Proposal for Water Management Including Provision of Water Resources of Atmospheric Origin for the Islamic Republic of Iran

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INTRODUCTION

This proven Ionospheric Climate Modification (ICM) program has the ability to resolve all the environmental issues faced by the Islamic Republic of Iran, to prevent, stop and even more importantly reverse the degradation of ecosystems such as eliminating pollution, rising sea levels, reviving hundreds of millions of hectares, covering terrestrial as well as aquatic ecosystems, along with many other climate issues on all parameters as well as most importantly deliver levels of clean water resources to ensure future water security for all within the Islamic Republic of Iran.

SUMMARY

The Islamic Republic of Iran is facing a severe and escalating water crisis. The resulting "water bankruptcy," in which demand far outstrips supply, has led to widespread drought, desertification and the depletion of aquifers.

Across Iran, the arid central plateau, southeastern regions, and several major cities are suffering most from desertification and water crises. These regions are experiencing the most severe effects of drought, poor water management, and climate change, which have destroyed ecosystems and displaced populations.

The Ionospheric Climate Modification technology has already proven to successfully resolve issues of this type in the Islamic Republic of Iran, albeit on a short term basis, having successfully delivered much needed water resources within the country previously, albeit on individual short term ‘test’ basis:

Project "Kerman" - Iran 2007

On the 31st May 2007 a two month demonstration began of the Climate Modification Program over a 100 square kilometre pre-determined area within the Hamun-e Jaz Murian region of Iran - coordinates 31.4360° N, 49.0413° E.

The Khanuj Weather station’s data showed an average monthly precipitation level in June as just 0.7 mm and 2.9 mm in July for the preceding five years.

The Mohammad Abad Koteki Weather station, which is situated close to the centre of the demonstration area (longitude of 58-36E, latitude of 27-49N) reported that on the 24th July 2007 the level of precipitation in the pre-determined area was 23 mm.

There was a further 13 mm precipitation on the 26th July 2007 - a total precipitation of 36 mm was achieved within the pre-determined area within sixty days.

An additional result of the operation included a change of the weather conditions over the region.

The precipitation in Iranshahr during the month of June was increased 64%, based on the average annual precipitation rate and the precipitation level in July was in excess of thirty times the previous five year average.

Project “Urmia" - Iran 2010

The aim of project Urmia was to raise precipitation levels above the seasonal norm by 30 - 40 mm during a month long trial. Project Urmia was a massive success, generating more than 60 mm of rainfall.

Precipitation for 30 days within the epicentre of the project target area from 30th May 2010 to 29th June 2010 was more than 100 mm and over the same period in excess of 150 mm of rain fell within bordering regions in Iran.

Notably Khuzestan Province, which was the epicentre of the first precipitation and Tehran, the epicentre of the second precipitation experienced in excess 250% increase in precipitation, in comparison to the historic climatic norm.

An additional result of project Urmia was that significant levels of precipitation fell over 85% of Iran during the “dry season”.

Project "Khuzestan" - Iran 2011

The month long demonstration took place from the 10th January 2011 through to the 9th February 2011, during the demonstration period the precipitation level over the entire region was between 50 to 200 mm of rainfall, which equates to approximately 250% above the seasonal norm for this region in addition, zonal anomaly ranged from 60 to 150 mm of precipitation equating to an annual rate of 280 mm rainfall.

Conclusion

To ensure long-term full recovery of all the water resources within the Islamic Republic of Iran — including fully replenished aquifers, reservoirs and lakes, reduction of sand and salt storms as well as reversal of regional desertification - it is proposed that the Ionospheric Climate Modification program should be operational for a period of two to three years minimum to ensure full distribution of water resources across the entire country.

The strategy for the delivery of water resources should initially focus on the worst affected cities and provinces. As of late 2025, Iran's water crisis is most severely impacting the provinces of Tehran, Isfahan, Khuzestan, Sistan and Baluchestan, and Razavi Khorasan.

Most impacted provinces

Sistan and Baluchestan

This southeastern province is one of the driest in Iran, experiencing some of the most dramatic rainfall deficits—as high as 72% below average in 2024–25.

Area: 181,785 km^2

Cities and villages affected: Entire villages are being abandoned as water resources disappear, forcing residents to migrate.

Ecological and health consequences: The drying of Lake Hamoun has created dust storms, worsening air quality and public health.

Source depletion: Reservoirs like the Chah nimeh have fallen to critically low levels.

Khuzestan

Despite being a historically water-rich province in the southwest, Khuzestan has been devastated by mismanagement, excessive dam construction, and drought.

Area:: The most commonly cited figures are between 63,238 km² and 64,057 km

Cities affected: Ahvaz, Mahshahr, Susengerd, and Shush have severe water shortages, with water delivered by tankers in some areas.

River salinisation: Projects like the Gotvand Dam have increased the salinity of the Karun River, damaging agriculture and causing skin and intestinal diseases.

Health and environmental issues: Dried wetlands, such as the Hoor-al-Azim marsh, have intensified dust storms and public health crises.

Tehran and Alborz

The capital and its neighbouring province face a critical and worsening water crisis due to overpopulation, overuse, and severe drought.

Tehran province

Area: 18,814 km²

Capital: The city of Tehran is approximately 615 km²

Alborz province

Area: 5,833 km²

Capital: The city Karaj is approximately 180 km²

Cities affected: Tehran and Karaj are experiencing water rationing, reduced water pressure, and infrastructure problems.

Dam levels: The capital's water reservoirs are at critically low levels, with some nearly empty.

Infrastructure risks: Decades of excessive groundwater extraction have caused significant land subsidence, with parts of Tehran sinking up to 31 centimetres per year, threatening infrastructure.

Isfahan

In central Iran, Isfahan is one of the cities most emblematic of the water crisis due to the drying up of the Zayandeh Rud river.

Area: The city of Isfahan is 551 km^2, while the larger Isfahan Province is 107,029 km^2. The Greater Isfahan metropolitan area covers 4,500 km^2

River's disappearance: The river, once the lifeblood of the city, now runs dry for much of the year due to drought and upstream water diversion projects.

Land subsidence: Excessive groundwater pumping to compensate for the dry river has led to major land subsidence, endangering the city's historical buildings and infrastructure.

Razavi Khorasan

Located in the northeast, this province and its major city, Mashhad, are experiencing extreme drought conditions.

Razavi Khorasan province is approximately 118,884 km^2

Mashhad's crisis: Mashhad, a major pilgrimage city, has one of the most severe urban water crises in the country.

Dam depletion: The Doosti Dam, a critical water source, was at "dead storage" in 2023, making its water unusable.

Emergency measures: Authorities have been forced to implement rationing and drill emergency wells to maintain supply.

Other impacted provinces

Other provinces facing significant water stress include:

Fars: The city of Shiraz faces strain on its water supplies due to years of drought and infrastructure failure. Fars province in Iran is approximately 122,400 to 122,608 km^2

Hormozgan and Bushehr: These southern provinces have seen major rainfall deficits.

Markazi and Hamadan: These provinces have also experienced critical water shortages. Hormozgan province is 70,697 km^2 and Bushehr province is approximately 1,163 km^2

West Azerbaijan: The ecological collapse of Lake Urmia has created environmental and health problems for nearby communities, including the city of Tabriz. The province of West Azerbaijan covers an area of 37,437 km^2, or 43,660 km^2 when including Lake Urmia

BRIEF OVERVIEW OF THE IONOSPHERIC CLIMATE MODIFICATION TECHNOLOGY (ICM):

ICM Technological solutions allow seasonal regulation of atmospheric processes in a defined area dictated by the client, by transferring wetted air masses from over-wetted areas of the Indian and Pacific oceans to arid regions and to ensure the long-term, even permanent, presence of additional moisture in arid regions and maintain a given climate regime.

This environment friendly Modification Technology program, is capable of resolving many of the environmental issues, both current and future, faced by the Islamic republic of Iran.

The Innovative Climate Modification Technology has successfully completed tests of the unique advanced Technology in the United Arab Emirates, Islamic Republic of Iran, India (Mumbai State), and other countries since 2007 and is safe and ecologically friendly and does not use any chemical components and is reversible.

BENEFITS OF THE TECHNOLOGY:

- The Client defines the weather regime and area for an agreed duration (minimum of 1 year).
- The results of the application of the technology will be visible within 2-3 months.
- Integrated use of the technology will solve the country's needs for water resources within 2 to 3 years.
- A stable change of weather conditions on the territory of the Client will occur within 5 to 7 years
- Within 5-7 years the country's water security will be completely secured

The ICM program would ensure the delivery of Mega-litres (ML) of water over vast distances and atmospheric precipitation in an area determined by the Client, presenting a real solution of water security for countries suffering from water scarcity.

The water of atmospheric origin has numerous advantages over the conventional methods of supplying fresh water and has a positive impact on the agricultural sector, energy sector, and the entire economy of any country.

IONOSPHERIC CLIMATE TECHNOLOGY:

1. Collection and processing of data on atmospheric processes, formation of control algorithms, and control of execution are carried out in real-time and over large areas.

2. Managing weather processes in an area of 100,000 square kilometres up to 3 million square kilometres. ICM is also able to manage weather processes within commercial projects (minimum of 2,000 square kilometres).

3. The advanced Climate Modification Technology ensures Controlled Climate Change is fully reversible

4. The Client determines the parameters; temperature, rainfall, humidity, groundwater level, etc.

5. If desired, the Client may change the parameters, subject to regional tolerances being compatible to the change.

The Climate Modification Technology can:

- Potentially save the Islamic Republic of Iran agriculture sector $Billions that are lost each year due to drought conditions

- Potentially save the Islamic Republic of Iran approximately $2Billion annually due to dust storms.

- Irradiate air pollution from greenhouse gases, which had reduced average Iranian life expectancy by one and a half years.

This Climate Modification Technology would ensure increased vegetation cover, reduce carbon emissions, combat pollution and land degradation and preserve marine life meet every one of its objectives.

Innovative Technology on Weather Management

The technological solutions proposed present the opportunity to carry out seasonal regulation of atmospheric processes within the defined areas, by transferring wetted air masses from the Indian and Pacific oceans to arid regions and to will ensure long-term presence of additional moisture in arid regions as well as maintain a given climate regime.

The Innovative ICM Weather Management program fully comply with the Environmental Modification Convention (ENMOD), formally “The Convention on the Prohibition of Military or any Other Hostile Use of Environmental Modification”, which is one of the main UN documents prohibiting its participants from military or any other hostile influence on the environment, through the deliberate management of natural processes in the biosphere, hydrosphere, the Earth's atmosphere and near- Earth space.

The proposed Weather Management program is safe and environmentally friendly, does not use any chemical components, provides reversibility of weather conditions and completely compensate the negative impact on the climatic processes caused by anthropogenic impact on the environment.

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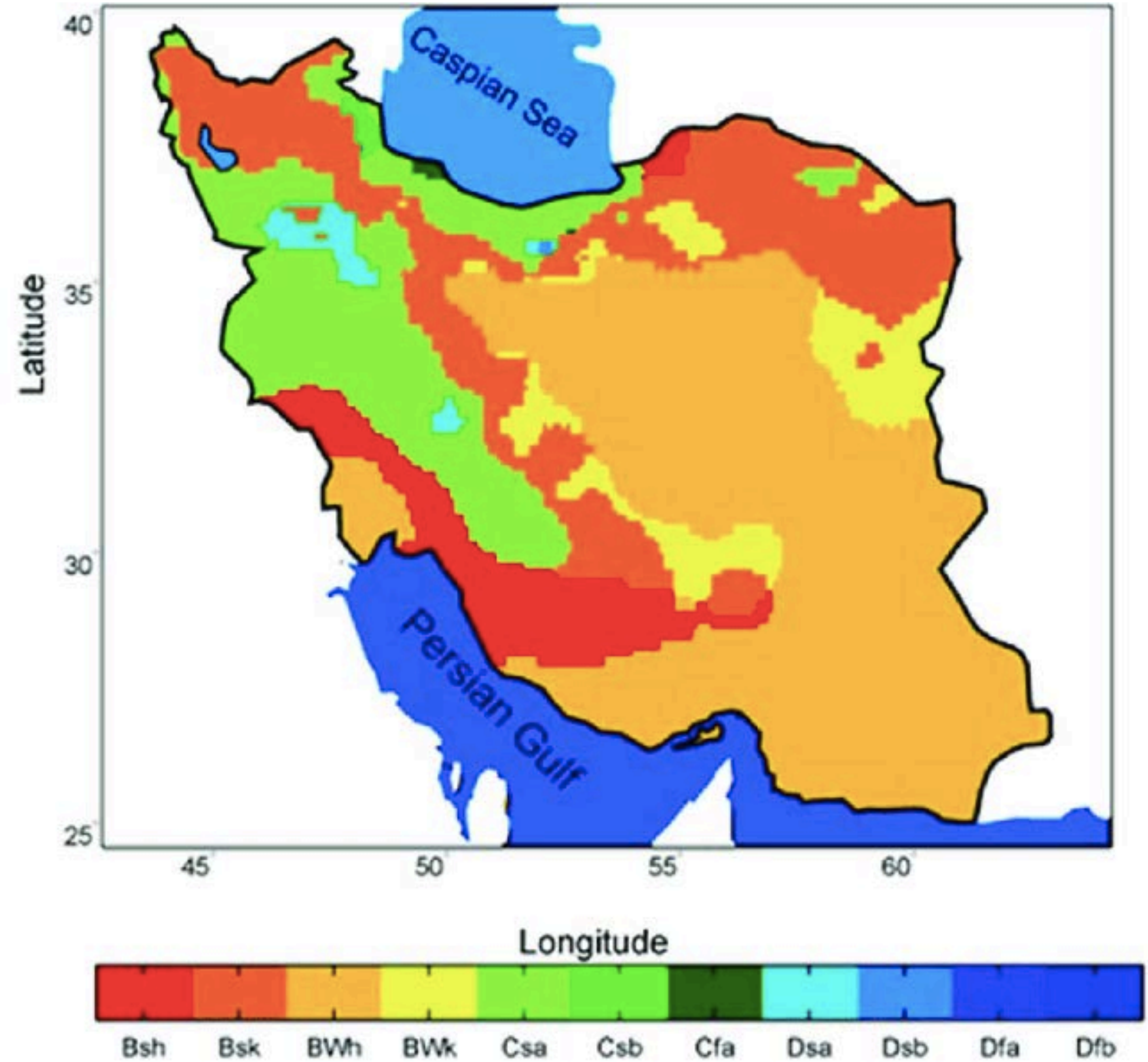
I. Köppen-Geiger, Climate of the Islamic Republic of Iran

The climate of Iran determined according to Köppen-Geiger, Feddema, and UNPEP climate classifications, computed with a high-resolution ground-based gridded dataset for the 1985–2017 period.



Köppen-Geiger climate types "Bwh," "Bsk," "Csa," "Bsh," and "Bwk" cumulatively account for more than 98% of the territory.

Fourteen Feddema's climate types were determined for Iran when only a combination of moisture and thermal factors were used for the classification, but a set of 24 climate types were identified when annual and seasonal characteristics were also incorporated in an exhaustive Feddema's climate classification.

From these 24 climate types, "dry cool with extreme seasonal temperature," "semiarid hot with extreme seasonal temperature," "semiarid warm with extreme seasonal temperature," "semiarid torrid with extreme seasonal temperature," and "dry warm with extreme seasonal temperature" cover 24.55%, 15.32%, 14.92%, 14.40%, and 8.90% of Iran, respectively.

These main climate types collectively cover more than 87% of Iran. Similarly, UNEP's climate types "arid," "semi-arid," "humid," and "sub-humid" characterised more than 98% of Iran.

A few other vertically stratified climate types appeared over the highlands of Iran as a result of changes in elevation and slope aspects of the mountains.

The spatial distribution of the climate types in all created climate classification maps reflects the general pattern of the topographical features of Iran, including the Alborz and Zagros mountain ranges.

The combined effect of topography and vicinity to the Caspian Sea also creates very distinct climate types in northern Iran.

The climate maps of the three used methods reflect the joint effects of topography, latitudinal variation, and land/sea surface contrast on the climate of Iran, which are jointly responsible for creating the diverse climate types of the country.

A pairwise comparison made between the three classifications showed a satisfactory agreement between the three schemes in representing the main climate types of Iran

Iran's diverse topography, including the Alborz and Zagros mountain ranges, causes a variety of Köppen-Geiger climate types across the country.

The primary climate classifications in Iran are B (Arid), C (Temperate), and D (Continental), with arid and semi-arid climates covering the majority of the nation.

Primary Köppen climate types in Iran

Arid climates (BWh and Bwk): These are the most widespread climates in Iran, particularly in the central and eastern regions.

- **BWh (Hot Desert):** Characterises the hot, dry desert regions of central and eastern Iran.
- **Bwk (Cold Desert):** Found in higher-altitude areas that are still arid but experience colder winters. Over time, this climate is projected to be replaced by the hotter BWh type in central and eastern Iran due to climate change.

Semi-arid climates (BSh and BSk): These climates have some precipitation but are still mostly dry.

- **BSh (Hot Semi-arid):** Occurs in the southern parts of the Zagros region.

- **BSk (Cold Semi-arid):** Predominant on the eastern slopes of the Zagros and southern slopes of the Alborz mountains, connecting to the central arid zones.

Mediterranean climates (Csa): These temperate climates are defined by hot, dry summers and mild, wet winters.

- **Csa (Hot-summer Mediterranean):** Found in northern Iran along the Caspian Sea coast and in the mountainous regions of the Alborz and Zagros.

Continental climates (Dsa and Dsb): These climates, with snow and hot or warm dry summers, are present in the mountainous areas.

- **Dsa (Hot-summer, Dry-summer Continental):** Found in specific high-altitude areas of the Zagros and Alborz ranges.

- **Dsb (Warm-summer, Dry-summer Continental)**: Also occurs in certain parts of the Zagros and Alborz mountains.

Local and humid climates (Csb and Cfa): These are more localised climate types.

- **Csb (Warm-summer Mediterranean):** A more localised climate, especially in the coastal regions of the Caspian Sea.

- **Cfa (Humid Subtropical):** A rare, localised humid climate type also found in the Caspian Sea coastal areas.

Geographic distribution

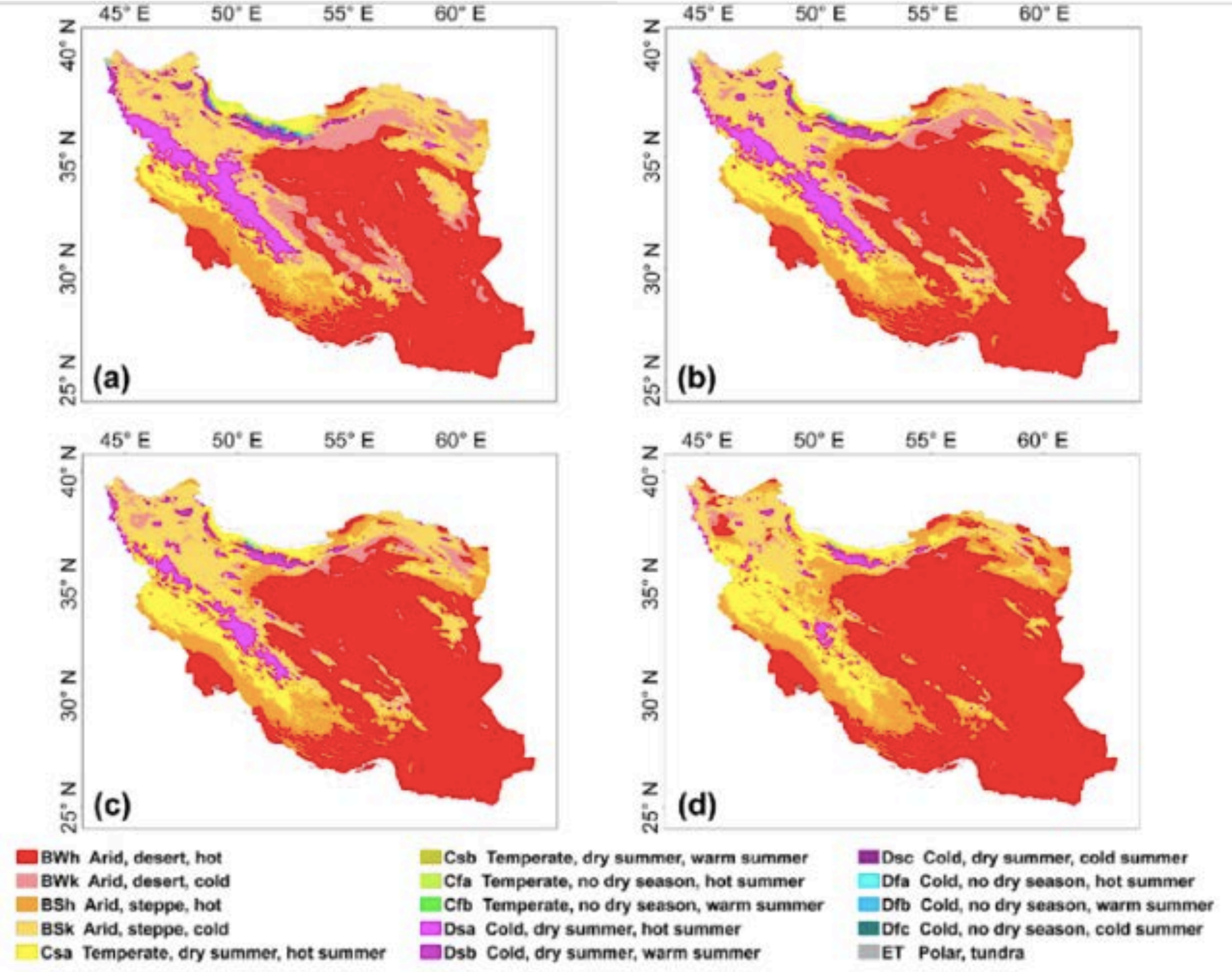
Central, Eastern, and Southern Iran: Dominated by arid (BWh and Bwk) and semi-arid (BSh) climates.

Western Iran: Characterised by cool, sub-humid, and cold, semi-arid climates in the northwest.

Northern Coastal Areas (Caspian Sea): The combined effect of topography and proximity to the sea creates distinct, temperate climates (Csa, Csb, and Cfa).

Mountainous Regions (Alborz and Zagros): Feature colder, continental climates (Dsa, Dsb) and Mediterranean climates (Csa).

II. Climate change projections



Comparison of Iran's map in of the Köppen-Geiger climate classification: a historical reference period (1991-2020), and future periods (2071-2099) under b SSP1-2.6, c SSP2-4.5, and d SSP5-8.5 scenarios

Climate change is expected to alter Iran's climate zones, with drier and warmer conditions predicted for the future.

