Water Security Risk – Part Two

Taking Water from the Sky: The Silent Revolution That Can Quench Iran's Thirst

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The River Flowing Above Our Heads

For decades, there have been disputes over the allocation of water from rivers and qanats, both among ourselves and with neighboring countries. Yet throughout all these years, a vast, clean, and inexhaustible river has silently passed above our heads: the air surrounding us. According to scientific findings published in reputable international journals, the volume of water vapor present in the Earth's atmosphere is estimated at approximately thirteen trillion cubic meters, a figure six times greater than the total volume of water in all the rivers of the world. Today, technology has enabled us to extract safe and sustainable drinking water from this divine resource. This is no longer a science-fiction story; it is an accessible economic revolution.

Chapter One: How Is Water Obtained from the Air?

Atmospheric water harvesting technology means extracting the hidden moisture present in the atmosphere and converting it into usable water. This technology is recognized in today's scientific literature as one of the serious pathways toward water resilience, food security, and the development of water-scarce regions. Atmospheric water generators operate much like highly advanced dehumidifiers. Moist air enters the device, is cooled until it reaches the dew point, and the water vapor is converted into liquid droplets. In another method, moisture-absorbing materials such as metal-organic frameworks are used to capture water vapor, which is then released through heating, usually using solar energy.

The least expensive method of harvesting water from the air is fog collection in coastal and mountainous regions. In this method, special mesh nets are installed to collect tiny droplets of fog.

Chapter Two: Nanobubbles; The Hidden Force Behind This Revolution

Water produced from the air has a high level of purity. However, nanobubbles transform this water into a stable and bioactive oxygen-delivering solution. Nanobubbles are bubbles with a diameter of less than one-thousandth of a millimeter and possess remarkable characteristics:

- A very large specific surface area for the transfer of oxygen and nutrients
- A negative surface charge that allows them to remain suspended in water for months
- The ability to generate free radicals for the natural disinfection of water

Combining atmospheric water with nanobubbles creates a new equation: water extracted from the air, through the injection of oxygen nanobubbles, becomes a stable and nutrient-rich oxygen-delivering water that is highly valuable for agriculture, fisheries, livestock farming, and even medical applications.

Chapter Three: Iran's Special Potential, an Advantage That Should Not Be Overlooked

Scientific research shows that Iran has a comparative advantage in one of the least expensive methods of producing unconventional water in the world. According to a study published in the reputable journal *Nature*:

The southern regions of the country (the coasts of the Persian Gulf and the Gulf of Oman) have the potential to harvest up to sixty-five liters of water from fog per day per square meter.

The northern and eastern regions also have a potential of between twenty-five and forty-five liters per day per square meter.

The cost of harvesting water from fog in Iran is estimated at approximately twenty-five cents per cubic meter.

Through the transfer of technical knowledge and the localization of technology, the 25-cent cost of harvesting water from the air in Iran can be significantly reduced. Successful examples demonstrate the scale of this reduction: the domestic production of a prototype device at one-third the cost of its foreign counterpart, as well as the use of locally produced nanostructured adsorbents (MOF-801), which has reduced the production cost to less than 100 tomans (less than $0.002) per liter. In addition, research on polymer membranes under different Iranian climatic conditions has reduced energy consumption by up to 29 percent, while solar-powered adsorption systems, with an energy-consumption reduction of up to 82 percent, and passive systems inspired by space-based concepts have made it possible to produce water at a cost of less than 2 cents per liter. Ultimately, mass production and the use of renewable energy sources such as solar power can reduce the final cost to the range of 2 to 5 cents per liter, making the water produced one of the most cost-effective water resources in the country.

For comparison, desalination of seawater costs approximately sixty cents per cubic meter. This means that even without localization, fog harvesting in Iran is nearly two-thirds cheaper than seawater desalination.

With localization and a reduction in cost to 2–5 cents, atmospheric water harvesting would be 12 to 30 times cheaper than desalination. This means that in a one-million-cubic-meter project, annual savings of between $550,000 and $580,000 could be achieved. In addition, atmospheric water harvesting requires lower initial capital investment, consumes far less energy (when free solar energy is used), and can be deployed in areas far from the coast, whereas desalination requires expensive infrastructure, high energy consumption, and access to seawater. This significant difference makes atmospheric water harvesting a strategic and economical alternative for supplying water to water-scarce and inland regions.

