The uncontrolled development of apple orchards and inefficient irrigation practices have put extreme pressure on water resources.

4. Unreleased Environmental Water (Right of the Lake):

- Due to decisions by the Ministry of Energy and economic priorities, **the lake has not received its full environmental water share**, with approximately 2.5 billion cubic meters withheld.

5. Construction of the Causeway and Bridge:

- The causeway and bridge connecting the northern and southern parts of the lake **disrupted natural water flow** and damaged the lake's ecosystem.

6. Evaporation and Natural Water Loss:

- About **69–71% of water from precipitation evaporates**, a process intensified by dams and reduced water inflow.

Importance of Gavkhuni Wetland

Ramsar Site (1971) – International ecological value

Habitat for migratory birds & ecotourism potential

Source of Artemia & medicinal plants

Environmental risks if dried:

- Toxic dust (cadmium, zinc, sodium) → 4 provinces
- Health hazards & high economic costs

Ecosystem services:

- Carbon absorption
- Pollution reduction
- Climate moderation

Current Situation of Zayandeh Rud River and Gavkhoni Wetland

- ✓ **~30 years** without allocated water rights
- ✓ **>99% of the wetland dried**
- ✓ River flow only a few days per year → **loss of dependent species habitats**
- ✓ **Drying of green spaces and centuries-old trees** in Isfahan city

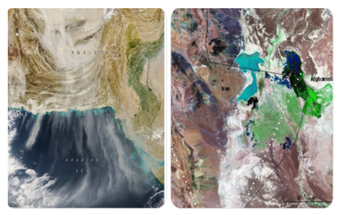

DRYING UP OF THE GAVKHONI WETLAND

Main Causes of Gavkhuni Wetland Crisis

- ✓ **Inter-basin water transfers** from Zayandeh Rud to other provinces & industries (steel, petrochemical)
- ✓ **Severe reduction of inflow** → drastic drop in water level
- ✓ **Destruction of vegetation and bird habitats** (over **106 bird species** at risk)
- ✓ Loss of **wetland water rights** (~173 million m³/year)
- ✓ **Mud and salt expansion** due to drying (Khodari Ghariband et al., 2018)
- ✓ **Climate change + unsustainable water use** intensified the crisis (Mollazadeh et al., 2024)

Hamun Basin Crisis (UNESCO Biosphere Reserve – Sistan & Baluchestan)

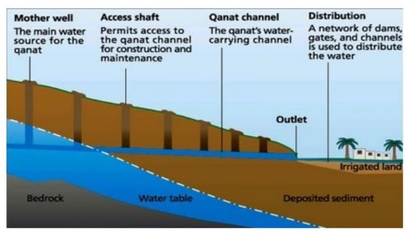
- UNESCO Biosphere Reserve (Registered in 2015, Lima Congress)
- Once a lifeline for millions, now mostly dried up
- Key Causes:
  - 20 years of drought
  - Decline of Hirmand River flow
  - Poor water management & land leasing to industrial agriculture
  - Kajaki Dam & river pumping
- Major Consequences:
  - Dust storms
  - Loss of livelihood for ~400,000 Sistani people
  - Decline of native birds & Sistani cattle
  - Damage to agriculture & horticulture
  - Widespread poverty, insecurity & migration



Source (NASA Earth Observatory. (2023, January 26). *A Dry Lake Hamun Means More Dust Storms*. NASA. Retrieved from: https://earthobservatory.nasa.gov/images/150941/a-dry-lake-hamun-means-more-dust-storms)

Reviving Indigenous Irrigation Systems

Qanat (Traditional Iranian Water System)



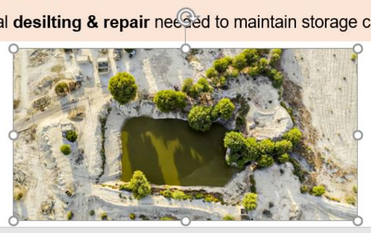
Hotak – Traditional Water Harvesting in Southwest of Iran

Benefits:

- Drinking water for **humans, livestock, wildlife**
- **Flood and soil erosion control**
- Water for **restoration projects**
- Tree planting & **green space enhancement**
- **Employment & livelihood improvement** via aquaculture

Maintenance:

- Annual **desilting & repair** needed to maintain storage capacity



Ab-Bandan – *Traditional Earthen Reservoirs in North of Iran*

Ecological Role:

- Support migratory birds (e.g., in Mazandaran, Iran)
- Regulate local hydrology by replenishing shallow aquifers
- Prevent uncontrolled flooding and soil erosion

Social & Cultural Role:

- Integrated into agro-ecosystems (rice farming, fishing, animal husbandry)
- Managed through communal labor and rotational water-use agreements (*bonk* systems)

Sources of food security and rural resilience

Causes of Decline of Indigenous Irrigation Systems

1- Environmental Drivers: Climate Variability & Ecological Stress

2- Political & Institutional Factors: Centralization & Loss of Customary Water Rights

3- Economic Pressures: Rural Depopulation & Modernization

4- Socio-Cultural Shifts: Decline of Traditional Knowledge & Social Cohesion

Consequences of Degradation of Indigenous Irrigation Systems

1- Groundwater Depletion & Hydrological Imbalance

2- Land Subsidence & Geomorphological Instability

3- Ecological Collapse

4- Decline in Agricultural Resilience & Rural Displacement

Revival Opportunities Restoring Indigenous Irrigation Systems for a Resilient Future

1– Integrating Traditional Knowledge with Modern Technology

2- Community-Based Institutions & Water Cooperatives

3- Green Economy & Aqua-Ecotourism

4- Participatory Water Governance & Policy Reform

Conclusion & Policy Implications

1- Re-establishing Bottom-Up Water Governance

- Empower local communities as custodians
- Integrate water cooperatives & Mirab councils into national strategies
- Ensures fair distribution, conflict prevention, long-term stewardship

2- Legal Recognition of Traditional Knowledge & Water Rights

- Grant legal status to customary water rights
- Provide financial incentives, heritage protection, education & training
- Supports intergenerational knowledge transfer

3- Indigenous Systems as Pathways to Water Security and Sustainable Development

- Adaptive, low-energy solutions for climate change
- Benefits: groundwater recharge, biodiversity restoration, rural livelihood resilience
- Contributes to water security, climate mitigation