- Desert climate types (BW) are projected to expand, replacing semi-arid (BS) and moderate (Cs) climate types.
- The cold desert (BWk) climate is expected to shrink due to the spread of the hot desert (BWh) climate.
- Significant shifts are particularly vulnerable in northwestern Iran, which is expected to become warmer and drier.

III. Overview of the Islamic Republic of Iran Climate Variations

Iran is a large country, three times the size of France. It is bordered by Turkmenistan and the Caspian Sea to the north, Afghanistan and Pakistan on the east, the Persian Gulf on the south, and Iraq and Turkey on the west. Much of the interior of the country consists of a high plateau between 900 and 1,500 meters (3,000–5,000 feet) above sea level.The Iranian plateau is surrounded by mountains on all sides: the Alborz ranges to the north and the Zagros to the west and south.In At higher elevations, these mountains rise between 3,000 and 4,600 meters (10,000–15,000 feet), allowing the winter snows to feed many of the country's rivers.

Much of Iran has an arid and semi-arid climate with great hot and cold extremes between summer and winter. There are four seasons: spring, summer, a short fall, and winter. The central deserts and the Persian Gulf coast are particularly hot in summer, with some of the world's highest recorded desert temperatures. Snow falls heavily on the mountain peaks and is the main source of water for irrigation in spring and early summer.

Large parts of central, southern and eastern Iran consist of desert and steppe with annual rainfall of less than 300 millimetres (12 inches). With the exception of the northern slopes of the Alborz Mountains and the Caspian coasts, precipitation is limited to the winter and spring months. In the extreme north of the country there is some rainfall throughout the year. Summers are warm to hot everywhere with almost continuous sunshine. Winter weather is changeable with a mix of mild, wet periods and some very cold weather with frost and snow when cold air blows from Siberia.

Winters are much milder along the coasts of the Gulf and Arabian Seas, as evidenced by those for Abadan and Bushehr. The high summer temperatures here are similar to those in the lowlands of Iraq and there is a risk of heat exhaustion and even heatstroke.

Climate data for Abadan (1951–2022)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average high °C (°F)	18.1 (64.6)	20.9 (69.6)	25.9 (78.6)	32.2 (90.0)	39.2 (102.6)	43.8 (110.8)	45.4 (113.7)	45.4 (113.7)	42.5 (108.5)	36.1 (97.0)	26.8 (80.2)	19.9 (67.8)	33.0 (91.4)
Daily mean °C (°F)	12.7 (54.9)	15.0 (59.0)	19.4 (66.9)	25.2 (77.4)	31.2 (88.2)	35.2 (95.4)	36.7 (98.1)	36.3 (97.3)	33.0 (91.4)	27.5 (81.5)	20.0 (68.0)	14.3 (57.7)	25.5 (77.9)
Average low °C (°F)	7.3 (45.1)	9.1 (48.4)	13.0 (55.4)	18.1 (64.6)	23.3 (73.9)	26.5 (79.7)	28.0 (82.4)	27.3 (81.1)	23.4 (74.1)	18.9 (66.0)	13.2 (55.8)	8.7 (47.7)	18.1 (64.6)
Average precipitation mm (inches)	35.5 (1.40)	20.0 (0.79)	19.2 (0.76)	14.4 (0.57)	3.2 (0.13)	0.1 (0.00)	0.0 (0.0)	0.0 (0.0)	0.1 (0.00)	3.9 (0.15)	20.5 (0.81)	36.4 (1.43)	153.3 (6.04)

Source: Iran Meteorological Organization

Climate data for Bushehr (1951–2010)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average high °C (°F)	18.6 (65.5)	20.2 (68.4)	24.2 (75.6)	29.6 (85.3)	34.5 (94.1)	36.4 (97.5)	37.8 (100.0)	38.1 (100.6)	36.6 (97.9)	32.9 (91.2)	26.6 (79.9)	21.0 (69.8)	29.7 (85.5)
Daily mean °C (°F)	14.5 (58.1)	15.8 (60.4)	19.3 (66.7)	24.3 (75.7)	29.0 (84.2)	31.4 (88.5)	33.1 (91.6)	33.3 (91.9)	30.8 (87.4)	26.9 (80.4)	21.3 (70.3)	16.5 (61.7)	24.7 (76.5)
Average low °C (°F)	10.3 (50.5)	11.4 (52.5)	14.4 (57.9)	18.9 (66.0)	23.6 (74.5)	26.3 (79.3)	28.4 (83.1)	28.4 (83.1)	25.1 (77.2)	20.9 (69.6)	16.0 (60.8)	12.0 (53.6)	19.6 (67.3)
Average precipitation mm (inches)	78.5 (3.09)	31.8 (1.25)	22.4 (0.88)	8.6 (0.34)	2.6 (0.10)	0.0 (0.0)	0.0 (0.0)	0.3 (0.01)	0.0 (0.0)	5.7 (0.22)	39.4 (1.55)	78.7 (3.10)	268.0 (10.55)

Source: Iran Meteorological Organization

Temperatures on the inner plateau are significantly lower in winter but high during the long sunny summer (see Tehran and Isfahan). In the southern coastal countries, the high humidity makes the high summer temperatures even more uncomfortable. Inland, daytime humidity is usually fairly low in summer and the most dangerous conditions arise when high temperatures are combined with the occasional strong, dusty winds.

Climate data for Tehran (1988–2005)													
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average high °C (°F)	6.1 (43.0)	8.1 (46.6)	12.9 (55.2)	19.8 (67.6)	25.0 (77.0)	31.2 (88.2)	33.9 (93.0)	33.5 (92.3)	29.3 (84.7)	22.4 (72.3)	14.3 (57.7)	8.6 (47.5)	20.4 (68.8)
Daily mean °C (°F)	2.3 (36.1)	4.4 (39.9)	9.2 (48.6)	14.9 (58.8)	19.8 (67.6)	25.6 (78.1)	28.5 (83.3)	27.6 (81.7)	23.4 (74.1)	17.2 (63.0)	9.9 (49.8)	4.8 (40.6)	15.6 (60.1)
Average low °C (°F)	−1.5 (29.3)	−0.2 (31.6)	4.0 (39.2)	9.8 (49.6)	14 (57)	19.6 (67.3)	22.6 (72.7)	21.9 (71.4)	17.5 (63.5)	11.6 (52.9)	5.4 (41.7)	1.0 (33.8)	10.5 (50.8)
Average precipitation mm (inches)	63.1 (2.48)	66.5 (2.62)	83.3 (3.28)	50.1 (1.97)	27.1 (1.07)	4.0 (0.16)	4.2 (0.17)	3.2 (0.13)	3.4 (0.13)	16.5 (0.65)	41.3 (1.63)	66.3 (2.61)	429 (16.9)
Source: Iran Meteorological Organization													

Climate data for Isfahan (1961–1990)													
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average high °C (°F)	8.8 (47.8)	11.9 (53.4)	16.8 (62.2)	22.0 (71.6)	28.0 (82.4)	34.1 (93.4)	36.4 (97.5)	35.1 (95.2)	31.2 (88.2)	24.4 (75.9)	16.9 (62.4)	10.8 (51.4)	23.0 (73.4)
Daily mean °C (°F)	2.7 (36.9)	5.5 (41.9)	10.4 (50.7)	15.7 (60.3)	21.3 (70.3)	27.1 (80.8)	29.4 (84.9)	27.9 (82.2)	23.5 (74.3)	16.9 (62.4)	9.9 (49.8)	4.4 (39.9)	16.2 (61.2)
Average low °C (°F)	−2.4 (27.7)	−0.2 (31.6)	4.5 (40.1)	9.4 (48.9)	14.2 (57.6)	19.1 (66.4)	21.5 (70.7)	19.8 (67.6)	15.1 (59.2)	9.3 (48.7)	3.6 (38.5)	−0.9 (30.4)	9.4 (48.9)
Average precipitation mm (inches)	17.1 (0.67)	14.1 (0.56)	18.2 (0.72)	19.2 (0.76)	8.8 (0.35)	0.6 (0.02)	0.7 (0.03)	0.2 (0.01)	0.0 (0.0)	4.1 (0.16)	9.9 (0.39)	19.6 (0.77)	112.5 (4.43)
Source: NOAA													

In the northwest and west, winters are cold, with heavy snowfall and subfreezing temperatures from December to February. Spring and fall are relatively mild, with rain in the early spring and late autumn. Summers are dry; days can be hot, but nights are mild to cool.

Climate data for Tabriz (1951–2010)													
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average high °C (°F)	2.3 (36.1)	4.9 (40.8)	10.6 (51.1)	17.0 (62.6)	22.8 (73.0)	28.8 (83.8)	32.8 (91.0)	32.7 (90.9)	28.3 (82.9)	20.7 (69.3)	12.0 (53.6)	5.2 (41.4)	18.2 (64.8)
Daily mean °C (°F)	−1.7 (28.9)	0.5 (32.9)	5.6 (42.1)	11.5 (52.7)	16.7 (62.1)	22.1 (71.8)	26.0 (78.8)	25.9 (78.6)	21.4 (70.5)	14.5 (58.1)	7.1 (44.8)	1.2 (34.2)	12.6 (54.7)
Average low °C (°F)	−5.7 (21.7)	−3.9 (25.0)	0.6 (33.1)	6.0 (42.8)	10.7 (51.3)	15.4 (59.7)	19.3 (66.7)	19.1 (66.4)	14.5 (58.1)	8.4 (47.1)	2.1 (35.8)	−2.9 (26.8)	7.0 (44.6)
Average precipitation mm (inches)	22.0 (0.87)	24.2 (0.95)	40.0 (1.57)	51.6 (2.03)	41.1 (1.62)	16.4 (0.65)	5.6 (0.22)	3.3 (0.13)	7.9 (0.31)	22.5 (0.89)	27.1 (1.07)	22.1 (0.87)	283.8 (11.17)
Source: Iran Meteorological Organization													

The small area of Iran along the Caspian coast has a very different climate than the rest of the country. Here, precipitation is heaviest from late summer to mid-winter and occurs year-round. This region is much wetter and cloudier than the interior and annual rainfall ranges from 800 to 2,000 millimetres (35 to 80 in). It is a fertile, forested region and contrasts strikingly with the arid landscape of interior Iran, where most agriculture depends on irrigation from underground water resources and streams fed by rain and snow falling on the surrounding mountains.

Climate data for Amol

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average high °C (°F)	13.1 (55.6)	12.5 (54.5)	12.4 (54.3)	16.2 (61.2)	23.7 (74.7)	27.7 (81.9)	28.7 (83.7)	30.3 (86.5)	25.9 (78.6)	23.2 (73.8)	18.9 (66.0)	15.1 (59.2)	20.6 (69.2)
Daily mean °C (°F)	8.7 (47.7)	8.1 (46.6)	8.2 (46.8)	11.9 (53.4)	19.1 (66.4)	21.9 (71.4)	24 (75)	25.4 (77.7)	21.1 (70.0)	18.4 (65.1)	13.8 (56.8)	10.2 (50.4)	15.9 (60.6)
Average low °C (°F)	4.4 (39.9)	3.8 (38.8)	4 (39)	7.7 (45.9)	14.6 (58.3)	16.2 (61.2)	19.3 (66.7)	20.6 (69.1)	16.3 (61.3)	13.6 (56.5)	8.7 (47.7)	5.4 (41.7)	11.2 (52.2)
Average precipitation mm (inches)	96 (3.8)	80 (3.1)	74 (2.9)	69 (2.7)	31 (1.2)	27 (1.1)	27 (1.1)	36 (1.4)	87 (3.4)	97 (3.8)	97 (3.8)	108 (4.3)	829 (32.6)
Source: Climate-Data.org													

In general, the climate in Iran is dry; Most of the relatively low annual precipitation falls from October to April. Annual rainfall averages 250 millimetres or less in most parts of the country. Some basins of the central plateau get 100 millimetres or less. This dryness means that agriculture in most areas of Iran is dependent on irrigation.

Spring and autumn are fairly short seasons in Iran between the heat of summer and the more changeable and often cold weather of winter. These seasons are the best time to visit Iran, although the weather can occasionally be a bit uncertain, with brief lapses into either the chills of winter or the heat of summer. Strong seasonal winds often kick up dust and sandstorms.

Diverse climate regions

Iran's climate is influenced by several geographical factors, including the two major mountain ranges—the Alborz in the north and the Zagros in the west—and the desert plateau in the central and eastern regions. As a result, the climate can vary dramatically from one region to the next.

Caspian Sea coast: The narrow coastal plain along the Caspian Sea has a humid, subtropical climate. It is Iran's wettest region, with lush forests, mild winters, and warm, humid summers.

Mountainous regions: The Alborz and Zagros mountains experience cold winters with heavy snowfall and sub-freezing temperatures. These areas are home to ski resorts and maintain snow cover on the highest peaks well into the spring.

Central plateau and deserts: The interior of Iran is dominated by a desert plateau, which includes the Dasht-e Kavir and Dasht-e Lut deserts.

- Summers are extremely hot and dry. Temperatures can rise over 40°C (104°F) in cities like Yazd and Isfahan.
- Inland temperatures in the deserts can be some of the highest recorded anywhere in the world.
- Winters are very cold due to the continental location and high altitude.

Southern coastal areas: Along the Persian Gulf and the Gulf of Oman, winters are mild, while summers are very hot and humid, with average daily highs exceeding 38°C (100.4°F) in July.

Temperature and precipitation

Temperatures:

- The difference between regional temperatures can be extreme. For example, in winter, the northwest can experience temperatures as low as –30°C, while the southern regions are mild.
- Daytime summer temperatures in interior provinces, such as Khuzestan, can reach over 43°C (110°F), while the average winter high in the northwest can be near freezing.

Precipitation:

- Approximately 90% of Iran's total area is arid or semi-arid.
- Average annual rainfall is low, around 228 mm to 240 mm.
- Rainfall amounts range from less than 50 mm in the deserts to over 2,275 mm in the Caspian Sea region.
- Precipitation is concentrated in the winter months (November to May), with about 50% falling in winter.

Climate change impacts

As a country vulnerable to climate change, Iran faces several threats, including rising temperatures and water stress.

Increasing temperatures: Iran has seen a significant increase in average temperatures over the past century. Projections estimate that maximum temperatures could rise by up to 5°C by the end of the 21st century.

Water shortages: The combination of rising temperatures, increased evaporation, and reduced precipitation has exacerbated water scarcity. This has led to environmental issues like the drying of lakes and rivers and increased desertification.

Extreme weather: Climate change is expected to increase the frequency and intensity of extreme weather events, such as severe heat waves, floods, and droughts.

IV. Land Use

Based on recent data, the majority of Iran's land is unsuitable for agriculture, with large portions covered by deserts, mountains, and rangelands. Despite this, agriculture remains a significant part of the economy and a major land-use sector, alongside forests and protected areas.

Primary land uses in Iran

Non-agricultural land

Roughly 53% of Iran's total land area is considered non-agricultural terrain.

Deserts and mountains: The largest portion of the country's land, about 39%, is covered by deserts, salt flats (kavirs), and bare-rock mountains that are not suited for farming.

Built-up areas: Cities, towns, industrial zones, and roads account for about 7% of Iran's land.

Agriculture and rangeland

Agriculture contributes significantly to Iran's food supply and economy, despite being limited by poor soil and water scarcity.

Cultivated land: About 12% of the total land area is cultivated, a figure that is constrained by low rainfall and limited water resources. The most fertile soils are found in the western and northwestern parts of the country.

Unsustainable farming: Approximately half of the country's existing cropland is located on low-quality land, a practice which research indicates is unsustainable.

Grazing land: Rangelands, especially in the semi-arid mountain areas surrounding the central deserts, are used extensively for livestock grazing. However, overgrazing and climate change have led to significant degradation of these rangelands.

Forests

Iran's total forest area has been estimated at around 12.4 million hectares, although there are differing reports on the total amount.

Geographic distribution: The most valuable woodlands are the dense forests located in the Caspian Sea region and on the northern slopes of the Alborz Mountains. Other forest areas are found in the west (Zagros Mountains), south, and central desert regions.

Threats: Deforestation due to agriculture, logging, and grazing has caused a significant loss of forest cover.

Protected areas

Iran has a network of protected areas established to conserve biodiversity, which covers about 11.8% of the country's land.

Types: Protected areas are classified into different categories, including National Parks, Wildlife Refuges, and National Natural Monuments.

Expansion: The government is working to expand this network to protect more of the country's biodiversity hotspots.

Challenges and management

Land use in Iran faces several critical challenges, primarily driven by climate and population pressure.

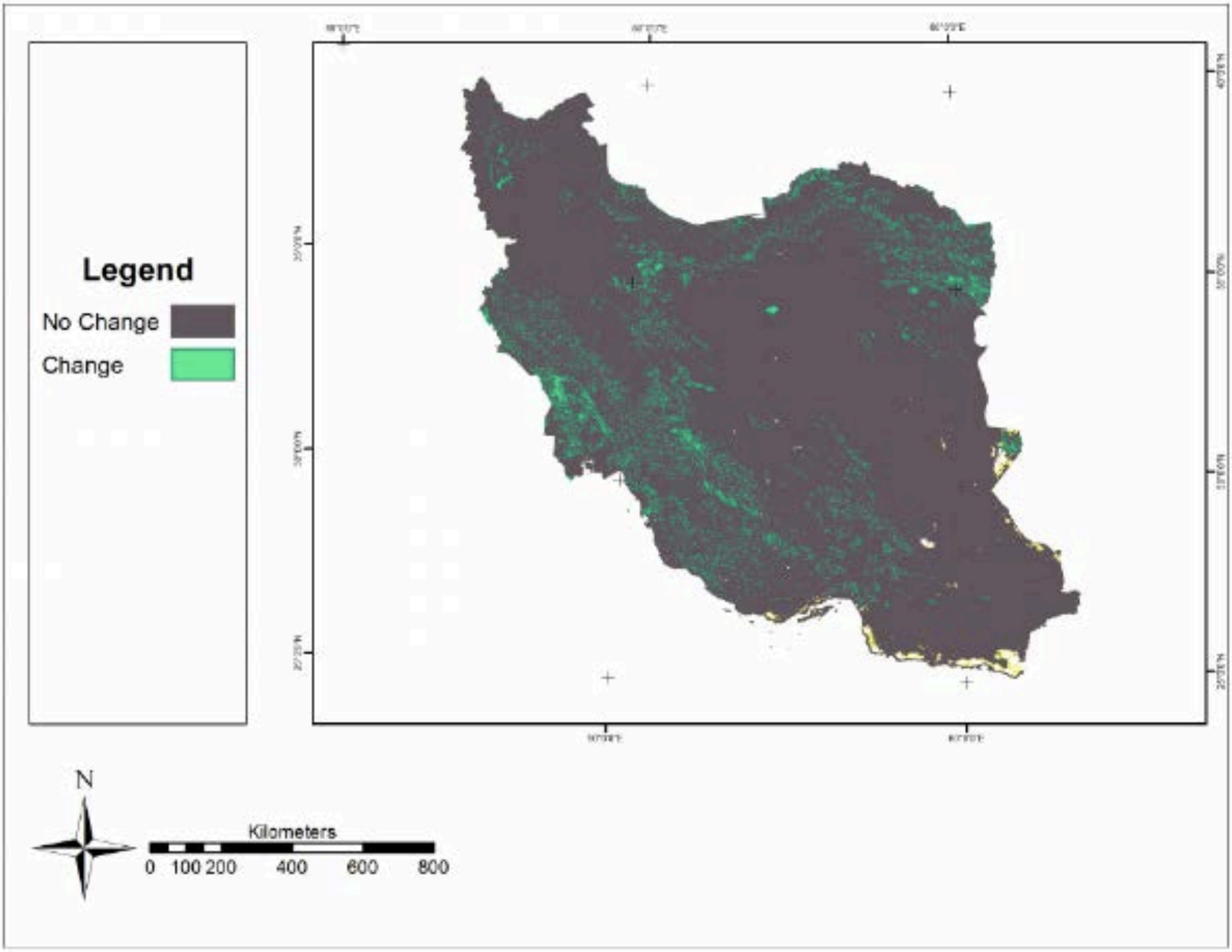
Water scarcity and soil quality: Low rainfall, poor soil organic content, and high soil salinity limit agricultural potential. This has resulted in a heavy reliance on irrigation, which strains already limited water resources.

Land use change and speculation: Valuable agricultural lands, especially in fertile areas, are being converted to urban and industrial uses. This is a significant concern for food security and environmental sustainability.

Environmental degradation: Factors like overgrazing, extensive land clearing, and intensive irrigation have led to severe soil degradation and desertification.

In response, the government has implemented policies and laws to manage and protect agricultural lands, forests, and rangelands, including conservation projects and attempts to reform inefficient agricultural practices.

Changes of Land Use in Iran 2007-2017



In 2007, non-vegetated lands (NVL) cover an area of 986,080 km² (59.8 % of the total land area of the country) and are therefore the major land cover type of Iran (Fig. 2). After non-vegetated lands, annual grass vegetation (AGV) with the area of 411,032 km² (24.9 %) and evergreen coniferous leaf (ENV) with 204,860 km² (12.5 %) are the next largest groups.

In 2017, the area of non-vegetated lands (NVL) is 993,820 km² (60.3%) which is an increase of 1% compared to 2007 (Fig. 3). The annual grass vegetation (AGV) has an area of 426,317 km² and evergreen coniferous vegetation (ENV) land an area 183,383 km².

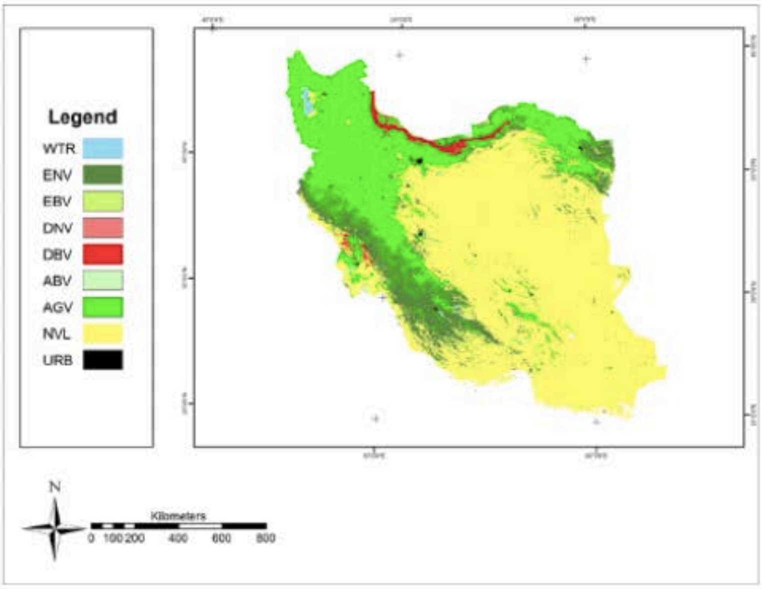


Figure 2: Land Cover Map of Iran in 2007.