The islands of Kish and Qeshm, along with the Chabahar region, have been identified as priority pilot locations.

In addition, Iran has an astonishing climatic diversity: from the humid southern and northern coasts to the mountainous regions of the Alborz and Zagros, and from the semi-desert regions of central Iran to the deserts of the Lut Desert and Dasht-e Kavir. This diversity means that a single technology is not suitable for all of Iran, but there is an appropriate technology for each region.

Chapter Four: Water from Air in Different Seasons and Climates — A Smart Integration with Earthen Dams and Storage

In spring, when air humidity increases in many regions, atmospheric water generation devices reach their maximum efficiency. During this season, we should store the water produced—in reservoirs, behind small earthen dams, and in underground aquifers. Imagine that in a foothill village, we store spring water in an earthen pond and, with nanobubbles, preserve it for the dry months of the year. In Golestan Province, following the 2019 floods, the construction of small earthen dams and the management of runoff in the upstream areas of the Gorgan River basin resulted in a forty percent reduction in the intensity of seasonal floods. Now imagine a similar picture: in a mountainous region, at the same time as spring rainfall, atmospheric water generators also become more active, and surplus water—from both rain and the air—is stored behind earthen dams and in storage reservoirs.

In summer, when the weather is hot and water consumption rises, condensation-based systems perform best in humid southern regions. In desert areas, adsorption-based technologies powered by solar energy come into play. During this season, priority should be given to producing drinking water, irrigating greenhouses, supplying water for livestock, and meeting emergency needs. In a greenhouse on the outskirts of Kerman, an atmospheric water generator with a capacity of five hundred liters per day supplies the greenhouse's water needs, while nanobubbles increase plant growth by up to thirty percent.

In autumn, when relative humidity decreases but remains acceptable, the focus should be on storage and supplementary irrigation. Water produced in autumn can be used for autumn planting and for restoring vegetation cover in dry areas.

In winter, when the air is cold, condensation-based systems consume more energy. During this season, adsorption technologies and dew harvesting are more suitable in humid northern and mountainous regions. In cold regions, waste heat from buildings can also be used to assist the water-generation process.

In the lush northern regions of the country, atmospheric water can complement rainfall and be used to irrigate green spaces and gardens. In mountainous areas, fog and dew harvesting should be prioritized and can be highly beneficial for remote and difficult-to-access villages. In semi-desert regions, such as many parts of central Iran, solar-powered adsorption-based systems are the best option and can supply the water needed by greenhouses, medicinal plants, and livestock farms. In desert regions, we should not become fascinated by technology; we must first calculate whether desalination is better or atmospheric water harvesting? Is a tanker better or atmospheric water harvesting? Is water transfer better or atmospheric water harvesting? Is treated wastewater better or atmospheric water harvesting? If atmospheric water harvesting wins, then we implement it.

Integration with Earthen Dams and Storage: Small earthen dams and storage ponds play a key role in this equation. Water generated from the air during humid seasons is stored in these dams and ponds and, through the injection of nanobubbles, maintains its quality for months. During the dry season, this stored water is used for supplementary irrigation, livestock farming, and drinking purposes. The successful experience of watershed management projects in Kerman Province has shown that, through flood spreading and artificial recharge, the groundwater level has increased by up to five meters. Now look at the bigger picture: rain + water from air + earthen dams + aquifer recharge + nanobubbles. This combination can significantly increase the country's water resilience.

Chapter Five: The Sun and the Air — A Heavenly Pair for Solving the Water Crisis

In the previous sections, we discussed how water can be produced from atmospheric humidity and how nanobubbles can turn this water into a stable oxygen-delivering solution. But one fundamental question remains: Where does the energy for this process come from?

The answer is the brightest energy source available to us: the sun. Integrating solar energy with atmospheric water harvesting technology not only drastically reduces costs, but also makes this technology usable in the most remote parts of the country, where there is no electricity grid.

How Does the Sun Help Produce Water from Air?