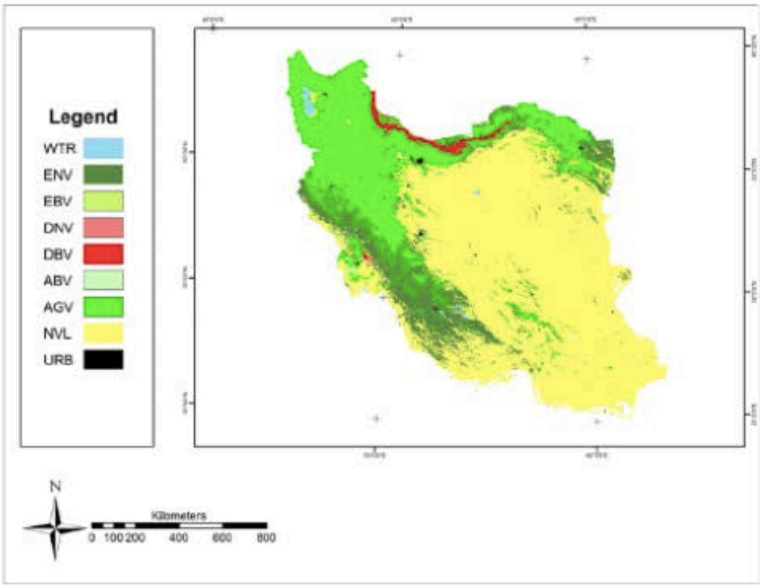


Figure 3: Land Cover Map of Iran in 2017.

These results indicate an increase in annual grass vegetation and a decrease in evergreen coniferous vegetation. The changes that occurred over the ten years between 2007 and 2017. The biggest change from one land cover to another is the conversion of evergreen coniferous vegetation to the arid areas with 9,265 km^2. Following, the conversion of coniferous forests to annual grassland and annual grass vegetation to arid areas are the next biggest conversions.

The deciduous broadleaf vegetation (DBV) of the country has not changed significantly. However, in the southwest of the country, the area of broadleaf species has declined over the past ten years. Finally, the area of Deciduous Coniferous Vegetation (DNV), Evergreen Broadleaf Vegetation (EBV) and Evergreen Coniferous Vegetation (ENV), has remarkably increased over the past 10 years

Ali Gholami - KTH Royal Institute of Technology

V. Iran Natural Water Resources

Iran's natural water resources are dominated by its arid and semi-arid climate, leading to uneven distribution and significant water stress exacerbated by decades of over-extraction and mismanagement. The country relies on a mix of surface water from rivers and dams, groundwater, and increasingly, desalination technology.

Surface water resources

Major rivers

Karun River: The country's largest and most navigable river flows into the Persian Gulf via the Shatt al-Arab. Its tributaries originate in the Zagros Mountains, and numerous dams control its flow

Sefid-Rud: This major river flows into the Caspian Sea and is important for agricultural and power generation projects.

Karkheh River: A tributary of the Tigris, its flow has been significantly impacted by upstream damming.

Zayandeh Rud: Historically vital to the city of Isfahan, this river has frequently run dry due to drought and diversion projects.

Transboundary Rivers: Several rivers are shared with neighbouring countries, including the Aras (with Armenia and Azerbaijan) and the Atrek (with Turkmenistan), which have been sources of political tension.

Lakes and wetlands

Caspian Sea: The world's largest inland lake, it lies on Iran's northern border and receives water from several Iranian rivers.

Lake Urmia: Once the largest saltwater lake in the Middle East, it has shrunk dramatically due to dam construction, agricultural water diversion, and climate change.

Mesopotamian Marshes: Iran shares this complex wetland system with Iraq. The region has been severely affected by dam construction and diversion projects in both countries.

Groundwater resources

Iran's groundwater resources are crucial but critically over-exploited, with agriculture accounting for over 90% of water withdrawals. The country is a global hotspot for groundwater depletion due to factors like rapid population growth, industrialisation, and extensive irrigation, leading to significant declines in water levels, extensive land subsidence, and socio-physical crises. Efforts to manage these resources are hampered by factors such as a lack of supervision and conflicting interests

Groundwater levels and reserves

Multiple studies and government reports reveal the dire state of Iran's groundwater resources:

Depletion of historic reserves: Between 2002 and 2019, the cumulative depletion of Iran's nonrenewable groundwater storage was approximately 133 km^3—more than three times the reservoir volume of China's Three Gorges Dam.

Rapid decline rate: The national average groundwater level dropped at a rate of 49 cm per year between 2002 and 2015. Another study found a decline of 28 cm per year between 2003 and 2019.

Near-total depletion: Experts state that Iran has exhausted its 1,000-year water reserve in just 30 years, with some 70% of total groundwater reserves depleted over the last five decades.

Aquifer collapse: In major urban and agricultural areas, the water table has dropped so low that aquifers are collapsing. The ground is sinking by up to 25 cm per year in some areas, including Tehran, resulting in land subsidence and sinkholes.

Widespread crisis conditions: As of 2018, only about 35% of Iran's plains were classified as "free plains" for new well permits. The number of "prohibited plains," where new wells are banned, increased dramatically, a sign that regulatory policies have failed to address overexploitation.

Groundwater withdrawal and consumption

Groundwater extraction has been driven to unsustainable levels, primarily by the agricultural sector.

Dominance of agriculture: The agricultural sector is overwhelmingly responsible for Iran's water over-consumption, using approximately 92% of the country's water resources, much of it from groundwater.

Increased well drilling: The number of deep and semi-deep wells nearly doubled between 2002 and 2015. Many wells are illegal, with some estimates putting the number of unauthorised wells at several hundred thousand nationwide.

Growing reliance on wells: As surface water resources have diminished due to dams and drought, the share of the water supply drawn from deep and semi-deep wells increased from 42% to 54% between 2002 and 2015.

s**Inefficient practices:** Widespread use of inefficient flood irrigation methods, combined with heavily subsidised water and energy costs, has disincentivized conservation among farmers.

Key statistics

Total depletion: Between 2003 and 2019, Iran lost about 211 ± 34 km^3 of its total water storage, more than double its annual consumption. Over five decades, Iran has depleted around 70% of its groundwater reserves.

Widespread overdraft: Over three-quarters of Iran's land is under extreme groundwater overdraft, meaning water extraction far surpasses natural replenishment.

Rising well numbers: The number of groundwater extraction points nearly doubled from 546,000 in 2002 to over one million in 2015. A large number of these are illegal and unregulated.

Depleting central basins: The most intensive groundwater depletion trends are concentrated in the Central Plateau, particularly the Salt Lake and Kavir Markazi sub-basins, which contain major population centers like Tehran.

High agricultural use: The agricultural sector consumes nearly 90% of Iran's water supply, much of it from groundwater, despite contributing only 10% to the country's GDP

Aquifers and extraction

Over-extraction: Unsustainable groundwater withdrawal, particularly for agriculture, has severely depleted Iran's aquifers.

Groundwater depletion: Decades of overexploitation have depleted about 70% of the country's groundwater reserves, leading to severe land subsidence in many areas, including Tehran.

Wells: Hundreds of thousands of deep and shallow wells, many illegal, contribute to aquifer depletion.

Iran's groundwater resources have shifted dramatically from a historically balanced, sustainable system to a state of severe depletion caused by over-abstraction, agricultural expansion, and climate change. While the ancient system of Qanats traditionally ensured responsible use, the widespread adoption of deep wells since the 1960s has led to a critical and alarming decline across nearly all regions of the country.

Historical context: Sustainable Qanat systems

For millennia, ancient Persians used an ingenious system of underground aqueducts called Qanats to transport groundwater to the surface.

Localised management: These systems were managed at a community level and promoted the sustainable use of groundwater. Settlements in regions like Yazd, Kerman, and Khorasan were founded and thrived on this delicate water balance.

Sustainable water harvesting: The Qanats were able to provide a reliable water supply without permanently damaging aquifers. However, in recent decades, many of these systems have been abandoned as deep wells offered faster—though less sustainable—extraction.

Present-day crisis: Regional depletion and subsidence

The current state of Iran's aquifers is marked by a severe negative water balance, with extraction rates far exceeding recharge. Provinces across the country are experiencing critical levels of depletion, leading to widespread land subsidence.

Central Plateau

Status: This basin, which includes major arid regions, is the most depleted in the country. It has experienced a significant negative trend in groundwater storage, particularly in the

Kavir Markazi sub-basin. Ancient settlements that relied on qanats in provinces like Yazd, Isfahan, and Kerman have seen these systems fail as water tables plummeted.

Key regions:

Tehran: The capital and surrounding aquifer systems are over-tapped to supply the growing urban population. The Tehran-Karaj aquifer is highly stressed, and the city experiences significant land subsidence.

Isfahan: Over-extraction and upstream water diversion have caused the Zayandeh Rud River to run dry, increasing reliance on already strained groundwater resources and causing social unrest.

Kerman and Fars: These provinces, with extensive agricultural activities, are experiencing high levels of depletion and are severely affected by land subsidence.

Caspian Sea Basin

Status: This water basin, while historically better supplied, is also showing a negative trend in groundwater storage. Provinces like Gilan and Mazandaran have traditionally had lower rates of groundwater depletion due to greater access to surface water.

Impact: Unsustainable extraction has worsened over time, particularly in aquifers like Nur-Nowshar, where urbanisation and climate change have increased pressure on resources.

Persian Gulf and Oman Sea Basin

Status: While less depleted than the central region, this basin is experiencing high groundwater extraction rates, which increased significantly in 2021.

Impact: Provinces like Khuzestan, historically known for water resources like the Karun and Karkheh rivers, have seen water levels drop significantly due to damming and upstream over-extraction, forcing a rural exodus.

Lake Urmia Basin

Status: This basin has experienced a smaller but still negative secular trend in groundwater storage. However, over-extraction and dam construction have significantly contributed to the near-total desiccation of Lake Urmia, with widespread environmental consequences.

Eastern Boundary and Gharaghom Basins

Status: These basins show negative trends in groundwater storage but to a lesser extent than the Central Plateau. They are, however, still vulnerable, with some transboundary aquifers of potential concern.

Drivers of depletion

Several factors, exacerbated by climate change, have contributed to the decline of Iran's groundwater:

Agricultural over-consumption: The agricultural sector accounts for over 90% of Iran's water consumption, with a large portion coming from groundwater.

Inefficient irrigation: Outdated farming practices and subsidised water have created a lack of incentive for water conservation.

Unlicensed well drilling: Despite government efforts to seal illegal wells, a large number of unlicensed wells continue to over-extract from aquifers.

Mismanagement and poor governance: A lack of integrated water management have led to inefficient and unsustainable policies.

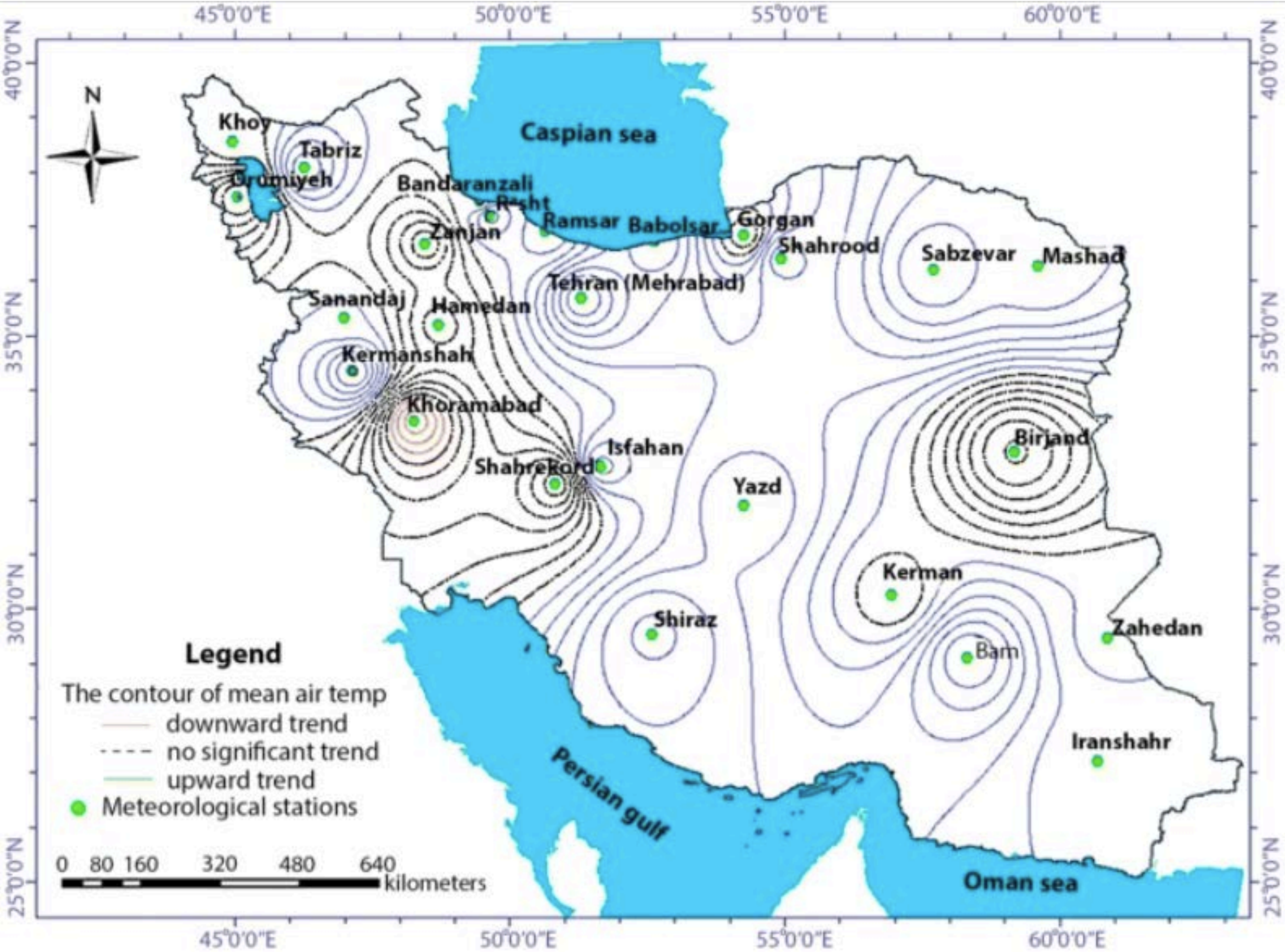
Consequences of decline

The chronic depletion has led to a cascade of environmental and social problems:

Land subsidence: The most visible consequence, affecting 30 of Iran's 31 provinces, with some areas dropping by up to 40 cm annually.

Environmental degradation: Dried-up lakes and rivers, increased soil salinity, and dust storms are a direct result of groundwater depletion.

VI. Climate and environmental factors



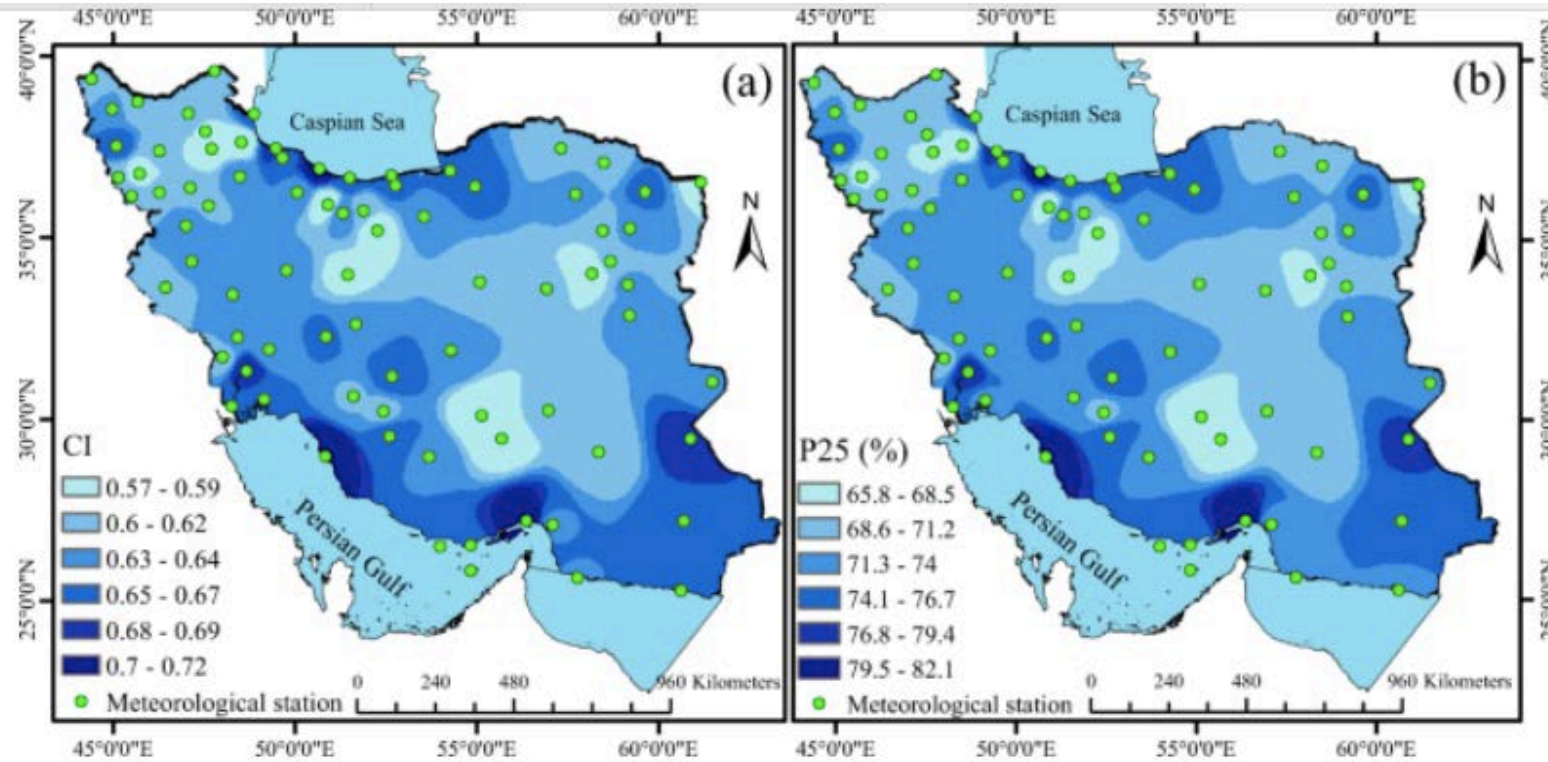
Rainfall patterns

Iran's rainfall patterns are highly variable, with major differences between its arid interior and wetter northern and western regions. Most of the country is arid or semi-arid, receiving little rainfall, while the Caspian Sea coast and the slopes of the Alborz and Zagros mountains are the wettest areas. The rainy season generally runs from November to May, followed by a long dry period from May to October.

Key characteristics

Spatial variation: Rainfall is highest along the northern coast, followed by the western mountain ranges, and decreases significantly towards the east and south. The central, eastern, and southeastern parts of the country are the driest.

Seasonal variation: The main rainy season is from late autumn to early spring (November to May). The summers are very dry, with minimal precipitation.



Mountain influence: The large mountain ranges, particularly the Alborz and Zagros, heavily influence rainfall patterns by affecting Mediterranean cyclones and moisture distribution.

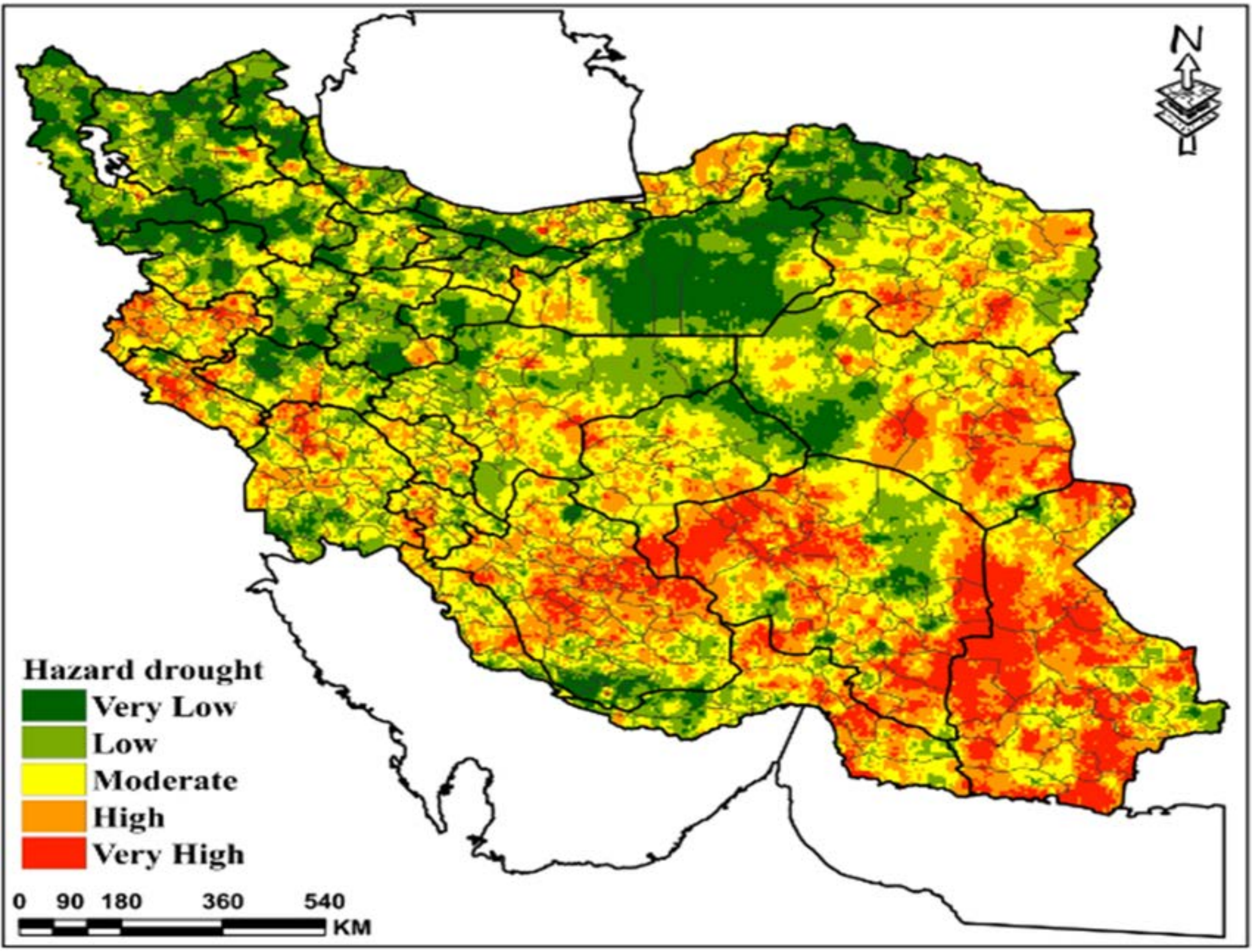
Intense rainfall events: Recent decades have seen an increase in the frequency and intensity of heavy rainfall events, particularly in the autumn and in areas like the Zagros Mountains. This can lead to flash floods.