Method One: Solar-Powered Cooling

Condensation-based systems require electricity to cool the air and convert vapor into water. Solar panels supply this electricity. On sunny days, the panels produce maximum power, and the system generates water at its highest capacity. The water produced is stored in reservoirs so that it remains available at night and on cloudy days. Companies such as Watergen in Israel and Zero Mass Water in the United States have been using this method for years.

Method Two: Solar Heating to Release Water from Adsorbents

This method is more sophisticated and better suited to drier regions. Moisture-adsorbing materials (such as hydrogels or metal-organic frameworks) absorb water vapor at night, when the air is cooler and relative humidity is higher. When the sun rises, its heat warms these materials and releases the absorbed water in the form of vapor. This vapor then condenses into liquid water droplets in the cooler section of the device.

A 2024 study published in *Nature Communications* showed that a hydrogel-based device, using sunlight and natural wind, was able to produce 14.9 liters of water per square meter per day under laboratory conditions and 3.5 to 8.9 liters under outdoor conditions.

Method Three: Hybrid Solar-Electric Systems

In areas with very low humidity or cloudy days, solar heat alone is not sufficient. Researchers have designed hybrid systems in which solar energy is given priority, while auxiliary electric heating is used when necessary. Experiments have shown that in a dry climate with humidity of around thirty percent during the day, this system was able to produce 10.56 kilograms of water per day while reducing daytime electricity consumption by up to forty percent compared with nighttime consumption. This means that the sun supplies more than fifty percent of the required energy for free...

The Latest Scientific Achievements: The Intelligent Integration of Sun and Water

Research conducted in 2026 has demonstrated remarkable advances in this field:

Energy Storage Within the Adsorbent Material Itself: Chinese researchers have developed a moisture-absorbing wooden sponge that not only absorbs moisture but also stores solar heat using phase-change materials, so that during the night or on cloudy days it can heat the released water and continue the water-generation process. This means the device can continue operating even when the sun is not available!

Simultaneous Production of Water and Electricity: A new technology introduced in the *ScienceDirect* journal combines solar panels with atmospheric water harvesting to produce both water and electricity simultaneously. In this system, the waste heat generated by the solar panels is used to release water from adsorbents, while the panels themselves provide the electricity required to operate the device. One study has shown that by selecting the appropriate adsorbent based on the climate of each region, water-production efficiency can be increased by up to 18.6 percent.

Next-Generation Hydrogels: Researchers have developed a type of hydrogel that, under one-sun irradiation (equivalent to the intensity of sunlight on a sunny day), releases 89.5 percent of its absorbed water within seventy minutes and has the ability to absorb an amount of water equivalent to 4.1 times its own weight. This means that one kilogram of this material can produce more than four liters of water per day.

Iran's Special Advantage: Abundant Sunshine, an Unprecedented Opportunity

With an average of more than three hundred sunny days per year, Iran has one of the highest potentials for solar energy in the world. This means that solar-powered atmospheric water harvesting devices can operate more efficiently in Iran than in many other countries.

A 2025 study by researchers at Germany's Fraunhofer Institute specifically simulated the performance of a hybrid atmospheric water harvesting and solar desalination system under different climatic conditions in Iran. The results showed that this system performs very well in different Iranian cities. For example, water production increased by seventy percent in Bushehr and by 57.6 percent in Ramsar. Under the best conditions, the system was able to produce more than twelve thousand kilograms (twelve cubic meters) of water annually.

Domestic researchers, in cooperation with international centers, are also working on hybrid atmospheric water harvesting and solar desalination systems, which could be highly effective for the southern regions of the country, where both humidity and solar radiation are abundant.

Integration with Nanobubbles: The Golden Triangle of Sun, Water, and Air

Now look at the complete picture:

Step One: Solar panels provide free and clean energy.

Step Two: The atmospheric water harvesting device uses this energy to convert atmospheric humidity into liquid water. In dry regions, advanced adsorbent materials are used, which release water through the heat of the sun.

Step Three: This pure water is transformed, through the injection of oxygen nanobubbles, into hyperoxygenated and bioactive water.

Step Four: The supercharged water is stored in reservoirs and used for greenhouse irrigation, feeding livestock and poultry, fish farming, or even drinking purposes.

The Final Result: A system completely independent of water and electricity grids that can produce safe, high-quality water in the heart of the desert, in a remote mountainous region, or on the rooftop of an urban building.