Climate change impacts: Iran's precipitation patterns are being affected by climate change, with a decrease in overall rainfall and shifts in timing.

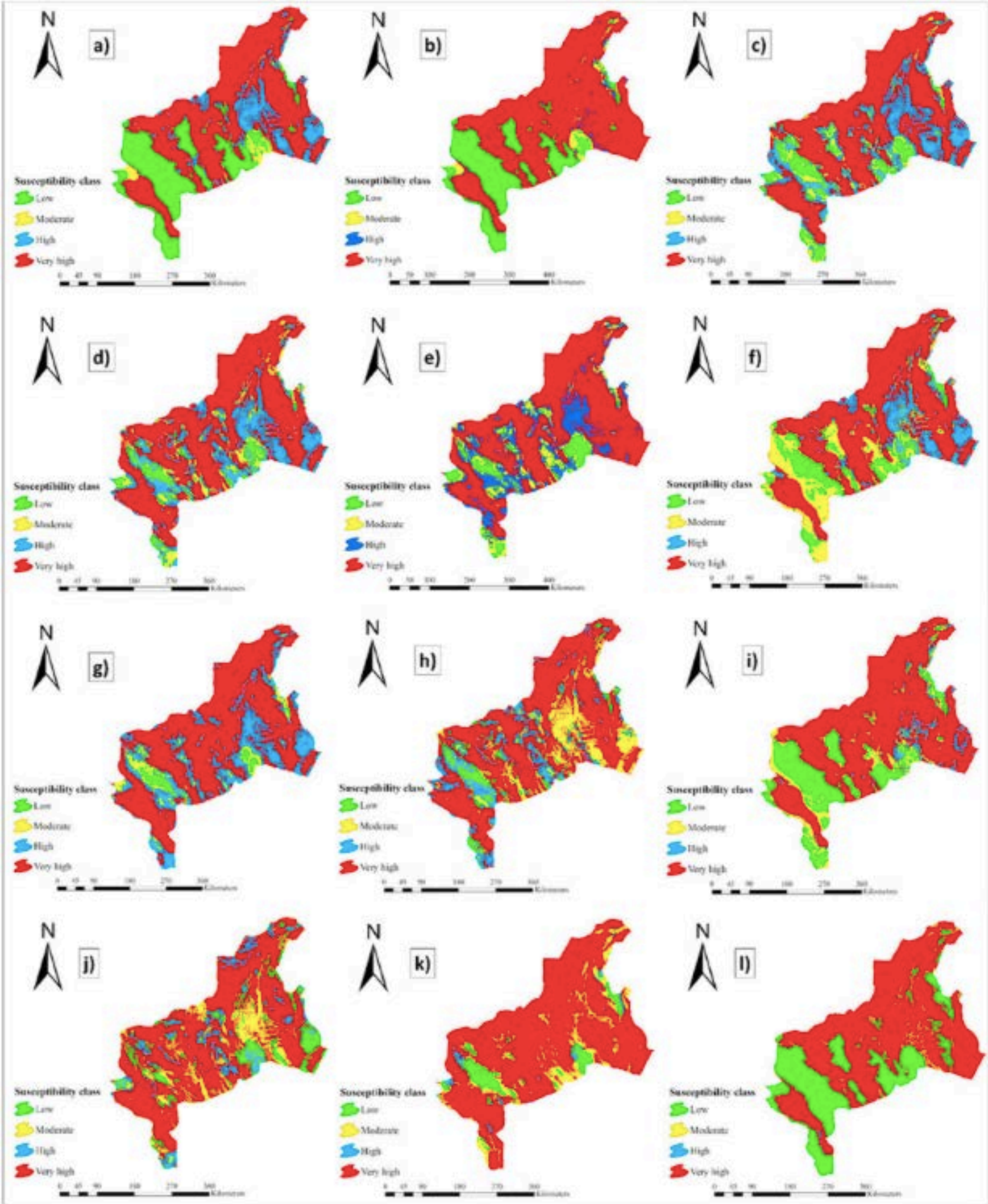
Of the average annual rainfall volume of 406 billion cubic metres (BCM), an estimated 68% evaporates before reaching the rivers. The total long-term annual renewable water resources are estimated at 120BCM, of which about 78BCM go to surface run-off.

Drought and warming

Drought-prone: Iran is a drought-prone country, and severe drought episodes have increasingly occurred, impacting agriculture and water supply.



Rising temperatures: Increasing temperatures accelerate evaporation, further reducing water availability.



VII. Additional Water infrastructure

Dams

Extensive construction: Iran is a prolific builder of dams, with hundreds constructed and planned for power generation, irrigation, and flood control.

Dam depletion: Reservoir levels in many major dams are critically low due to prolonged drought and water mismanagement.

Desalination and transfer projects

Massive investment: The government is investing heavily in desalination plants and long-distance pipelines to transfer water from the southern coasts to the central plateau, though these projects face environmental and economic opposition

Iran's history with water desalination dates back to 1960 when a small desalination plant with a capacity of 1000 m3 /day was installed on the island of Khark. In 2020, about 73 water desalination units were operating in different regions of the country, mainly in the south, producing a total capacity of approximately 420,000 m3/day of fresh water.

Most of the installed desalination systems are fossil fuel-driven. The largest desalination plant in Iran is located in Bandar Abbas. It started operating in December 2018 with an initial production capacity of 20,000 m3 /day at the first stage using reverse osmosis technology. The project's cost was 204 Million USD and was funded by the private sector. The facility was to be updated to produce 100,000 m3 /day.

As reported in 2020, the government planned to install additional 50 desalination plants to serve 45 million people in 17 provinces. The new plants were expected to be powered, at least partially, by a (small) nuclear power plant. However, there is limited information available on the costs, funding sources, or environmental impacts if these desalination plants

Non-conventional sources

Wastewater reuse

In Iran, wastewater reuse is a critical strategy for managing severe water scarcity, primarily targeting the agricultural, industrial, and municipal sectors. Despite significant investment and policy goals to expand treatment capacity, the practice faces considerable challenges, including inadequate infrastructure, inconsistent monitoring, and public perception issues.

Context for wastewater reuse in Iran

Severe water stress: Iran is located in an arid region with low rainfall and has severely overused its surface and groundwater resources due to population growth and agricultural demands.

Heavy agricultural water use: The agriculture sector consumes an overwhelming majority of the nation's water, an estimated 92%, including the extraction of non-renewable water reserves.

Government initiatives: Iran's government has set targets for expanding wastewater treatment and has initiated projects in major cities. For example, Tehran has a large-scale sewage system to improve treatment capacity, and cities like Shiraz have pursued projects to reduce reliance on groundwater.

Public acceptance: Public attitudes toward recycled water vary, with higher acceptance for low-contact uses like car washing and landscape irrigation than for drinking or cooking. Education and awareness campaigns are needed to increase trust.

Applications of wastewater reuse

Agricultural reuse: This is the most significant potential area for water reuse, particularly with agricultural drainage water, which could be a vast resource if managed effectively.

- Reclaimed water is mainly used for irrigating non-edible crops, forestry, and landscaping near urban centres.

- Untreated or partially treated wastewater is often used informally by farmers downstream from urban centres, leading to health and environmental risks due to the lack of quality monitoring.

Industrial reuse: Reclaimed wastewater is used for industrial parks and power plants, reducing the burden on freshwater supplies.

Municipal and urban reuse: In urban areas, treated wastewater is used for non-potable purposes such as:

- Irrigating public parks, green spaces, and golf courses.

- Flushing toilets and other low-contact applications.

Groundwater recharge: In some areas, treated effluent is used to recharge brackish aquifers, which can then be used for irrigation downstream. This helps combat severe land subsidence caused by over-extraction of groundwater.

Urban agriculture: The use of treated wastewater for urban food production is an emerging opportunity, offering potential for nutrient recycling and reduced carbon emissions.

Major challenges and barriers

Outdated and insufficient infrastructure: While treatment capacity has grown, many plants are outdated, and many regions lack proper collection and distribution networks. This leads to a high volume of untreated sewage being discharged and intentional or unintentional informal reuse.

Lack of monitoring and regulation: The quality of treated effluent is often inconsistent, and Iran's official standards for reuse may be outdated. A lack of effective monitoring for water quality and unregulated water use presents health and environmental risks.

High agricultural water consumption: Government policies, including heavy subsidies for water and energy, have historically incentivised water-intensive agriculture and disincentivized efficiency. This makes it difficult to reallocate water to higher-value uses.

Economic sanctions: International sanctions have limited Iran's access to modern technologies and foreign investment, hampering efforts to upgrade water infrastructure.

Centralised governance: A highly centralised water management system can cause bureaucratic hurdles and delays in responding to local needs for water resource management.

Future outlook

To realise the full potential of wastewater reuse, Iran must adopt more comprehensive and integrated water management strategies. Experts recommend upgrading wastewater treatment technology, improving delivery infrastructure, and developing more robust regulatory frameworks. Aligning water pricing and incentives could also encourage the shift away from over-relying on finite freshwater sources.

VIII. Iran Water Crisis Overview

The Islamic Republic of Iran is facing a severe and escalating water crisis, driven by a combination of climate change and decades of government mismanagement. The resulting "water bankruptcy," in which demand far outstrips supply, has led to widespread drought and the depletion of aquifers.

Across Iran, the arid central plateau, southeastern regions, and several major cities are suffering most from desertification and water crises. These regions are experiencing the most severe effects of drought, poor water management, and climate change, which have destroyed ecosystems and displaced populations.

Most affected regions

Central Plateau

Isfahan Province: The Zayandeh Rud, once the lifeblood of the province, has frequently run dry due to dam construction and diversions for agriculture and water-intensive industries like steel. This has decimated local agriculture and triggered protests.

Yazd and Kerman provinces: These desert regions are experiencing some of the most severe effects of desertification, with over-tapped aquifers and land subsidence. Many ancient settlements and farms have been abandoned as underground water channels (Qanats) and wells run dry.

Tehran: The capital, home to over 9 million people, is under critical water stress. Overpopulation, compounded by internal migration from rural areas, has pushed demand beyond available resources, with dam reserves dangerously low.

Southeastern Iran

Sistan and Baluchestan Province: This region has faced a devastating combination of drought, dust storms, and a collapsed water supply, particularly from the now-dry Lake Hamoun, once Iran's largest freshwater lake. The collapse of farming and fishing has led to mass migration from the area.

H**ormozgan Province:** Located on the Persian Gulf, this region has experienced a significant drop in rainfall, worsening its already limited water resources.

Water-rich regions facing mismanagement

Khuzestan Province: Historically one of Iran's most water-rich provinces, it has been severely impacted by the mismanagement of water resources. Diversion projects and damming have depleted the Karun and Karkheh rivers, crippling agriculture and provoking widespread protests.

Western provinces: While relatively more water-rich than the central and eastern deserts, provinces like Hamadan in the west have also experienced severe drought and dam depletion. The ongoing water crisis threatens to put further pressure on these areas as migrants move westward.

Consequences

Economic disruption: The agricultural sector, a pillar of the economy, is in retreat, leading to decreased food production, rising inflation, and unemployment. Water-intensive industries like steel and petrochemicals are also seeing production cuts.

Social unrest and migration: Water shortages and mismanagement have fuelled protests across the country, particularly among farmers. Rural-to-urban migration has dramatically increased as farmers and villagers lose their livelihoods, placing immense strain on urban infrastructure and leading to the growth of informal settlements. Up to 50 million Iranians could be displaced by 2050.

Environmental collapse: Iconic water bodies have dried up, including Lake Urmia and the Zayandeh Rud river in Isfahan, leaving behind vast salt flats and increasing dust storms. This degradation contributes to public health issues and respiratory problems.

Increased geopolitical tension: Water disputes with neighbouring countries over shared rivers, such as Afghanistan and Iraq, create potential security flashpoints.

Government's response and proposed solutions

Short-term measures: The government has resorted to emergency measures like water rationing and temporary cuts to high-use households in cities like Tehran. Officials have occasionally released water from dams to placate protesters.

Technological projects: Large-scale projects, such as expensive seawater desalination and inter-basin water transfers, are being pursued despite high costs and environmental concerns.

Traditional methods: Some experts advocate for reviving traditional, sustainable water management practices, such as the ancient qanat system, though this alone is not enough.

Comprehensive reform: Experts argue for abandoning water-intensive crops, investing in efficient irrigation technology, repairing leaky water infrastructure, and phasing out environmentally damaging industrial practices.

IX. Causes of the water crisis

Mismanagement: A culture of poor environmental governance has fuelled the crisis, one such example is;.

- **Unscientific dam construction:** Hundreds of dams have been built, often without proper environmental impact assessments, disrupting natural river flows and drying up wetlands. For example, the Gotvand Dam was built on salt beds, which led to high downstream salinity.

Unsustainable water usage: Iran's development policies have promoted wasteful consumption, far exceeding international norms.

Inefficient agriculture: The agricultural sector accounts for 80–90% of Iran's total water use, largely due to inefficient flood irrigation techniques and the cultivation of water-intensive crops in arid regions. The government's historic push for agricultural self-sufficiency has contributed significantly to this overconsumption.

Industrial overconsumption: Water-hungry industries, such as steel and petrochemical plants, have been established in desert provinces like Isfahan and Yazd, depleting local water resources.

Climate change and drought: Environmental factors, exacerbated by decades of policy failure, have intensified the crisis.

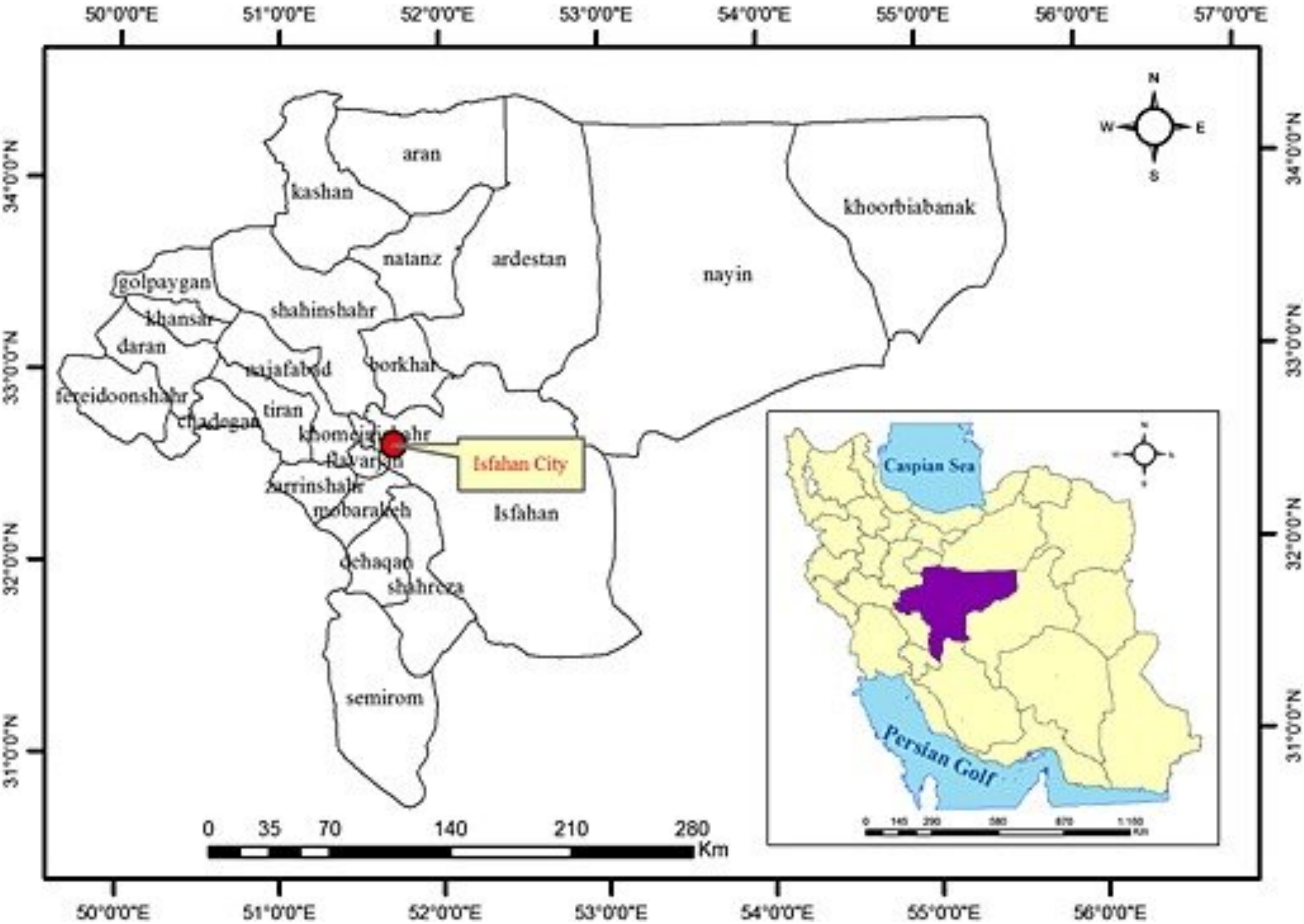
- **Long-term drought:** Iran is in its fifth consecutive year of drought, with national rainfall down significantly.

- **Higher temperatures:** Rising temperatures increase evaporation and water demand for cooling, further straining supplies.

Depleted groundwater: Over-extraction through both legal and thousands of illegal deep wells has led to rapid depletion of groundwater reserves. This overuse causes severe land subsidence, posing a threat to ancient and modern infrastructure in cities like Tehran and Isfahan.

X. Key examples of the effects of the water crisis regionally

A. Isfahan Province



The water crisis in Iran's Isfahan Province, primarily driven by the drying of the Zayandeh Rud river, has led to a cascade of severe environmental, social, and economic effects. While specific monetary costs are difficult to quantify, the expenses include billions of dollars in lost agricultural and industrial production, damage to infrastructure, and investments in unsustainable water projects.

Environmental effects

Land subsidence: The over-extraction of groundwater to compensate for the dry river has led to massive land subsidence across the province, especially in the city of Isfahan. This is threatening historical monuments, urban infrastructure like metro stations, hospitals, and schools.

Desertification and wetland loss: The Gavkhouni wetland, located at the end of the Zayandeh Rud, has dried up, contributing to desertification and threatening the local ecosystem.

Dust storms: The drying of wetlands and lakes, including Gavkhouni, leads to more frequent dust storms that worsen respiratory problems for residents.

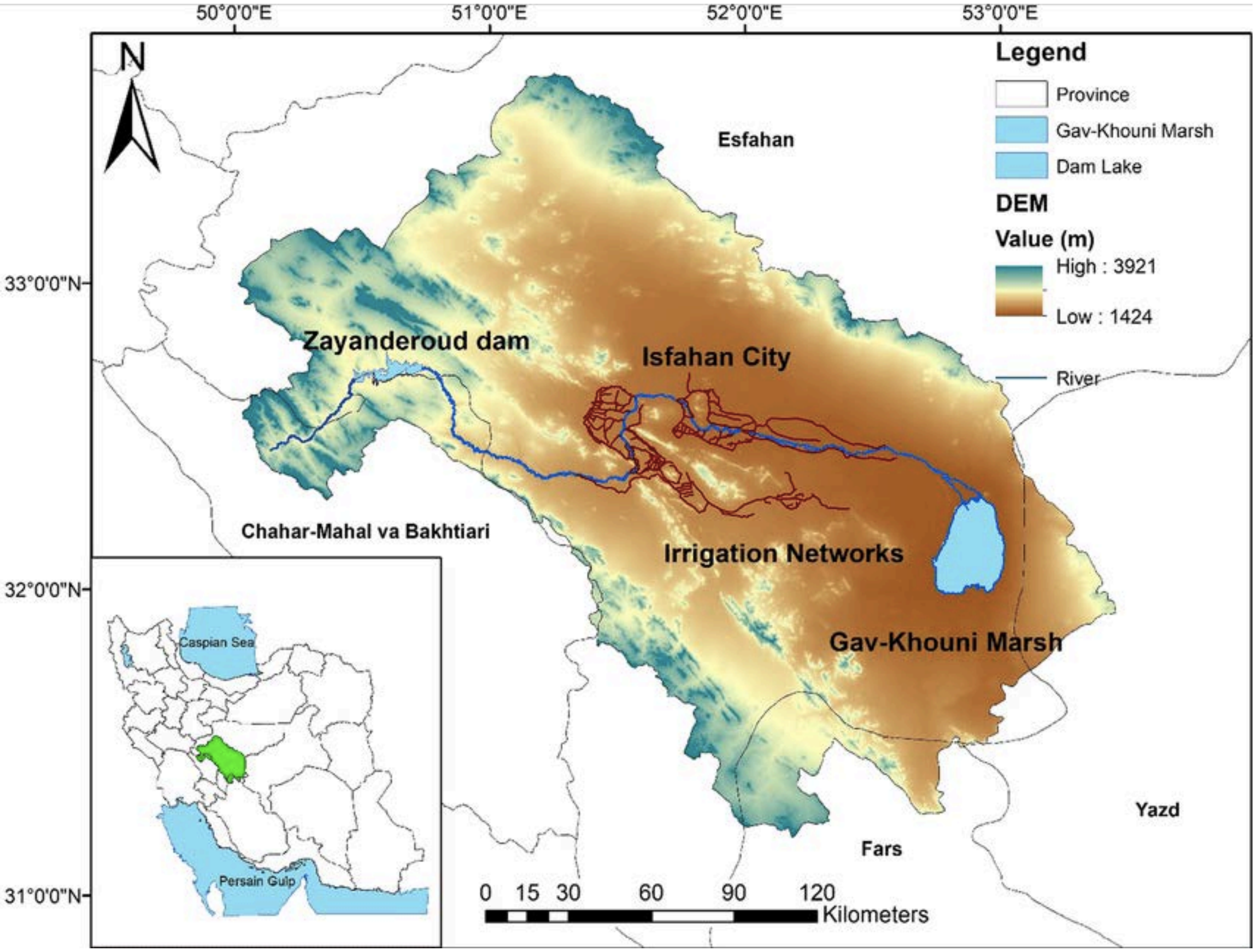
Zayandeh Rud River

As of October 2025, the Zayandeh Rud River remains mostly dry, particularly as it flows through the city of Isfahan. While historically a life-giving waterway, the river has been reduced to a cracked bed for much of the past two decades due to a combination of climate change and severe mismanagement of water resources

The climate of the Zayandeh-Rud River Basin has a dramatic range. The average rainfall is ~1500 mm and is comprised of snow falling in the west of the basin, and ~110 mm of rain in the eastern parts, including the Gavkhouni wetland.

The Zayandeh Rud river was last consistently full of water in the early 2000s, but has experienced prolonged dry spells since 2000 due to drought and increased water diversion for agriculture. While the river has had temporary flows into Isfahan, such as in July 2025 following a dam release, it has not been permanently full for decades and was last cited as completely dry in 2006.

The Zayandeh-Rud River Basin is one of the most populous and industrialised watersheds in the country of Iran. In the past several decades, the water and vegetation of the basin have been highly abundant, resulting in the identification of more than 910 plant species, 390 genera, and 83 families, including native plants, with genetic, medicinal, ornamental, edible, and industrial values. These plants also serve as a natural filtration system. In contrast, the Zayandeh-Rud River has recently been dried up for several years and has turned the wetland into a salt pan, which has negatively affected the climate, environment, life of related organisms and the natural ecosystem of it and the surrounding region. Especially changes in the biological and environmental conditions of the Gavkhouni wetland as the most critical wetland in this arid region, have many different consequences, such as a drastic decline of flora and fauna in the wetland, which has been observed in recent years.



The Zayandeh Rud, or "life-giving river," is Iran's largest river on the central plateau and has been the heart of the city of Isfahan for thousands of years. However, the river's water crisis, driven by extensive diversion, mismanagement, and climate change, has caused it to dry up for much of the year, leading to severe environmental, economic, and social consequences.

Long-Term Drying Trends

Since 2000: The river has frequently dried up due to a combination of natural drought conditions and increased human water diversion for irrigation.

2006: The river lost its permanent flow in 2006.

Post-2000s: The river's flow has been severely reduced for extended periods.

Recent Temporary Flows

July 2025: The river experienced a temporary flow into Isfahan after a temporary increase in outflow from the Zayandeh Rud Dam, according to IFP News.

Significance of Temporary Flows: These are often short-lived and are not indicative of a return to its historically full state.

Causes of the water crisis in the Isfahan Province

The drying of the Zayandeh Rud is primarily man-made, resulting from decades of poor water management and overuse.

Government mismanagement: Authorities have repeatedly failed to manage the basin's water resources effectively, including allowing the conversion of pasture land into water intensive farmland.

Water diversion: Water has been controversially diverted to supply other provinces, like Yazd and Kerman, and to meet the needs of water-intensive industries.

Inefficient agriculture: The agricultural sector consumes approximately 80% of the river's water, largely due to inefficient and traditional irrigation methods.

Industrial use: Water-intensive industries such as steel, petrochemicals, and power plants established in the arid central provinces have placed immense strain on the river's resources.

Climate change: Multi-year droughts and reduced precipitation levels exacerbate the water crisis. The lower reaches of the river completely dried up in the early 2010s after several years of seasonal droughts.

Effects of the water crisis in the Isfahan Province

The severe water shortage in the Zayandeh Rud basin has led to a cascade of negative effects across multiple sectors.

Economic impacts

Agricultural collapse: The agricultural sector is the largest water consumer in Iran, and the Zayandeh Rud's desiccation has devastated farming in Isfahan. Farmers have lost their livelihoods, forcing many to abandon their fields.

Decline in tourism: As the river runs dry, the parks and historical bridges that once made Isfahan a major tourist destination have lost their appeal. The decline in tourism has hit the local economy hard.

Subsidised water prices: Historically, the government has heavily subsidised water, providing little incentive for industries to conserve. Industries have paid less than 2% of the true economic value of the water they use.

Industrial decline: Water-intensive industries, like steel and petrochemicals, have been forced to cut production, leading to significant losses. This affects both local and national economic output.

High infrastructure costs: The ongoing land subsidence requires the evacuation and demolition of buildings, while damaging infrastructure like highways and airports creates costly repair and replacement expenses.

Inefficient water projects: The government's reliance on large-scale projects, such as dams and desalination, has proven to be costly and environmentally damaging. Some desalination projects are criticised for high energy consumption and negative ecological impacts on water bodies like the Persian Gulf.

Influx of migrants and urban strain: The rural-to-urban migration of displaced farmers strains city infrastructure and services, requiring further public investment.

Environmental impacts

Land subsidence: Excessive groundwater extraction has created a 10-meter underground void in the Isfahan city basin, affecting an area of up to 2,700 square kilometres. This causes sinkholes and damages buildings, historical monuments, roads, and crucial infrastructure like refineries and power plants.

Wetland loss: The drying of the Zayandeh Rud has led to the loss of the Gavkhoni wetland, destroying local ecosystems. As of early 2025, it was reported that 43% of Iran's wetlands were at risk of drying up and becoming dust storm hotspots.

Desertification: Decreased rainfall and higher temperatures are accelerating desertification in the region, degrading soil quality and causing dust storms.

Contaminated aquifers: Lowered water tables lead to salt intrusion, contaminating freshwater aquifers and making land uninhabitable.

Increased pollution: With lower river flow, the concentration of pollution from urban and industrial runoff has increased, leading to a deterioration of water quality.

Ecological destruction: The once-thriving Gavkhouni swamp, where the river ended, has completely dried up, destroying local ecosystems.

Social effects

Migration: The water crisis is a major driver of internal migration, with thousands of farmers and rural communities leaving Isfahan and other regions for cities in search of work.

Health and public well-being: Water rationing and limited access to clean water create sanitation and public health risks. The uncertainty of a stable water supply also causes severe mental and physical stress for residents.

Endangered cultural heritage: Land subsidence threatens Isfahan's historical monuments, many of which are located in high-risk areas. This destruction undermines the cultural identity and tourism appeal of the region.

Loss of identity: For the people of Isfahan, the drying of the river represents a profound cultural and psychological loss, with the "life-giving" river becoming a source of despair.

Cost of the water crisis Zayandeh Rud River and the entire Isfahan Province

The costs of the Zayandeh Rud river and the entire Isfahan Province water crisis are both direct and indirect, encompassing failed projects and broader economic fallout.

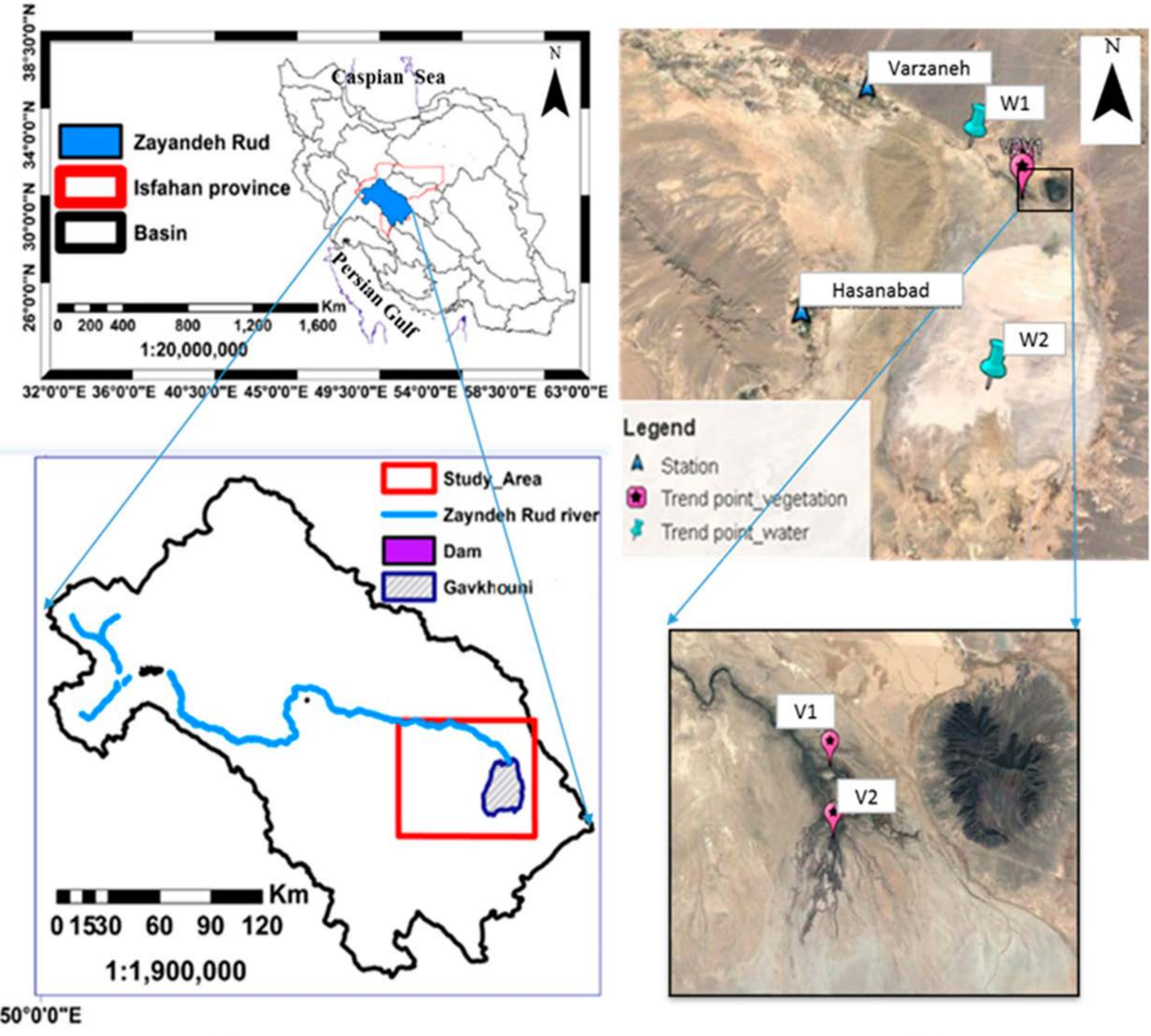
Ineffective mitigation projects: The Iranian government has invested billions in large-scale, and often criticised, projects like seawater transfer and desalination. A proposed $8 billion investment aims to shift industrial water sources, but critics warn of high energy costs and adverse environmental impacts from these methods.

Failed water transfer promises: Despite government promises, multi-billion dollar water transfer projects have been under development for decades, with completion dates repeatedly missed, fuelling public distrust.

Agricultural losses: The direct cost to the farming sector is significant, with crop losses and unemployment affecting hundreds of thousands. The estimated water required for melon production alone highlights the scale of water misuse and resulting economic losses.

Infrastructure damage: Land subsidence caused by the depletion of groundwater is a major threat to historical structures and urban infrastructure, requiring costly repairs.

Gavkhouni Wetland



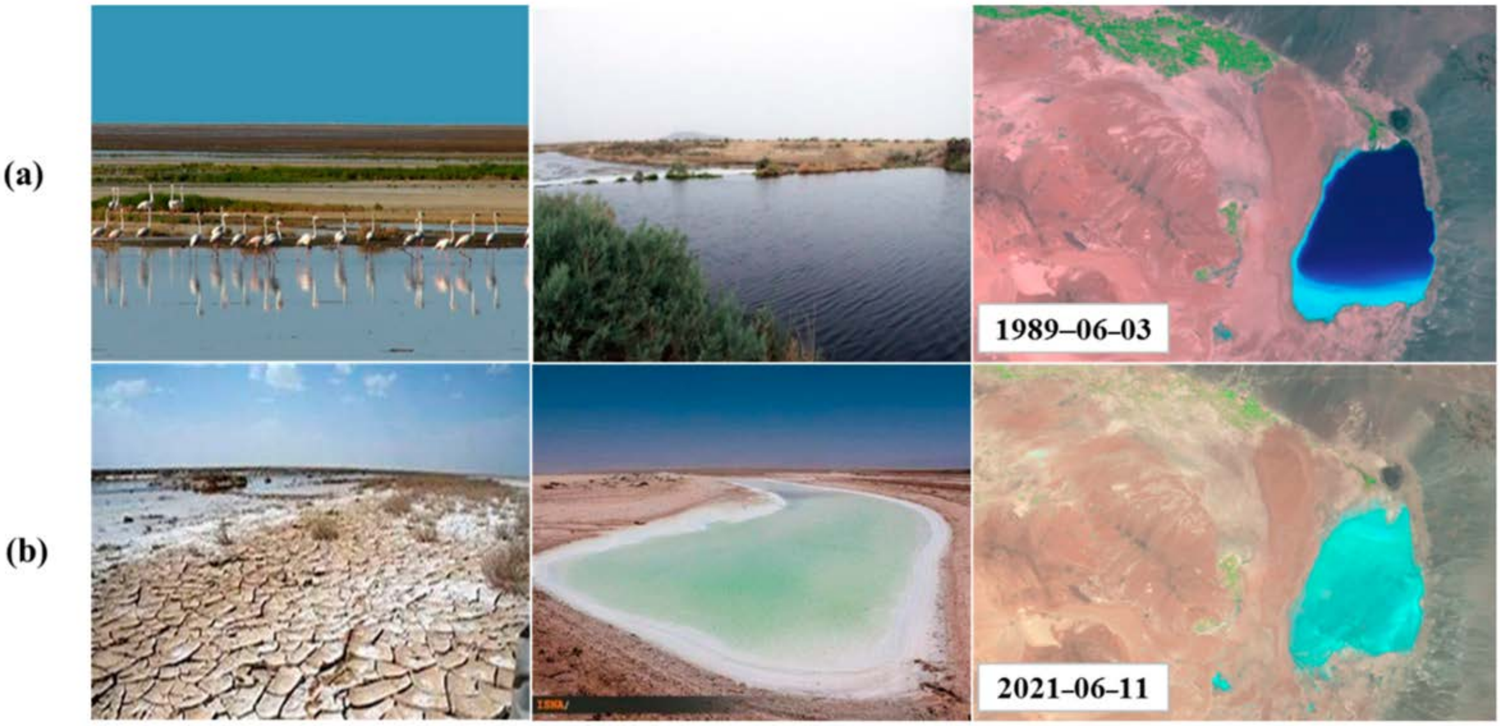
(a) (b)

The Zayandeh-Rud River Basin, which is located in the most central and arid region of Iran, is the Zayandeh-Rud River, which originates from the Zagros Mountains in the west at an altitude of 4500 m (32°22′ N, 50°04′ E) and flows ~350 km to the east to end in the Gavkhouni wetland at 1470 m [45].

Located in the eastern part of the Zayandeh-Rud River Basin is the Gavkhouni wetland and its surrounding area (52°39′ E, 32°25′ N). The Gavkhouni wetland, which was included in the international Ramsar Convention as an international wetland in 1975 has an area of 476 km2 and is situated downstream of the Zayandeh-Rud River. According to the reports of the Iran Meteorological Organization, the maximum depth of stored water in the wetland is about 80 to 150 cm.

The drying of Iran's Gavkhouni wetland, a consequence of drought and severe water mismanagement, has resulted in widespread environmental and social and economic costs. The dry lakebed has become a major source of dust storms, while the loss of this vital ecosystem has had damaging effects on the regional climate, local wildlife, and human populations.

Environmental effects and costs



Dust storms and air pollution: The exposed, dry bed of the Gavkhouni wetland has turned it into a major source of fine dust particles and salt.

- Wind erosion picks up these particles, creating severe dust storms that can travel far beyond the immediate region.
- These storms impact air quality, degrade agricultural lands, and can carry pollutants from Isfahan and other urban areas that once settled in the wetland.
- The spread of dust and pollutants threatens the health of millions in multiple provinces and may even reach the capital, Tehran.

Local climate change: The wetland's disappearance has altered the local climate.

Research has shown that the wetland's dryness has led to a significant increase in air temperatures in the surrounding areas.

Between 2000 and 2019, mean seasonal air temperatures in the surrounding area increased by approximately 1.6 °C in the spring and 1 °C in the summer.

Temperatures also see larger daily fluctuations without the wetland to moderate them.

Loss of biodiversity: Once a haven for flora and fauna, the dried-up Gavkhouni wetland has seen a catastrophic decline in its ecosystem.

- The loss of water and habitats has led to a drastic reduction in plant and animal species.
- The wetland was once a crucial home for migratory birds, including flamingos, ducks, and pelicans.
- With its disappearance, many species face endangerment or extinction, contributing to a regional biodiversity crisis.

The condition of Gavkhouni Wetland as severe drought has affected many parts of Iran, Isfahan

Groundwater depletion and land degradation:

- The drying of the Zayandeh River and Gavkhouni has led to a decrease in the region's groundwater levels.
- This places further stress on local water resources, contributing to land subsidence and other forms of land degradation.

Socioeconomic effects and costs

Health impacts: The increased dust storms expose millions of people to fine particulate matter, which has severe health consequences.

- The dust is associated with an increase in cardiovascular and respiratory illnesses.
- Reports have also linked the environmental degradation to a rise in certain diseases, such as cancer, in local populations.

Economic collapse: The drying wetland has had devastating effects on the local economy, which relied on agriculture and tourism.

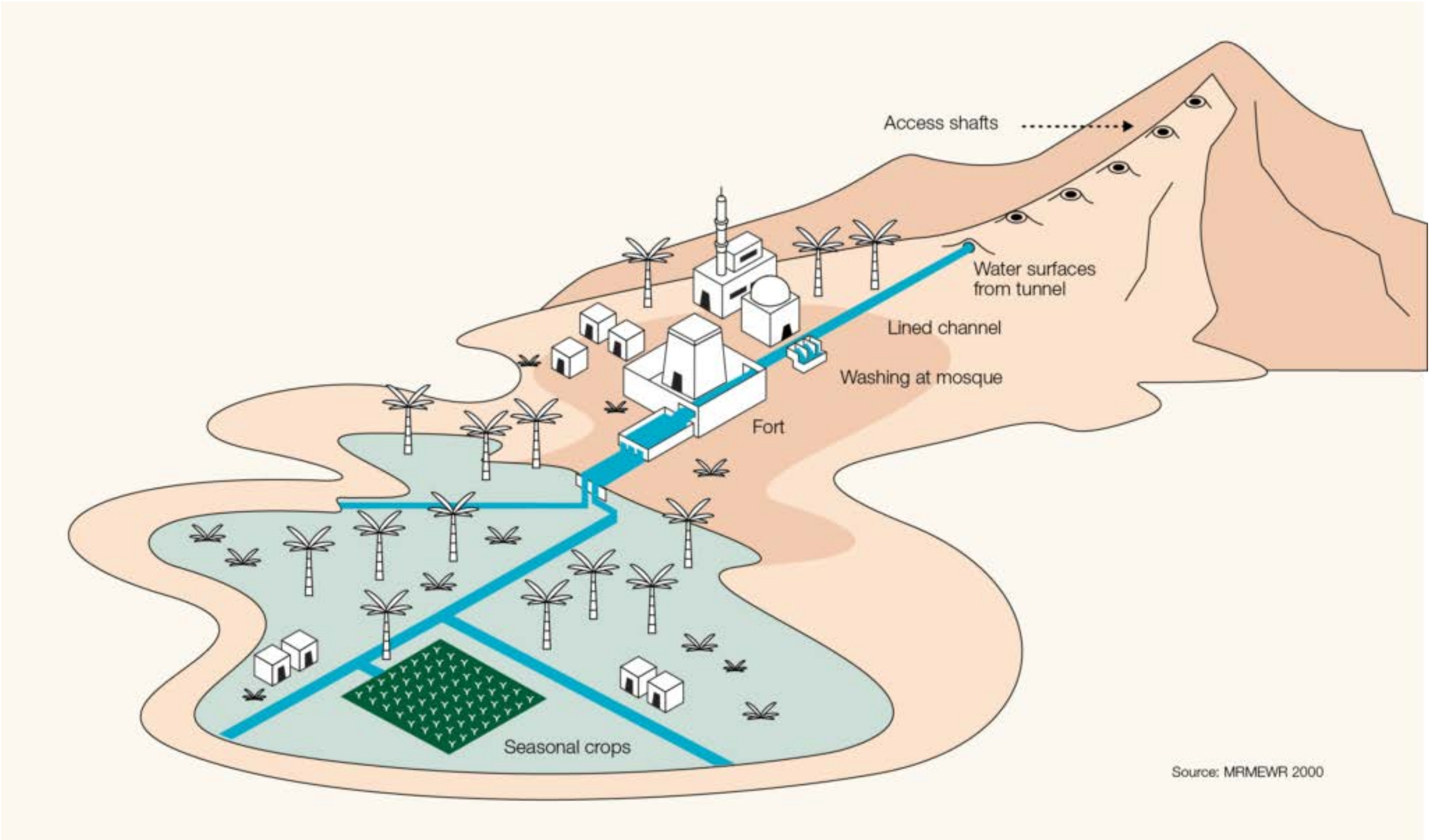
- Agricultural productivity has plummeted due to water shortages and the impact of dust storms on crops.
- Tourism-related job opportunities, previously supported by the wetland's natural beauty, have disappeared.
- The overall economic cost to the region has been immense, impacting local livelihoods and causing increased unemployment.

Population displacement: Economic hardship and environmental degradation have forced many local residents to leave their homes.

- The drying of the wetland has resulted in a significant increase in migration from the region, causing a humanitarian crisis.

- Hundreds of thousands of residents and farmers downriver have been forced to migrate to other areas in search of employment and a more stable environment.

Kashan Region Qanat System



The Kashan Region Qanats are an ancient system of underground aqueducts that have sustained life and agriculture in the arid landscape of central Iran for millennia.

Recognised by the Food and Agriculture Organisation (FAO) as a Globally Important Agricultural Heritage System, the Qanats rely on gravity to transport water from mountain aquifers to the desert plains.

Function and structure

A qanat system typically consists of the following components:

Mother well: A deep vertical shaft sunk into the aquifer, usually in the foothills of mountains where the groundwater is closest to the surface.

Underground tunnel (Kooreh): A gently sloping subterranean channel that draws water from the aquifer and carries it over a long distance.

Vertical access shafts (Millehs): A series of wells dug at regular intervals along the tunnel's path. These shafts served to remove excavated soil during construction and to provide ventilation for the workers.

Outlet: The point where the tunnel emerges onto the surface, allowing water to flow into fields and settlements.

The system's ingenious design minimises evaporation, a crucial advantage in the hot desert climate, and prevents the contamination of the water supply.

Historical and cultural significance

The qanat system in the Kashan region is one of the oldest in Iran, with a history dating back to at least 800 BCE. The technology made permanent human settlement and agriculture possible in a region that would otherwise have been uninhabitable desert. Key aspects of its importance include:

Sustainable water management: The Qanats utilise gravity, requiring no mechanical power and minimising operational costs. They provide a reliable water source that is insulated from drought and flooding.

Agricultural heritage: The Qanats have enabled the cultivation of important crops, such as pomegranates, figs, and pistachios, and have supported a rich biodiversity of plant and livestock species.

Communal governance: The construction, maintenance, and equitable distribution of water from the Qanats fostered a strong sense of community and cooperation among local villagers. Historical documents detail the rules and regulations governing water rights and distribution.

Cultural expression: The technology reflects the ingenuity and deep respect for water held by ancient Persian civilisation. The Qanats also helped drive urban development by supplying water to cities far from natural water sources.