Why Is This Integration Transformative?

Cost Reduction: Solar energy is free. Therefore, after the initial investment, the cost of producing water is drastically reduced.

Grid Independence: These systems can be used in areas where the electricity grid does not exist or is unreliable.

Environmental Sustainability: No fossil fuels are consumed and no pollutants are produced.

Easy Transportation and Installation: Solar-atmospheric water harvesting systems are modular and can be installed anywhere.

Production at the Point of Consumption: Water is produced exactly where it is consumed, bringing transmission costs and network losses down to zero.

Strategic Conclusion: Sun, Air, and Water — Three Heavenly Gifts

The combination of solar energy, atmospheric water harvesting technology, and nanobubbles creates a golden triangle that can help Iran overcome its water crisis. The sun provides energy, the air provides water, and nanobubbles enhance quality. This triangle can be implemented in the Lut Desert and along the shores of the Persian Gulf, in the Zagros Mountains and on the rooftops of urban homes.

The true value of this integration lies in the independence it provides to the country and to every residential, industrial, and service unit: independence from water networks, independence from electricity grids, and independence from technology imports. This is the path that can transform Iran from a technology-consuming country into a country that produces and exports technology.

Chapter Six: Strategic Applications — From Homes and Villages to Agriculture and Industry

In agriculture, this technology creates a remarkable transformation. In rainfed farming, water from the air is highly useful for planting seedlings, initial establishment, and emergency plant nourishment during periods of drought. In greenhouses, the water produced is free from microorganisms and harmful salts, and with nanobubbles, water consumption is reduced by up to forty percent. In hydroponic cultivation (soilless farming), water from the air eliminates the need for very high-quality water, while nanobubbles increase growth by twenty to forty percent by increasing dissolved oxygen around the roots. The greatest economic justification in agriculture is for greenhouses, nurseries, vegetables and horticultural crops, and hydroponic systems.

In livestock and poultry farming, supplying hygienic, oxygen-rich water to animals and poultry, while significantly reducing diseases, increases the quality and quantity of milk and meat production. The use of nanobubble water in livestock drinking troughs improves the health of the animals' digestive systems.

In fisheries and fish farming, this is one of the best applications of nanobubbles. Nanobubble systems, with their very high oxygen-transfer efficiency, can increase dissolved oxygen by up to seventy-one percent compared with conventional methods. Combining atmospheric water with nanobubbles in closed systems makes it possible to raise fish at high densities anywhere in the country, even in the heart of the desert.

In light industries such as workshops, packaging, food, textile, and pharmaceutical industries, atmospheric water can supply the water required for production processes. In heavy industries such as power plants, mines, refineries, and steel, the best application is in locations where water at the point of consumption is expensive, unreliable, or high-risk.

In residential homes, household devices can produce twenty to fifty liters of high-quality drinking water per day, replacing expensive bottled mineral water. In villas and buildings located far from water-supply networks, this technology can fully meet their water needs.

Rangeland Restoration and Desertification Control: By deploying atmospheric water harvesting devices in critical areas and irrigating seedlings with nanobubble water, green belts can be created, soil erosion can be prevented, and the country's need to import livestock feed inputs can be reduced through rangeland restoration.

Chapter Seven: Bringing Prosperity Back to Villages — Water, Employment, and Hope

Imagine how a remote village that has struggled with drought and the migration of young people for years could be transformed by this technology:

First, an atmospheric water generator is installed in the center of the village, producing two hundred to five hundred liters of clean water per day.

Second, this water is enriched with nanobubbles and used to irrigate a small greenhouse and supply a fish-farming unit.

Third, the greenhouse produces valuable products such as medicinal plants or out-of-season vegetables, while the fish-farming unit raises high-quality or ornamental fish.

Fourth, these products are packaged in the village itself and shipped to major cities through online sales.

Fifth, the young people of the village who had moved to cities for work return to the village after witnessing this transformation and launch new businesses.

Sixth, the village changes from a point of water consumption into a point of water and wealth production.

Seventh, the successful model of this village spreads to neighboring villages, forming a network of water- and food-producing villages.