Examples in the Kashan region

Notable Qanats and related water systems in or near Kashan include:

Fin Garden (Bagh-e Fin): This historic Persian garden in Kashan is fed by a spring and a qanat system that has been used for thousands of years, potentially serving the ancient site of Tepe Sialk.

Ebrahim Abad Historical Aqueduct: Another example of the region's ancient water infrastructure.

Mozd Abad Qanat: A significant qanat in the area that continues to function.

Present-day status

While modern infrastructure has replaced some traditional water systems, many Qanats in Iran remain operational, providing water for rural communities and agriculture. However, traditional agricultural heritage systems like the Kashan Qanats face modern challenges, including the need for effective conservation plans.Qanats enabled agriculture and settlement in the province's central desert and on alluvial fans in piedmont zones, regions that would otherwise have been uninhabitable. The system’s success fostered agriculture, urban development, and a communal tradition of water management.

Function and importance

Sustainable water supply: Qanats minimised water loss from evaporation and ensured a steady, reliable supply for drinking and irrigation in an otherwise parched environment.

Enabling civilisation: By transforming arid landscapes into fertile oases, the qanat system supported agriculture and allowed for the growth of settlements like Kashan and Isfahan. The development of elaborate Persian gardens was also made possible by these aqueducts.

Communal management: The qanat system fostered strong community cooperation for construction, maintenance, and equitable water distribution, often managed by a water master using ancient "water clocks".

Associated technologies: Qanats were integrated into other architectural and engineering solutions, such as providing cooling for buildings via wind-catchers (badgirs) and powering underground watermills.

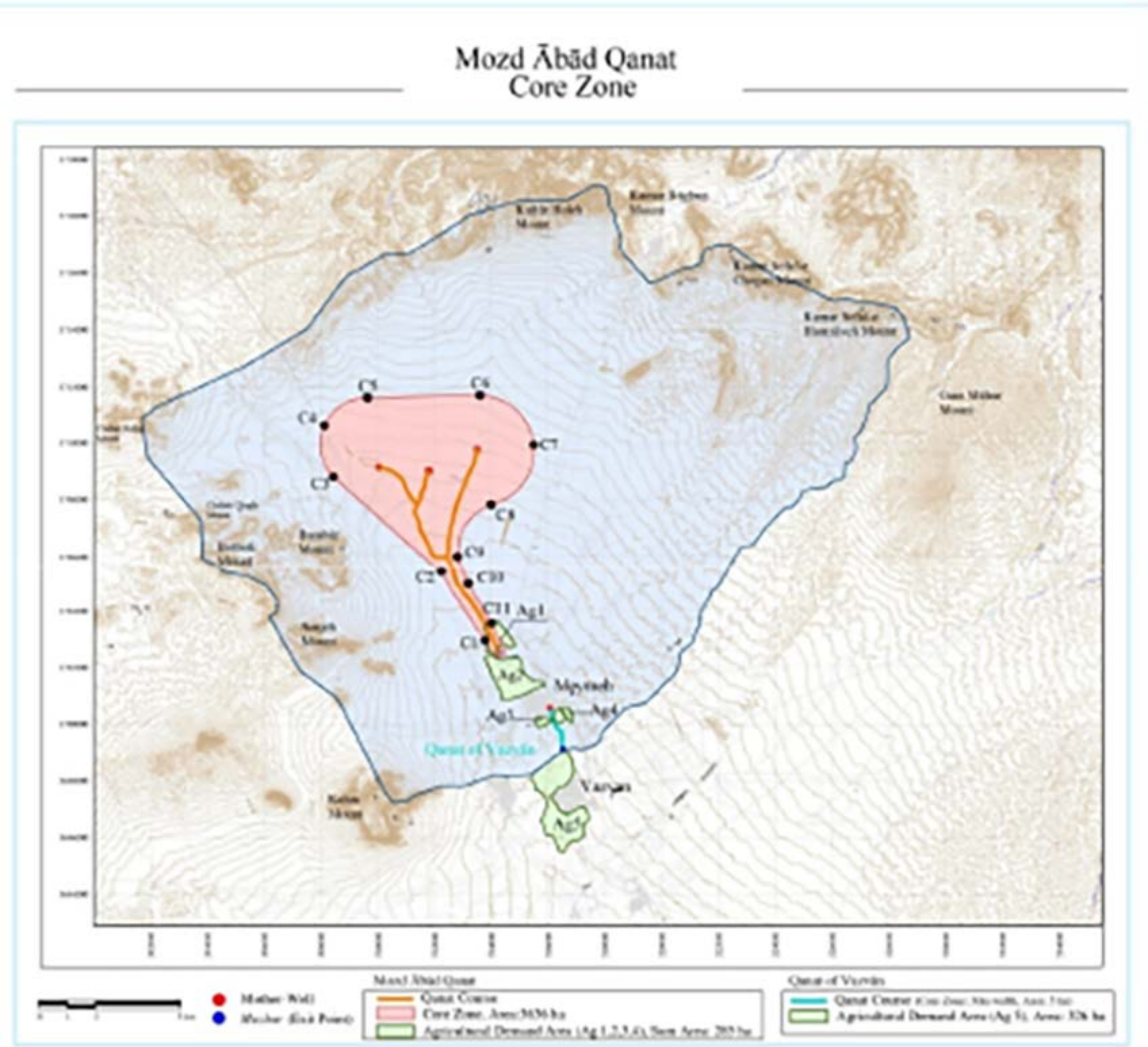
UNESCO recognition: Eleven of Iran's Qanats were designated a UNESCO World Heritage site in 2016, with two of them, the Moon Qanat and Vazvan Qanat, located in Isfahan Province.

Modern challenges

In recent decades, overuse and mismanagement have led to the drying of the Zayandeh River and a falling water table, which poses a severe threat to the viability of Isfahan's qanat systems. Some Qanats have dried up completely, a sign of severe environmental stress in the region.

Notable Ganats in Isfahan Province

1. **Mozd Abad Qanat:**



Located near Isfahan, this ancient Qanat showcases advanced hydraulic engineering with multiple subterranean dams that regulate water flow and minimise sedimentation. It is a prime example of the resilience and longevity of these systems.

The Mozd Abad Qanat, also known as the Mazdabad Qanat, is an ancient, 2,500-year-old subterranean water system near Isfahan, Iran. This remarkable feat of Persian engineering is part of the larger Persian Qanat system, which was collectively designated a UNESCO World Heritage site in 2016.

Key features

Location: The Mozd Abad Qanat is located in the Shahin Shahr and Meymeh County of Isfahan Province.

Engineering innovation: The system includes three underground dams designed to regulate water flow and minimise sedimentation, demonstrating advanced ancient hydraulic knowledge. This infrastructure helps control the water's speed and direction.

Unique geology: The Qanat's great depth—at around 100 meters—has caused limestone crystallisation over centuries. This has created an underground cave system with stalagmites and stalactites that is reminiscent of the Ali Sadr Cave.

Split water sources: The Qanat has a unique two-branch structure that carries both warm and cold water.

Water transport: As with all Qanats, the Mazdabad system uses a gently sloping underground tunnel to transport water from a mountain aquifer to dry, arid land via gravity, without the need for pumping.

Historical significance: The Qanat enabled agriculture and settlement in a desert region. It stands as a testament to the sophisticated engineering and resource management of ancient Persian civilisation.

The water crisis in Isfahan province has severely affected the Mazdabad Qanat by contributing to the over-extraction of groundwater, which has lowered the water table that feeds the qanat system. This has diminished the qanat's flow, degraded water quality, and destabilised the subterranean channels, ultimately threatening the ancient engineering marvel and the agricultural communities dependent on it.

The Mazdabad Qanat is an ancient Persian underground aqueduct system that has transported water by gravity for centuries. Its decline is symptomatic of Iran's broader water insecurity, which is caused by a mix of climate change, overdevelopment, and poor resource management.

Hydrological and environmental effects on the Mazdabad Qanat

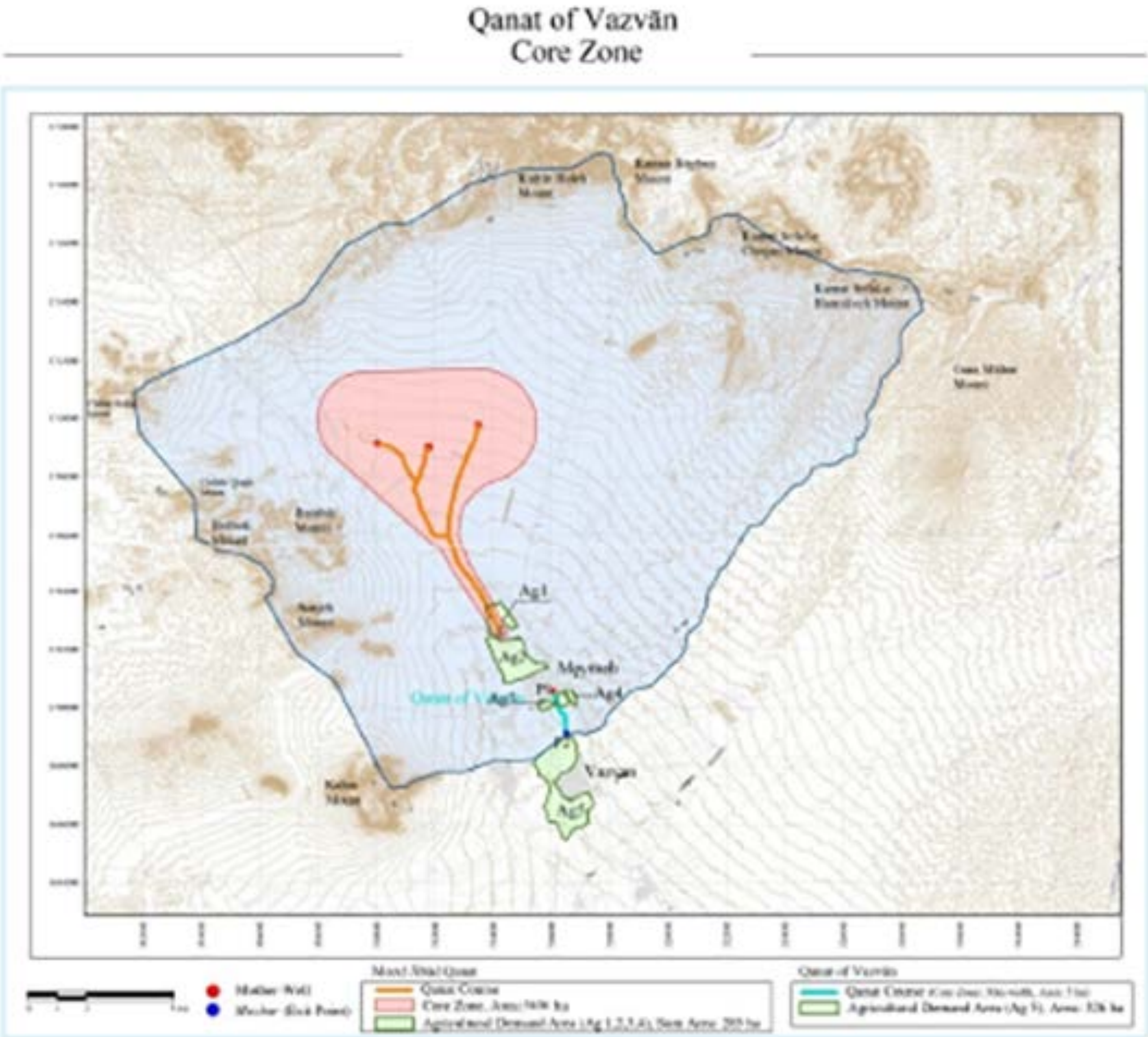
Depletion of groundwater: The primary threat to the Mazdabad Qanat is the widespread use of deep and semi-deep motorised wells. These modern pumps extract groundwater much faster than it can be naturally replenished, causing the water table to drop below the qanat's channels and causing them to dry up.

Land subsidence: The excessive withdrawal of groundwater leads to the compaction of soil, which causes the ground to sink. This land subsidence has been documented in the Kashan Plain north of Isfahan and can cause earth fissures that damage infrastructure and farmland. Such seismic shifts can also destroy the delicate tunnels of the Qanat system.

Declining water quality: The depletion of fresh water resources has led to an intrusion of saline water into aquifers. The reduced flow also means less flushing of the qanat's channels, increasing sediment and pollution, which makes the water less suitable for drinking and irrigation.

Accelerated desertification: As water flow from the qanat decreases, the surrounding land becomes drier and less arable. The resulting desertification further strains agricultural productivity and exacerbates the water scarcity issues in the region

2. **Vazvan Qanat:** Found near Kashan, this Qanat is known for its underground dams that can be used to store water during the winter for use in the dry summer months. The system's ingenious design maximises water storage and conserves resources.



Key features of the Vazvan Qanat

Location: The Vazvan Qanat is found in the city of Vazvan, near Meymeh, in Iran's Isfahan province.

Underground dams: Unlike many other Qanats, the Vazvan Qanat has multiple underground dams built into its channels. In the winter, the exit shafts can be closed to allow water to collect behind these dams. In the spring, the water can be released for agricultural use when it is most needed.

Construction: The main channel is approximately 1,800 meters long, with 64 vertical shafts and a mother well that is about 18 meters deep. The entire system was dug by hand.

UNESCO recognition: The Vazvan Qanat is one of several Persian Qanats collectively designated as a UNESCO World Heritage Site. This status recognises the system as an ancient and sophisticated engineering marvel.

Cultural heritage: This remarkable hydraulic system is a testament to the ingenuity of ancient Iranian water management and remains a significant cultural and historical site.

The water crisis in Iran has profoundly impacted the Vazvan Qanat, causing it to face the same decline and environmental damage affecting traditional water systems across the country. The primary effects stem from modern water over-extraction and climate change, which have dried up the ancient system and contributed to desertification and land subsidence.

Effects of the water crisis on the Vazvan Qanat

Drying and water table decline: Intensive groundwater pumping from deep wells has drastically lowered the water table, causing the Vazvan Qanat and others like it to run dry. While Vazvan's deeper wells initially offered some resilience to drought, persistent lack of rainfall exacerbated the problem.

Destruction of a sustainable system: The crisis has caused the decay of Vazvan's unique engineering, which includes an internal dam system to store winter water for summer use. This means losing an ingenious and sustainable technology for arid regions that relied on gravity and natural recharge, not energy-intensive pumps.

Loss of agricultural productivity: For generations, the qanat supported local agriculture. As the water supply diminishes, farmers can no longer grow water-intensive crops like cotton. This reduces agricultural output and farm incomes for the local community.

Reduced community cohesion: The traditional qanat system included community-based water rights and management, which fostered cooperation. The shift to individual deep wells has replaced this shared resource system with a more competitive and inefficient approach to water use.

Environmental costs of the water crisis on the Vazvan Qanat

Land subsidence and sinkholes: The widespread over-extraction of groundwater is causing the land to collapse as aquifers are depleted. This is particularly devastating in Isfahan province, where Vazvan is located. This subsidence destroys roads, historical monuments, and buildings.

Desertification and loss of vegetation: As less water is available for irrigation and natural ecosystems, vegetation declines. This increases evaporation and transpiration, accelerates the desertification process, and reduces biodiversity.

Soil and pasture degradation: With less water for agriculture and pastures, soil fertility decreases. This affects livestock production and contributes to the loss of topsoil through erosion.

Cultural heritage erosion: The Vazvan Qanat is part of Iran's cultural heritage. The crisis threatens its physical structure and risks the loss of the traditional knowledge and social structures that have sustained it for centuries.

Factors contributing to the water crisis on the Vazvan Qanat

While Vazvan's deterioration is specific, it is emblematic of a broader national crisis caused by a combination of factors:

Over-reliance on modern technology: The shift to energy-intensive deep wells for agriculture has undermined the sustainable traditional qanat system by depleting shared water tables.

Climate change and drought: Low rainfall has reduced the natural replenishment of aquifers, worsening the effects of over-extraction.

Inefficient management: Government mismanagement, inadequate regulation of water permits, and a focus on large, environmentally damaging projects like dams and water transfers have exacerbated the crisis.

Qanat Underground Dams

Underground dams were an ingenious addition to Iran's traditional qanat system, designed to collect and store excess groundwater during wet periods. This innovative technology maximised water availability during dry seasons and helped sustain communities in Iran's arid and semi-arid regions for centuries.

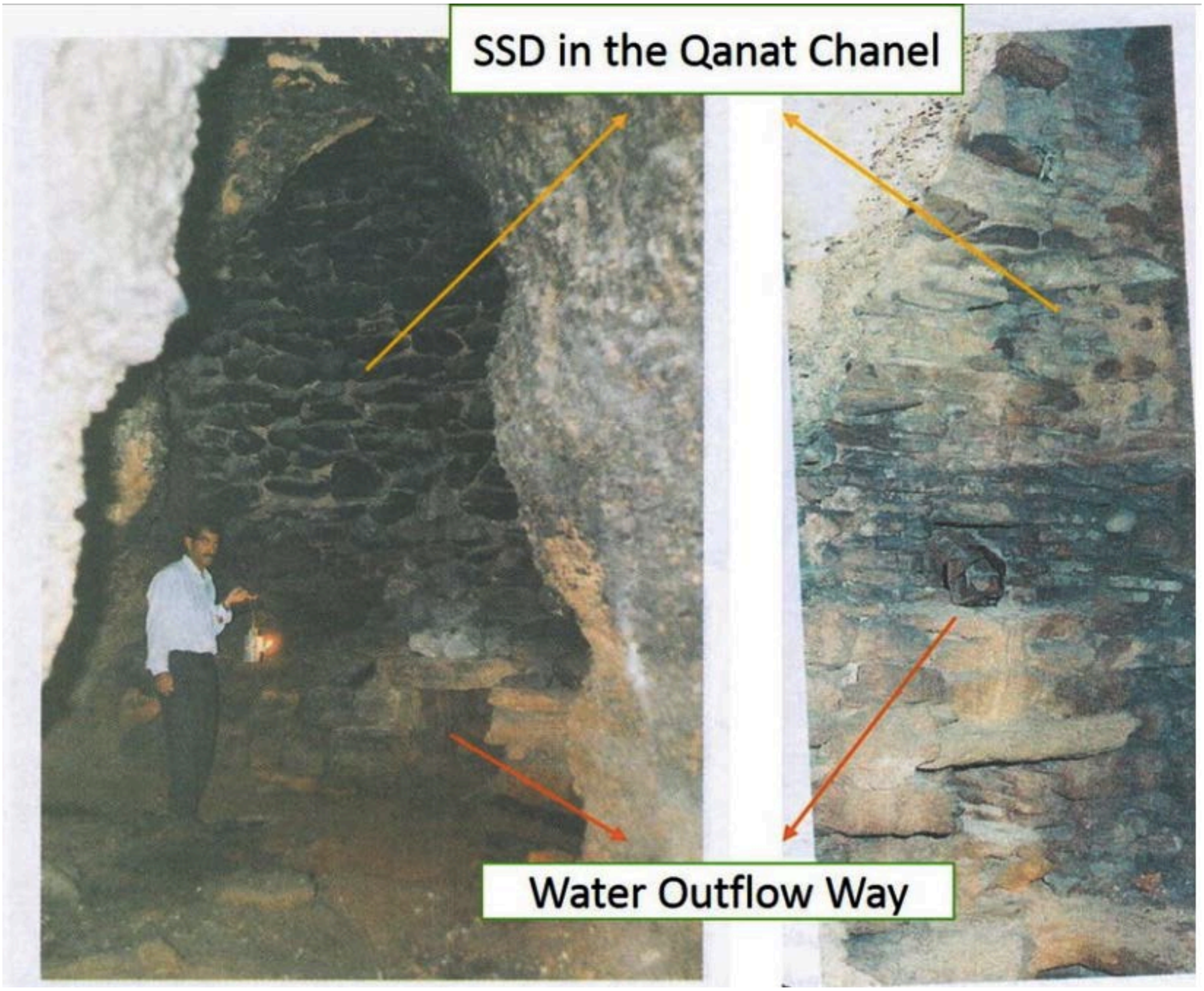
How underground Dams function in Qanats

A typical qanat is a gently sloping underground channel that brings water from an aquifer to the surface, powered entirely by gravity. Underground dams were built within the qanat's main tunnel to improve its efficiency.

Water storage: The primary function was to store groundwater. In winter or during periods of low agricultural demand, gates in the dam would be closed to block the Qanat's flow. This allowed water to accumulate in the underground reservoir behind the dam, ensuring a larger, more reliable supply for the spring and summer planting seasons.

Increased flow: By raising the water level in the aquifer, the dam increased the pressure and flow rate of water entering the qanat's gallery during the seasons of peak demand.

Water table management: The dams helped manage the local water table, supporting the natural replenishment process of the aquifer that fed the qanat.



The Vazvan Qanat dam

One of the most famous examples of an underground dam in Iran is located in the Vazvan qanat, near the city of Meymeh in Isfahan province.

Ancient engineering: The dam is an impressive feat of ancient engineering, built with stone and mortar within the qanat's tunnel.

Water control: It features multiple gates at different levels, which allowed operators to control the amount of water released depending on the season and demand.

Strategic location: The Vazvan dam was strategically constructed between the qanat's wet zone (the water source) and the dry zone (the area leading to the outlet) to maximise storage efficiency.

The decline of Qanats and Dams

Over the last few decades, many Qanats, including those with underground dams, have fallen into disuse. The primary cause is the proliferation of deep wells and powerful pumps, which draw groundwater at a much faster rate than it can be naturally replenished. This over-extraction has lowered the water table, causing thousands of traditional Qanats to dry up and become obsolete.

Nevertheless, Qanats remain a testament to sustainable water management and are a vital part of Iran's cultural heritage. Some systems are still maintained, and there is a renewed interest in their design as a model for sustainable water solutions in arid climates.

Current status and challenges

Effects of the water crisis on Qanats in Isfahan

The Qanat system has provided a sustainable water supply in Iran's arid central plateau for millennia. However, in Isfahan, this traditional system is now failing due to a combination of human and environmental pressures.

Qanat collapse: The over-extraction of water from deep wells for modern agriculture and industry has lowered the water table, causing the ancient qanat systems to dry up. With the ground losing its underground water support, the very channels of the Qanats are losing their balance and collapsing.

Widespread land subsidence: Excessive groundwater extraction has led to alarming rates of land subsidence in and around Isfahan. This compaction of the soil and creation of underground voids directly threatens the structural integrity of the Qanats and their surface infrastructure, in addition to the historical monuments and urban areas above.

Depletion of the Zayandeh Rud: The Zayandeh Rud, the primary river in Isfahan, now runs dry for large parts of the year due to upstream damming and diversions. This drying reduces the surface water available for the Qanats' catchment areas, further starving them of water and increasing reliance on groundwater.