Chapter Eight: Passive Defense — Water, the Front Line of National Defense

In critical situations such as earthquakes, floods, war, and severe drought, access to safe water is the most vital need. Atmospheric water harvesting technology is considered a strategic tool for passive defense:

During an earthquake, when water-supply networks are destroyed, mobile atmospheric water harvesting units can provide safe drinking water for affected areas and relief forces within a few hours. These units do not require infrastructure and operate using solar energy or small generators.

During war and blockade, when an enemy may target surface and underground water resources, atmospheric water harvesting systems in shelters, military bases, and command centers ensure water security for the armed forces and the population. In difficult-to-access and border areas, these systems greatly reduce dependence on water-supply tankers, which themselves are vulnerable targets.

During prolonged droughts, when groundwater levels decline sharply and rivers dry up, atmospheric water harvesting can serve as a supplementary source, reducing pressure on natural resources and increasing the country's resilience.

At border posts and in difficult-to-access areas, where transporting water by tanker is extremely costly and risky, atmospheric water harvesting devices can sustainably meet the water needs of stationed personnel.

The integration of nanobubbles into passive defense transforms the produced water into disinfected and stable water that can remain stored in reservoirs for months while maintaining its quality.

Chapter Nine: Rule Architecture for Widespread Adoption — From Law to Practice

For this technology to become widespread across the country, we need a smart policy package consisting of the following layers:

Layer One: Technical and Health Standards
Developing national standards for the quality of water produced from air, energy consumption, and equipment safety. The National Standards Organization and the Ministry of Health should define separate standards for drinking, agricultural, and industrial uses.

Layer Two: Legal Requirement for Installation in Buildings
Just as the installation of fire-alarm systems and emergency stairways is mandatory in buildings today, the installation of atmospheric water harvesting systems should also be considered a legal requirement in new buildings, particularly government buildings, hospitals, schools, hotels, and large residential complexes. Members of Parliament can establish this requirement by approving an article in the Engineering Organization Law. In addition, issuing completion

certificates for new buildings could be made conditional upon the installation of these systems.

Layer Three: Legal and Regulatory Facilitation
The government, in cooperation with Parliament, should enact a law supporting the development of new water-related technologies. This law should provide for tax exemptions for domestic manufacturers and component importers, facilitate the issuance of permits, and establish preferential tariffs for domestically manufactured equipment. The Plan and Budget Organization should also allocate an independent budget line to support pilot projects.

Layer Four: Support from Military, Security, and Passive Defense Institutions
The Ministry of Defense, the General Staff of the Armed Forces, the Crisis Management Organization, the Red Crescent, the Ministry of Health, the Ministry of Energy, and the Passive Defense Organization should participate in developing standards for portable and mobile systems and allocate budgets for deploying these systems at military bases, border posts, and public shelters.

Layer Five: Support from the Ministry of Health and the Crisis Management Organization
The Ministry of Health should establish and supervise standards for the quality of drinking water produced from air. The Crisis Management Organization should also plan the strategic storage of these systems in emergency warehouses throughout the country so that they can be immediately deployed during crises. The Red Crescent can also use this technology in its humanitarian assistance operations.

Layer Six: Support for Domestic Production and Exports
The Ministry of Industry, Mine and Trade should support domestic manufacturers of atmospheric water harvesting equipment, nanobubbles, solar panels, and storage tanks by providing low-interest bank facilities and tax exemptions. It should also create specialized industrial parks and support exports, paving the way for Iran to become a regional hub for atmospheric water technology exports. The export of engineering services, implementation consulting, and equipment to

water-stressed countries in the Middle East, Central Asia, and North Africa could generate significant foreign-exchange revenue for the country.

Layer Seven: Ecosystem for Popularizing the Knowledge-Based Economy

By establishing a University Water and New Technologies Cooperative Foundation, managed professionally by universities with relevant academic disciplines, an effective model can be designed for the industrialization of atmospheric water harvesting and nanobubble technology. By establishing credit and obtaining bank financing and resources from national development funds, this foundation can reduce the financial risk of the initial steps and, by smoothing the implementation and financing process for projects, create the conditions for connecting academic elites, knowledge-based companies, and industries.

Within this structure, professors, employees, students, graduates, and local residents of each region can join the foundation by allocating participatory shares and, while attracting small-scale public capital, transform the knowledge-based economy from a centralized model into a cellular, participatory, and people-based structure. By establishing a specialized accelerator and a joint innovation center, this foundation can facilitate the reverse migration of talented people and create synergy among knowledge-based companies in the fields of designing, manufacturing, installing, and operating atmospheric water systems. By assigning operational projects according to the specialization of each entity, it can accelerate the cycle from research to production.

Furthermore, by utilizing the capacity of academic theses and internship projects, specialized human resources can be trained within universities, and by allocating shares to students and graduates, their retention in their native regions can be ensured. The foundation's key role in establishing credit, obtaining financing, and facilitating the legal pathway for projects not only reduces investment risk, but also creates the conditions for attracting both small and large-scale capital and encourages major water-intensive industries to participate in this ecosystem.

By creating a domestic market for knowledge-based products, reducing dependence on imports, creating sustainable employment, and laying the groundwork for exporting technology and engineering services to neighboring countries, this model can transform Iran into a regional hub for atmospheric water technology.

Chapter Ten: Economic Justification — Why Is Water from the Air Cheaper Than Many Other Methods?

According to published scientific data, the cost of harvesting water from fog in Iran is about twenty-five cents per cubic meter, which, through localization and the use of solar energy, will be reduced to 2–5 cents. For comparison:

- **Seawater desalination:** about sixty cents per cubic meter
- **Transporting water by tanker over long distances:** several dollars per cubic meter
- **Drilling deep wells in desert areas:** high initial costs and a gradual decline in water yield
- **Wastewater treatment:** between thirty and fifty cents per cubic meter (depending on scale)

This means that atmospheric water harvesting in suitable areas of Iran costs at least close to two-thirds of seawater desalination and is far cheaper than transporting water by tanker.

However, the real value of this technology lies not only in the cost of producing water. Its main value lies in producing water at the point of consumption and eliminating the costs of transmission and distribution. When water is produced exactly where it is consumed, the costs of pipelines, pumping, network maintenance, and losses during transmission—which in Iran sometimes reach thirty percent—are reduced to zero.

Combining it with nanobubbles increases the value of the produced water several times over. Water enriched with nanobubbles can reduce water consumption in agriculture by up to thirty percent, increase fish growth in aquaculture by up to twenty percent, and improve the quality of final products in light industries. This means that every liter of water extracted from the air and combined with nanobubbles creates far greater economic value than one liter of ordinary water.

Chapter Eleven: Strategic Conclusion — From Water Crisis to Water Power

Atmospheric water harvesting technology and its integration with nanobubbles are not merely a technical solution; they are a manifesto for socioeconomic transformation. This technology can:

- Increase gross domestic product by creating new industries and jobs.
- Reduce imports and increase exports through the production of strategic agricultural products.
- Transform the economy from a centralized state-controlled model into a cellular, distributed, and people-centered economy.
- Store water during humid seasons and in humid regions for dry seasons, thereby creating sustainable water security.
- Make reverse migration to villages possible and revitalize rural areas.
- Reduce pressure on support institutions by creating employment and income.

The true value of water from the air does not lie in the amount of water a device produces, but in the amount of water that can be conserved through it by preventing unsustainable extraction from rivers, aquifers, and natural resources.

This is precisely the point at which water from the air can move from being an attractive technology to becoming a real tool for water security, food security, economic security, and Iran's resilience.

The slogan of this manifesto for a silent revolution:

From the water present in the air to the water economy — let every region have its own water source.

Connection with Previous Strategic Proposals

This memorandum is one link in the chain of solutions presented in previous memoranda on managing water-security risk and the role of watershed management in strengthening water security. Those memoranda emphasized the dredging of dams, the restoration of qanats, aquifer management, floodwater spreading, and public participation. Now, atmospheric water harvesting is added to this set as a new complementary resource.

The complete picture of water management in Iran is a combination of these solutions:

Natural water (rain, rivers, aquifers) + **non-conventional water** (atmospheric water harvesting, desalination) + **recycled water** (treated wastewater) + **storage** (dams, earth dams, aquifer management, reservoirs) + **efficiency** (nanobubbles, smart irrigation, leakage reduction) + **public participation** (cooperatives, local funds, people-centered economy)

This is the smart and decentralized portfolio of water resources that can help Iran move beyond water scarcity and toward a sustainable, resilient, and green future...