Irreversible ecological damage: The widespread drying of Qanats and other water sources is contributing to desertification and has a devastating effect on local ecosystems. The collapse of the traditional water system is a symptom of a larger ecological breakdown.

Estimated costs and broader economic impacts

The financial costs of the crisis are astronomical, impacting multiple sectors and adding to the environmental and social fallout.

Agricultural decline: With Qanats and other water sources failing, Isfahan's farming communities are collapsing. The agricultural sector uses up to 90% of Iran's water, but mismanagement and water shortages are devastating farm incomes, leading to mass unemployment and food insecurity.

Infrastructure destruction: The severe land subsidence caused by depleted aquifers is damaging Isfahan's infrastructure, including historical sites, roads, power plants, and schools.

- According to a 2025 report in the Guardian newspaper, subsidence in Isfahan has been described as "an erupting volcano," with major city infrastructure—including metro stations, hospitals, and historical monuments—all at risk of collapse.

Restoration expenses: While the cost to repair the Qanats is high, the overall financial burden of water scarcity in Iran far exceeds it.

- In 2022, local officials requested a 130 billion rial ($434,000 USD at the time) budget for historical restorations in Aran-Bidgol, including ancient water networks like Qanats.

- However, these small-scale restoration efforts are dwarfed by the multi-billion dollar projects that are frequently mismanaged, such as expensive seawater desalination and transfer schemes.

Mass rural-to-urban migration: As farming becomes impossible, thousands of villagers in Isfahan have been forced to migrate to cities. This internal migration puts immense strain on urban infrastructure and services, including housing and water supplies, and creates new social and economic pressures.

Causes of the Qanat collapse

The primary drivers of the crisis and the subsequent demise of the Qanats are multifaceted.

Introduction of motorised wells: Beginning in the 1960s, the introduction of modern deep-drilling technology allowed farmers to extract water far faster than the natural recharge rate, causing water tables to plummet. This made the gravity-fed Qanats obsolete, leading to their abandonment.

Unsustainable water policies: Decades of government mismanagement and a push for agricultural self-sufficiency have promoted water-intensive industries and farming practices in arid regions, such as Isfahan.

Dam construction: Upstream dam construction and inter-basin water transfers—including diversions of the Zayandeh Rud—have significantly reduced the water available to Isfahan's low-lying areas and its aquifer systems.

Climate change: Intensifying drought conditions and lower rainfall, particularly since the 2000s, have exacerbated the effects of human mismanagement, further depleting Iran's already strained water reserves.

Despite their historic success, the Qanats of Isfahan and across Iran face serious threats today:

Depletion of aquifers: The over-extraction of groundwater through the drilling of deep and semi-deep wells has caused water tables to drop dramatically. This competition for water is a primary reason for the drying up of many Qanat.

Drought and climate change: Prolonged periods of drought have compounded the water scarcity problem, further reducing the water supply to Qanat.

Lack of maintenance: Economic factors and the migration of young people to cities have resulted in a decline in traditional knowledge and labor for Qanat maintenance, leading to disrepair.

Geological instability: In some areas, the collapse of aquifers has led to land subsidence and the abandonment of historic settlements that were once supported by Qanats.

Limited funding: Financial constraints hinder efforts to reconstruct and reorganise Qanats, a process that is often costly.

Government and local community revitalisation and preservation efforts

Recognising the threats to this vital heritage, efforts are underway to preserve and revive Qanats:

UNESCO World Heritage status: In 2016, several Persian Qanats, including the Vazvan and Mazdabad systems in Isfahan Province, were designated as a UNESCO World Heritage Site, providing legal protection and drawing attention to their cultural value.

Community-based initiatives: Local community participation is crucial for managing and restoring Qanats. Projects often aim to encourage communal management and increase awareness of the system's vulnerable condition.

Modernising water management: Revitalisation strategies include:

- Reforming water governance policies to prioritise sustainable, indigenous water sources.

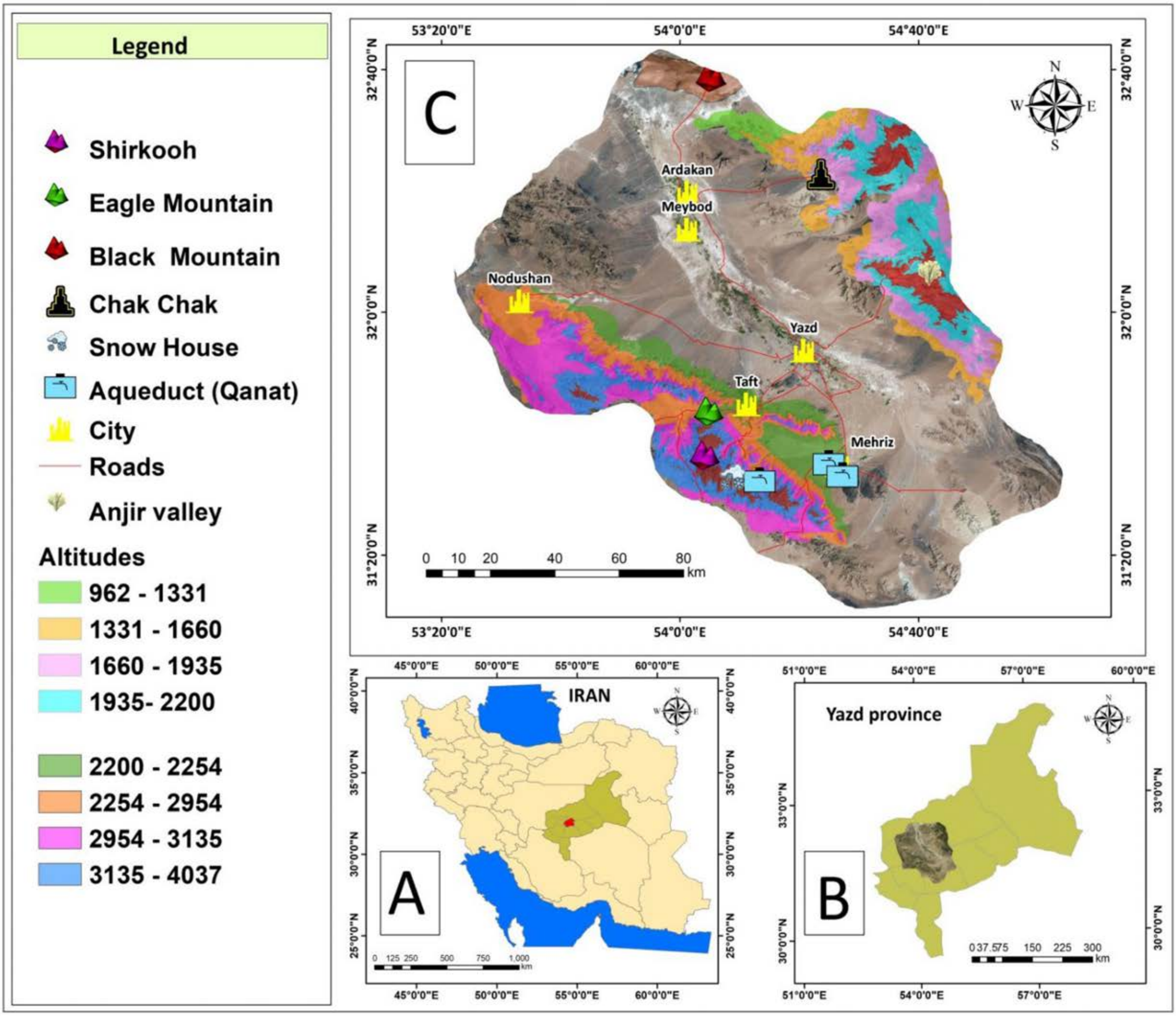
- Encouraging the adoption of more efficient irrigation techniques to reduce water consumption.

- Implementing watershed management in upstream areas to help recharge aquifers.

- Monitoring and preventing illegal well drilling.

Tourism and education: Organisations promote Qanats as a cultural and historical asset to attract tourists and educate the public on the importance of sustainable water management.

B. **Yazd Province**



The geographical position of geotourism and ecotourism attractions in the Yazd–Ardakan Plain: location of Yazd Province in Iran (**A**,**B**); satellite image with the spatial distribution of geotourism and ecotourism attractions (**C**).

Yazd Province is a historic and culturally significant region located in central Iran, named after its capital city, Yazd. Situated between the Dasht-e Kavir and Dasht-e Lut deserts, the province is celebrated for its unique architecture and centuries-old adaptations to the harsh desert environment. Its provincial capital, the historic City of Yazd, is a UNESCO World Heritage site.

Overview

Yazd is a testament to sustainable living in a desert climate, characterised by its traditional earth-based architecture, intricate water management systems, and a deep rooted cultural heritage. It is nicknamed the "City of Wind-catchers" (Shahr-e Badgirha) for its many examples of this ingenious architectural feature. The region is also notable for the peaceful coexistence of different religious communities, including Muslims, Zoroastrians, and Jews.

Key Facts:

Capital: Yazd

Area: Approximately 76,469 km²

Population: 1,138,533 (as of the 2016 census)

Location: Central Iran, bordering the provinces of South Khorasan, Isfahan, Fars, and Kerman.

Climate: A hot desert climate (BWh), with long, dry, hot summers and cold, sunny winters.

Geography and climate

Yazd Province sits in an oasis region surrounded by Iran's central deserts. The landscape is dominated by dry plains and rugged mountain ranges, including the prominent Shir Kuh. The province is one of the driest regions in the country, with very low annual rainfall.

Mountain Ranges: Significant ranges include Shir Kuh, Kharanoq, and Heresht. Shir Kuh, the tallest mountain, helps moderate the climate in its vicinity.

Desert Adaptation: The residents of Yazd have long perfected techniques for desert survival, such as the Qanat system, an ancient method of underground aqueducts for water transportation. Thick earthen walls, sunken courtyards, and wind-catchers (badgirs) are also used to create pleasant indoor microclimates.

History

The history of Yazd stretches back over 3,000 years, with roots in the ancient Median Empire.

Ancient and Medieval Eras: The city was a centre for Zoroastrianism during the Sassanid period. Following the Arab conquest in the 7th century, many Zoroastrians sought refuge in the city, contributing to its religious diversity.

Silk Road: Located near the major Spice and Silk roads, Yazd became an important hub for trade. In 1272, Marco Polo passed through, praising the city's fine silk weaving industry.

Muzaffarid Dynasty: Yazd briefly became the capital of the Muzaffarid dynasty in the 14th century. Many of its most notable architectural landmarks, including the Friday Mosque, date from this period.

Modernisation: While some modernisation has occurred, particularly on the city's outskirts, the core historic districts of Yazd remain well-preserved.

Economy

Yazd's economy has historically been centred on its expertise in textiles, silk weaving, and trade. Today, its economy is diverse and includes significant industrial activity.

Industry: The province is known as the fifth-most industrialised province in Iran. Major industries include textiles, carpets, steel, and mining.\

Mines: Yazd has important mines for resources like iron, marble, sandstone, and lead.

Agriculture: In regions with access to water, agriculture is a key economic driver, with crops including wheat, barley, cotton, oilseeds, and fruits.

Handicrafts and Confectionery: Yazd is famous for its handwoven cloth (Persian termeh) and traditional sweets, such as baklava, ghotab, and pashmak, which are popular tourist attractions.

Culture and attractions

Yazd's distinct culture is shaped by its unique desert setting and multi-religious history, offering a wealth of historical and architectural sights.

Notable attractions include:

The Historic City of Yazd: A maze of winding alleys, courtyards, and mud-brick houses recognised as a UNESCO World Heritage Site.

Jameh Mosque of Yazd: A magnificent 14th-century mosque with the tallest minarets in Iran, decorated with stunning mosaic faience.

Zoroastrian Fire Temple: A sacred site for the Zoroastrian community, where a fire has reportedly been kept burning since 470 AD.

Towers of Silence (Dakhmeh): The ancient, circular, raised structures where Zoroastrians traditionally performed funeral rites.

Amir Chakhmaq Complex: A prominent architectural landmark featuring a three-story facade and a mosque.

Dowlat Abad Garden: A historic Persian garden featuring one of the tallest badgirs in Yazd.

Persian Qanats: A system of underground water channels, many of which can be explored in the city.

Cycling Culture: Yazd is known as the "City of Bicycles" due to its early adoption of cycling, which is still a popular mode of transport.

Water Resources

Yazd Province's water resources are primarily groundwater, sourced from wells, springs, and traditional Qanats. The province faces a severe water crisis due to extremely low precipitation, high evaporation rates, and significant over-extraction, leading to a substantial groundwater deficit, declining water levels, and a drop in quality. Management strategies must focus on sustainability, efficiency, and preserving the unique qanat system, which is a vital source of water for agriculture, notes IWA Publishing.

Primary water sources

Groundwater: The most crucial water source, accessed through wells (59%), springs (5%), and Qanats (36%).

Qanats: A traditional and significant system of underground canals that tap into groundwater. Yazd has about 3,193 Qanats providing a significant amount of water for agriculture.

Surface water: Very limited, with only small, seasonal rivers like the Azam and Bavanat entering the province from neighbouring areas.

The main river associated with Yazd Province is the Zayandeh River, which historically provided water to the region, though it is now often dry due to drought and water diversions. Another river, the Azam River, is located within the province and flows into an inland basin.

Zayandeh River: The Zayandeh River historically supplied water to both Isfahan and Yazd provinces. However, it frequently runs dry before reaching the Gavkhouni swamp, its historical end point, due to upstream water diversions for agriculture and drought.

Azam River: The Azam River is a smaller river that is located within Yazd province. A study of the Azam River found that precipitation and temperature changes affect its sedimentation. It flows into an inland basin, a common feature in this part of Iran

Major challenges

Low precipitation: The region is arid to semi-arid, with an average annual rainfall of only 103 mm, significantly less than the national average.

Groundwater depletion: Aquifer water levels are dropping, with an average annual drop between 0.02 and 1.03 meters. The long-term groundwater balance deficit is about 243 million cubic meters annually and is increasing.

Deteriorating quality: Over-extraction and other factors are leading to a decline in the quality of both drinking water and groundwater.

High demand: The majority of pumped water is used for agriculture, with 85% going to irrigation, followed by drinking (11%) and industry (4%).

The water crisis in Iran's Yazd Province is causing severe effects, including desertification, land subsidence and declining agricultural output, due to groundwater over extraction and high evaporation rates in its arid climate.

The cost is significant, encompassing economic impacts like lower farm incomes and the high cost of government projects like inter-basin transfers, as well as social costs such as health issues and increased migration, which strain social cohesion.

Effects of the water crisis in Yazd Province

Environmental:

Land subsidence: The excessive drilling of wells puts immense pressure on groundwater resources, causing the land to sink.

Desertification: Water scarcity contributes to the expansion of deserts and degradation of pastures, reducing the land's ability to support life and crops.

Increased salinity: Over-extraction and reduced water levels lead to increased salinity in the remaining groundwater.

Economic:

Agricultural decline: The lack of water decreases crop yields and quality, leading to lower farm incomes and production.

Livestock: Declining pasture fertility reduces livestock numbers and production.

Cost of projects: The government has invested in expensive projects like inter-basin water transfers, which have a high economic cost and also create negative social and environmental consequences.

Social:

Health issues: Studies have shown potential health issues related to drinking water quality in some rural areas of Yazd, exacerbated by the crisis.

Rural-to-urban and inter-province migration: As rural areas become unsustainable due to water shortages, people are forced to migrate to cities, creating pressure on urban infrastructure and potentially fuelling social tensions.

Water conflicts: The scarcity of water has led to conflicts, both within the province and between different provinces, due to competition for limited resources.

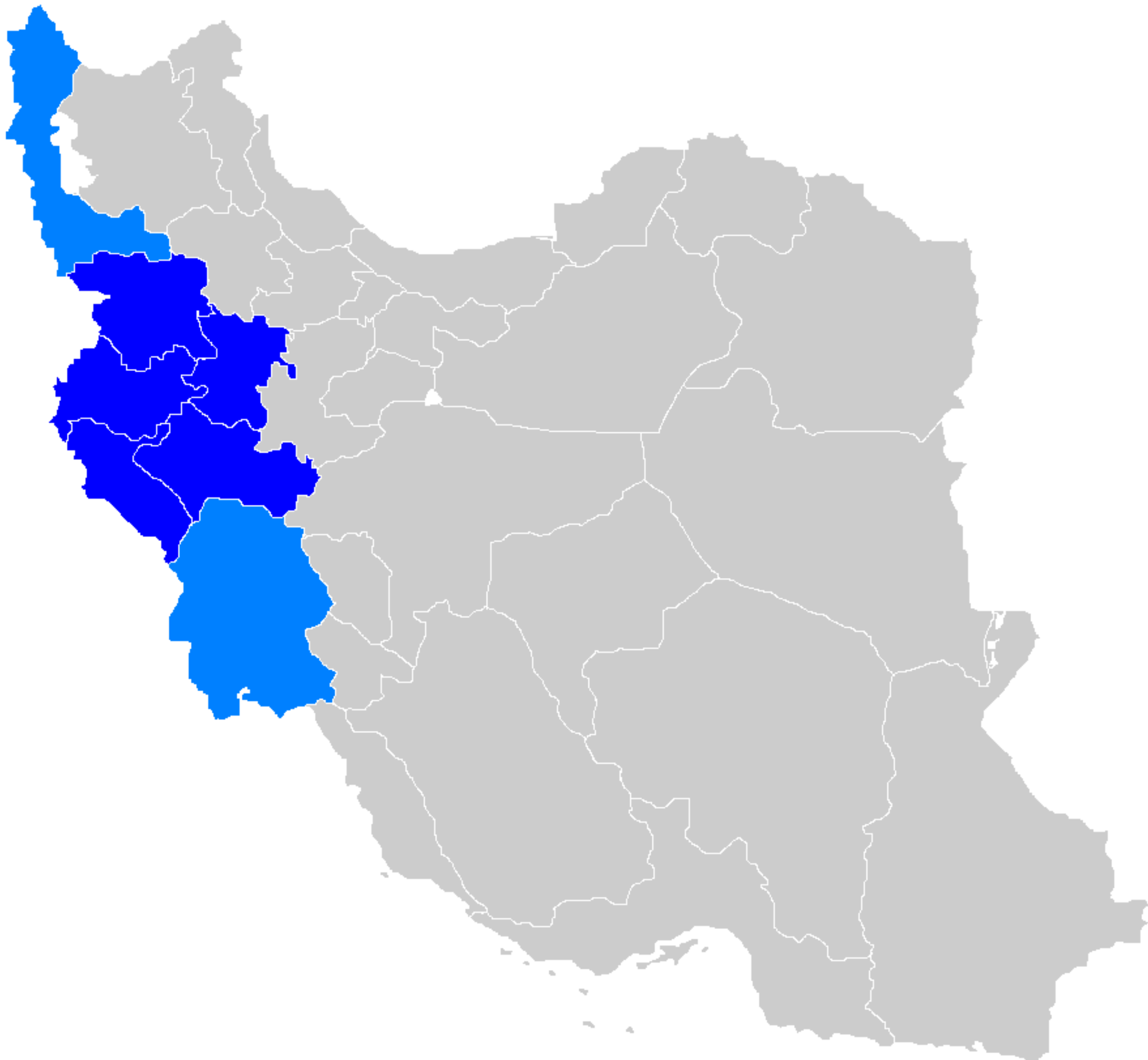
Cost of the water crisis in Yazd Province

High cost of large-scale projects: The government has resorted to large-scale, expensive water transfer projects, such as the one aiming to bring water from the Gulf of Oman and Persian Gulf. These projects, like the one for the Iranian plateau, had a budget around $285 billion as of 2021, which may be a cost Yazd indirectly contributes to through provincial contributions and the overall national strain.

Unsustainable solutions: Critics argue that many solutions like dams and inter basin transfers are not cost-effective or efficient compared to nature-based solutions and can create their own environmental problems.

Cost of health and social impacts: The long-term costs include public health issues, economic losses from agricultural decline, and the social cost of increased migration and potential conflict, which are difficult to quantify but are substantial.

C. Western Provinces



The water crisis in Iran's western provinces is driving significant economic, social, and environmental damage. Decades of mismanagement and unsustainable water use, compounded by climate change, have led to acute water scarcity, impacting agricultural production, displacing populations, and fuelling social unrest. While the total financial cost to the region is not comprehensively quantified, a 2000s drought was estimated to have cost the Iranian economy over a billion dollars in a single crop year, highlighting the scale of the financial impact.

Economic effects

Decline in agriculture: Provinces like Khuzestan, despite being historically water rich, have suffered a severe decline in agricultural output due to drying rivers like the Karkheh and Karun. The reliance on water-intensive crops in an arid region has become unsustainable, leading to reduced yields and financial damage for farmers.

Damage to industry: Water-dependent industries, including the steel and petrochemical sectors, have had to cut production or shed jobs due to water scarcity, increasing unemployment. Hydropower generation has also been severely impacted, contributing to power outages and hurting the industrial sector.

Reduced national GDP: Nationwide, drought has been shown to reduce overall GDP by several percentage points, with significant drops in manufacturing and services sectors alongside agriculture.

Costly water solutions: Government attempts at short-term fixes, like desalination plants and large-scale water transfers, are extremely expensive, with some estimates in the billions of dollars. In contrast, effective, nature-based solutions like aquifer recharging are often dismissed in favour of profitable infrastructure projects.

Social effects

Internal migration: Water shortages are a major cause of rural-to-urban migration, as farmers and villagers lose their livelihoods. This has accelerated urbanisation, with provinces like Hamadan experiencing severe shortages that drive people to cities.

Strained urban areas: The influx of environmental migrants from rural areas places immense strain on urban infrastructure and services, including already strained water systems, housing, and sanitation.

Rise in protests: Anger over water scarcity and mismanagement has repeatedly fuelled protests across Iran, including in western provinces. Farmers have demonstrated against river drying and water diversion projects, with security forces sometimes clashing with protestors.

Public health risks: Reduced water resources can increase the risk of water-related diseases, such as cholera and typhoid. In areas where water bodies have dried up, salt and dust storms have led to respiratory and cardiovascular problems.

Environmental effects

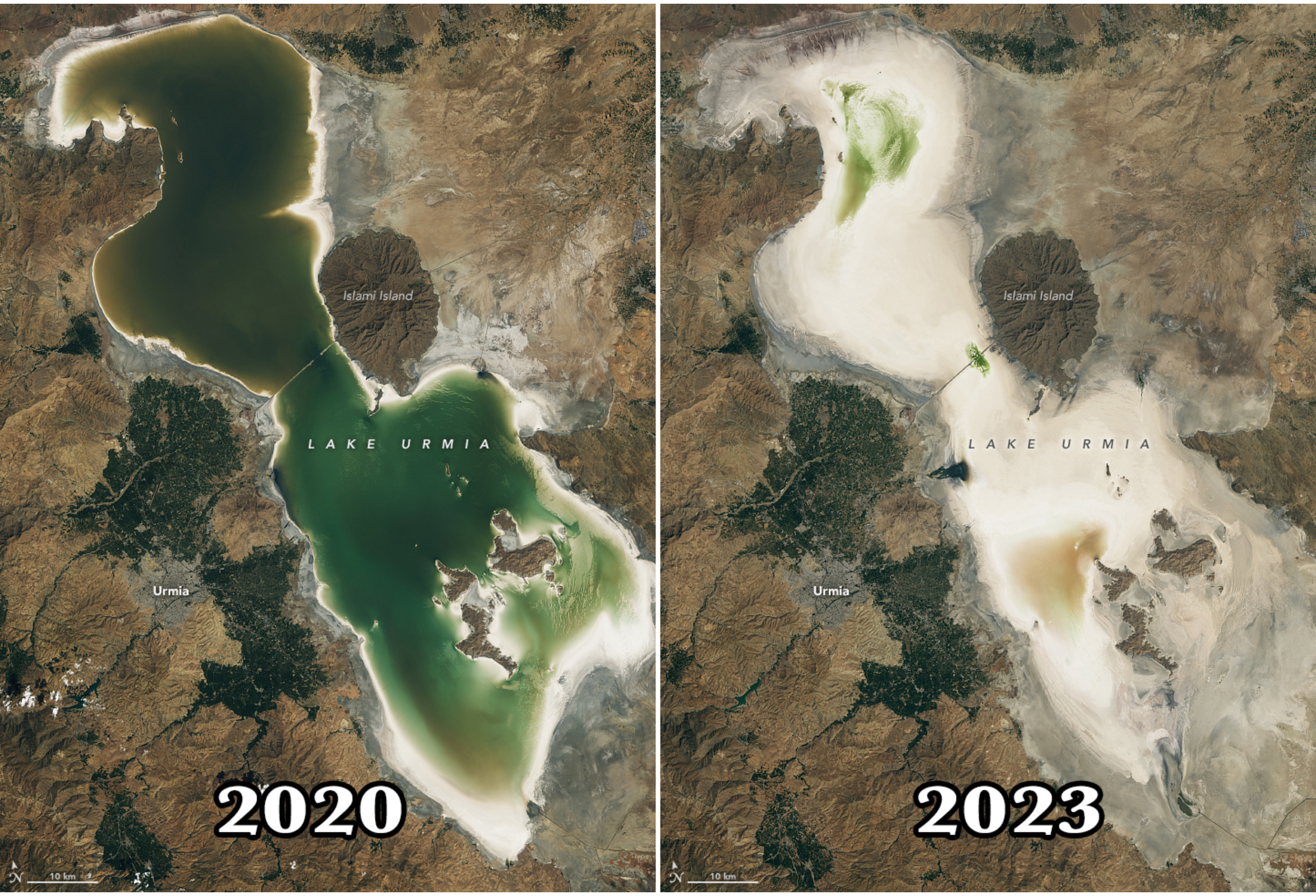
Dried rivers and lakes: Mismanagement and upstream diversions have severely impacted water bodies, leading to rivers running dry and dams operating at critically low capacity. For example, dams in the western province of Hamadan have reported alarming falls in water volume.

Groundwater depletion and subsidence: Over-extraction of groundwater is causing water tables to fall and land to subside in many areas, including the sinking of plains beneath western cities and infrastructure.

Desertification and salinisation: The rapid depletion of water resources is accelerating desertification, which is turning fertile land into dust and exposing fragile ecosystems to damage. The subsequent salinisation of soil renders land unfit for farming.

Exacerbation by climate change: Declining rainfall and rising temperatures driven by climate change are intensifying the water crisis across Iran, with experts projecting further decreases in renewable water resources in the coming decades.

Lake Urmia



Once the Middle East's largest saltwater lake, Urmia has shrunk to a fraction of its former size due to a combination of climate change, dam construction, and agricultural diversions. Its drying has led to salt storms that harm public health and the environment.

Lake Urmia in northwestern Iran has shrunk dramatically over the past two decades, threatening a major ecological, economic, and social crisis for the region's 7 million residents. Once the largest hyper-saline lake in the Middle East, its area and volume have decreased by over 80% due to a combination of climate change, improper water management, and upstream water diversion.

The Iranian government approved a $7 billion restoration program in 2013, which included agricultural and irrigation reforms. However, despite some temporary improvements, these efforts have largely failed to save the lake, which is now considered ecologically dead by many experts. The exact financial cost of the lake's drying is uncertain, but it is clear the economic toll from the destruction of agriculture, tourism, and fisheries will be devastating and ongoing.

Causes of Lake Urmia drying

The decline of Lake Urmia is a complex issue driven by both natural and human factors.

Climate change: Increases in temperature and reduced rainfall have accelerated evaporation and reduced the inflow of fresh water.

Water mismanagement: The over-extraction of groundwater from more than 80,000 illegal wells and the construction of over 50 dams on rivers that feed the lake have starved it of its natural water supply.

Agricultural expansion: The government's policy of supporting water-intensive agriculture, like growing sugar beets and apples, has led to a major increase in water use in the region.

Causeways: The construction of a causeway in 2008 split the lake into northern and southern halves, disrupting the normal flow of water and increasing salinity in the northern section.

Effects of Lake Urmia drying

The desiccation of Lake Urmia has created widespread consequences that threaten the health and livelihoods of millions in the region.

Localised Health crisis:

Salt storms: The dry lakebed has become a source of salt and dust storms. The wind carries these corrosive salt particles to surrounding cities, causing respiratory illnesses, allergies, and increasing the risk of abnormal cancers.

Contaminated water: Higher salinity levels in groundwater and surface water sources threaten the quality of drinking water.

Lake Urmia an Ecological Disaster:

Soil and water salinisation: The windblown salt contaminates fertile farmlands and aquifers, dramatically reducing agricultural productivity and rendering land unusable.

Loss of biodiversity: The lake was a UNESCO Biosphere Reserve and a habitat for unique species, such as the Artemia urmiana brine shrimp, a food source for migratory birds like flamingos. High salinity levels have killed off these species and disrupted the ecosystem.

Economic collapse due to Lake Urmia drying:

Agricultural failure: The decline in farming due to water shortages and salinisation has devastated the rural economy and incomes for farmers.

Migration: The collapse of agriculture and increased health risks have forced a "silent evacuation," with millions of residents migrating from rural areas to larger cities.

Social and political instability: Competition for dwindling water resources has led to conflicts between different water users.

Cost of the Lake Urmia water crisis

While the total cost is hard to quantify, it involves failed restoration investments, lost economic output, and extensive human and environmental damages.

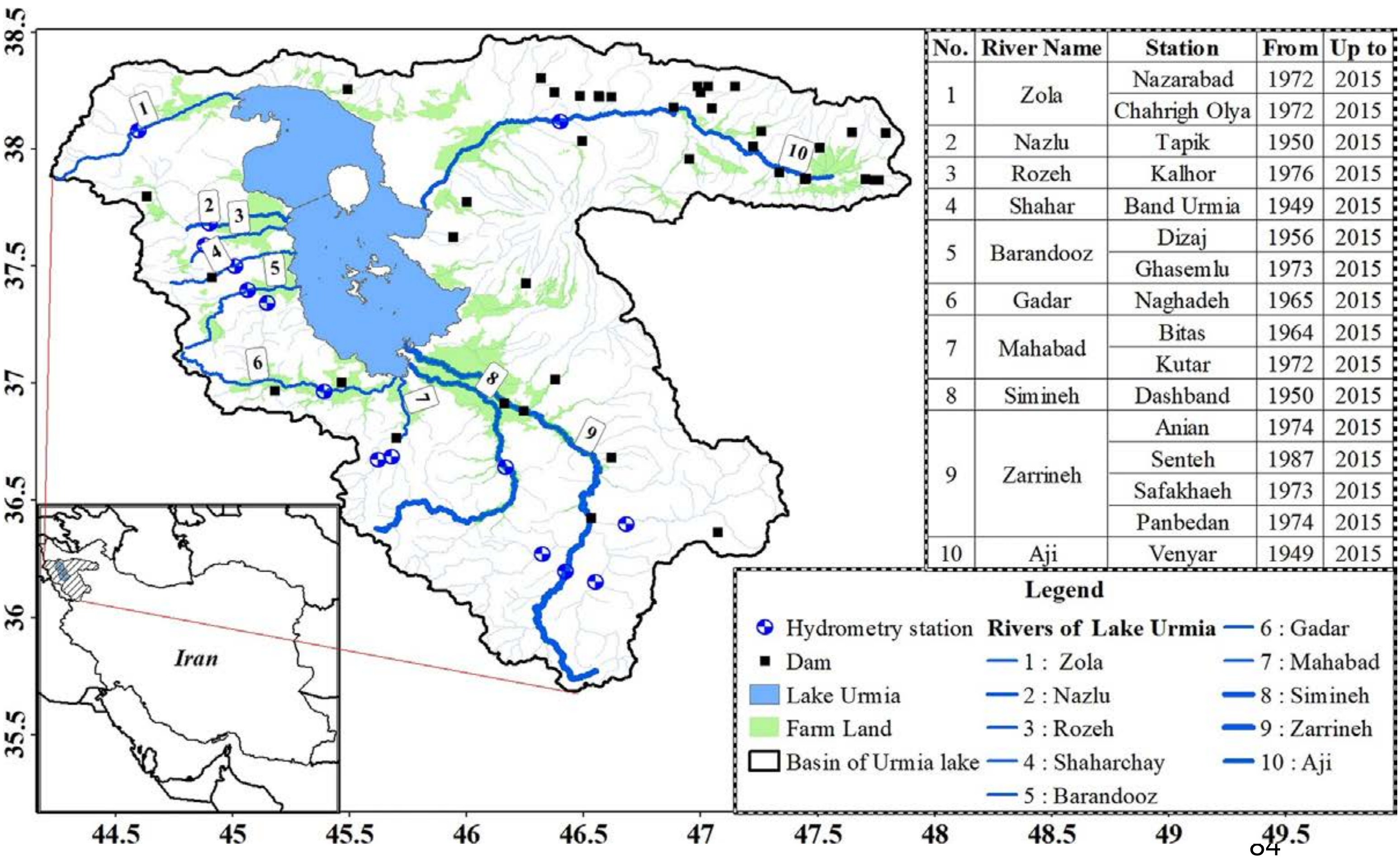
Failed restoration efforts: The 2013 Urmia Lake Restoration Program was allocated $7 billion, but despite some short-term gains, the lake has continued to shrink. In 2020, Japan also contributed almost $7 million to support restoration.

Loss of food production: The Urmia Lake Basin is a major food-producing region in Iran. The salinisation of productive farmlands will lead to significant long-term economic losses and impact national food security.

Healthcare expenses: The long-term health effects from toxic salt dust will impose significant healthcare costs on the government and residents.

Mass migration: The social disruption and costs associated with resettling millions of people and managing the stress on urban infrastructure will be substantial.

Assessment of rivers environmental flows into the Urmia Lake



No.	River Name	Station	From	Up to
1	Zola	Nazarabad	1972	2015
		Chahrigh Olya	1972	2015
2	Nazlu	Tapik	1950	2015
3	Rozeh	Kalhor	1976	2015
4	Shahar	Band Urmia	1949	2015
5	Barandooz	Dizaj	1956	2015
		Ghasemlu	1973	2015
6	Gadar	Naghadeh	1965	2015
7	Mahabad	Bitas	1964	2015
		Kutar	1972	2015
8	Simineh	Dashband	1950	2015
9	Zarrineh	Anian	1974	2015
		Senteh	1987	2015
		Safakhaeh	1973	2015
		Panbedan	1974	2015
10	Aji	Venyar	1949	2015

Studies assessing environmental flows into Urmia Lake reveal that while there was a period of fragile stabilisation between 2015 and 2019, primarily due to unusually high rainfall, the overall long-term trend remains one of decline. The lake's deterioration is driven by a combination of human mismanagement and climate change, necessitating a holistic approach to restore its ecological balance.

Assessment of river environmental flows

To determine the required environmental flow (e-flow), studies have utilised various methods to assess river needs, which vary across the different rivers feeding the lake. For example, the ecological water demand for the lake has been estimated at over 3 billion cubic meters (Mm^3) per year, with much of this volume supplied by its major tributaries.

The assessment highlights several key points:

Insufficient flow allocation: An action plan is urgently needed to restore the lake by delivering surface water from the surrounding rivers, which include Zarrineh, Simineh, and Aji. It is recommended that 20–40% of the rivers' potential annual flows should be allocated to the lake, which is significantly more than the 10% previously observed.

Inter-basin transfers: Some strategies include inter-basin transfers, such as diverting excess water from the Zab River in northwest Iran to Urmia Lake. This is an expensive and complex endeavour, but it could help increase inflow during critical periods.

Dam management: The operation of dams on the rivers is crucial to the environmental flow. For example, the Bukan Dam on the Zarineh River regulates flow to downstream agricultural land. More water needs to be released from dams to meet the lake's environmental needs.

Threats to inflow and restoration

Several factors jeopardise the rivers' ability to supply the environmental flows needed for the lake's recovery:

Water mismanagement: Human activities, including the construction of dams and excessive extraction of water for agriculture, are the primary drivers of reduced river inflow. Agriculture accounts for up to 90% of the basin's water use, and a 40% reduction is needed to mitigate the lake's decline.

Climate change: Decreased precipitation, higher temperatures, and increased evaporation due to climate change have accelerated the drying process. This limits the natural availability of water, and models predict that climate change will intensify pressure on water resources.

High salinity: The high salinity of the remaining lake water poses a threat to biodiversity, particularly to species like the brine shrimp Artemia. The environmental goal is to raise the water level to 1,274.67 meters, which would lower salinity to the tolerable limit for aquatic life.

Outlook and future actions

While stabilisation efforts from 2015–2019 provided a short reprieve, the long-term trend remains negative. Forecasts through 2030 show that without drastic intervention, the lake's peripheral areas will become arid.

Effective action requires an integrated and comprehensive approach:

Modify agricultural practices: Implementing water-saving techniques like drip irrigation and transitioning to less water-intensive crops can significantly reduce water consumption.

Coordinate management: Stronger coordination is needed among different sectors and provinces within the basin. Fragmented and uncoordinated policies hinder restoration efforts.

Improve monitoring: More effective monitoring is needed, especially regarding groundwater extraction and compliance with environmental flow requirements. Many past efforts have been slow and ineffective.

Lake Urmia water crisis Impact on Agriculture

The drought and shrinking of Lake Urmia have significantly impacted the agricultural sector in the surrounding basin.

Economic Impacts

Decreased Agricultural Income: Reduced soil fertility due to salt and dust storms decreases agricultural yields and income.

Increased Unemployment: The drought and its effects on agriculture have led to job losses for farmers and agricultural workers. It is estimated that between 225,000 and 450,000 people were left unemployed.

Migration: Decreased agricultural income is a major factor driving farmers and agricultural workers to migrate from the Urmia basin to larger cities like Tabriz and Tehran, causing social and economic problems in both areas.

Reduced Food Production: The drought has substantially reduced food production in the region over the past three decades, and this trend is projected to continue.

Damaged Farmlands and Contaminated Water: Salt particles blown from the dried lakebed damage agricultural lands and contaminate water supplies.

Land Subsidence: Over-extraction of groundwater for agricultural needs causes land subsidence, threatening infrastructure and farmlands.

Groundwater Salinisation: Excessive groundwater extraction has led to a negative balance in the aquifer, resulting in groundwater salinisation, making water unsuitable for agricultural and drinking purposes.

Cost to the Agricultural Sector

Estimated Cost: The damage to cereal crops, vegetable crops, and livestock is estimated to have cost almost $1 billion USD.

Irrigation Dependence: The intensive agriculture in the Urmia basin relies heavily on irrigation systems using river and groundwater, contributing to the shrinking of the lake.

Unsustainable Practices: The expansion of irrigated agriculture and the cultivation of high-water demand crops like onions, tomatoes, and sugar beets have contributed significantly to the lake's desiccation. Traditional flood irrigation methods waste a large percentage of water.

Policy Implications: Agricultural policies prioritising food self-sufficiency have contributed to the expansion of agriculture in the Lake Urmia Basin, hindering sustainable approaches and impacting the lake's water level.

D. Khuzestan Province

In October 2025, Khuzestan Province, Iran, is in the throes of a severe water crisis exacerbated by decades of mismanagement, inefficient agriculture, and declining rainfall. This "water bankruptcy" sees dwindling dam levels, dry wells, and land subsidence.

President Pezeshkian has warned of empty reservoirs and growing pressure on groundwater, while experts point to systemic failures and potential social and political instability. The crisis threatens millions with severe water shortages, with 11 cities and 700 villages in Khuzestan already facing drought and lack of potable water, underscoring the crisis's structural nature.

Khuzestan is one of the most significant provinces of Iran in terms of politics, economics, and strategy. While it is the centre of the region, which is known as the “Strategic Energy Ellipse”, due to its oil and gas reserves, it also plays a crucial role in reaching major energy markets of south and east Asia through its geopolitical location.

Khuzestan is one of the wealthiest provinces in terms of oil and natural gas resources, which constitute a significant part of Iran’s state revenues and exports. Khuzestan is the country’s second most significant province, with 33 Petrochemical facilities in Mahshahr, four large refineries, and Iron and Steel manufacturing.

All these factors increase its Geo-economic importance. While crucial harbours, such as Imam Khomeini, Mahshahr and Hendijan, that are located in the province, connect Iran to open waters, it also contributes in enabling Iran to engage in trade relations with other countries in the region. It's geographical proximity to the Gulf and the 650 kilometre border with Iraqare other factors the compound the Geostrategic significance of Khuzestan

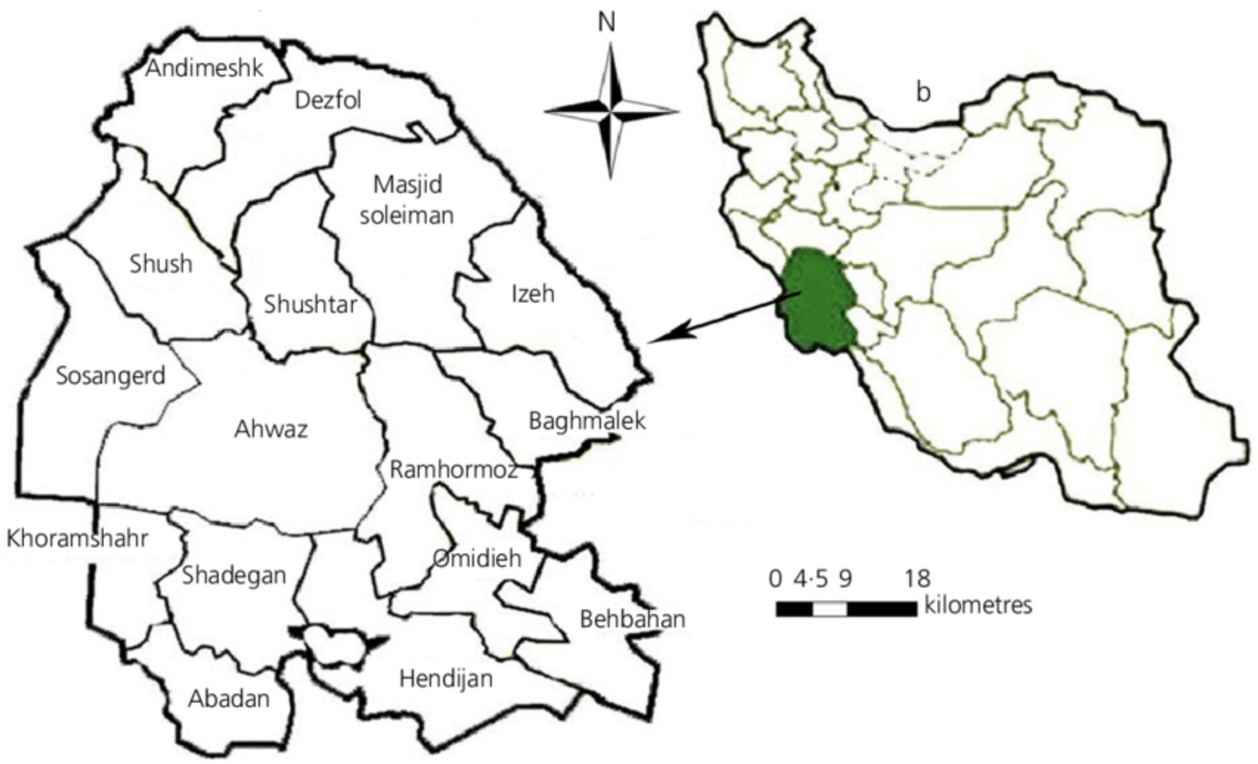
Geographically, Khuzestan is one of the major water basins of the country, along with the Gulf, Arabian Sea, and several other provinces. It contains Big Karun, Karkheh and Zohreh-Jarrahi basins. The province receives an average of 330 mm of rainfall annually. According to the findings in 2020-2021, the annual rainfall in the Big Karun basin is 399 mm while Karkheh and Zohreh-Jarrahi basins receive 294 mm and 345 mm rainfall per year, respectively.

The total capacity of the dam reservoirs in the province is 21.3 billion cubic meters, and their occupancy rate is 13.3 billion cubic meters. The total water storage volume of the seven large reservoir dams in Khuzestan is 16 billion cubic meters.

As of December 25, 2021, the reservoir deficit rate in Khuzestan is 74%. The province has an exclusive position in the country with its annual inflow volume of 31 billion cubic meters and the water stored in the underground aquifers of 3 billion cubic meters. In terms of water consumption, it is possible to state that 31 billion cubic meters of water are consumed annually throughout the province. 90% of the surface water in Khuzestan is used in the agricultural sector, while the remaining 10% of this water is consumed by the industrial sector and as drinking water. The province consumes about 13% of the water used in the agricultural sector of the country.

Despite being a water-rich region, it has suffered from severe water shortages due to river diversions and damming. The drying of wetlands has led to dust storms that impact air quality and public health.

The water crisis in Iran's Khuzestan province has caused severe environmental damage, led to the collapse of local agriculture, and triggered mass protests. While specific overall cost figures are not available, the economic and social costs are considerable and long-term.



Effects of the water crisis in Khuzestan Province

Shushtar Historic Hydraulic System

The Shushtar Historical Hydraulic System is affected by Iran's water crisis, though not in the way one might initially assume. The ancient system is threatened less by water scarcity and more by the associated issues of mismanagement, infrastructure decay, and water quality degradation.

Threats to the Shushtar Historic Hydraulic System

Leakage: In 2021, an official announced that water leaks in the UNESCO-listed ensemble were an immediate concern, which could lead to its destruction if not controlled. While short-term measures were implemented, this issue highlights the system's structural vulnerability.

Water contamination: A contributing factor to the system's decay is the pollution of the Karun River. Experts noted in 2019 that urban wastewater was entering the river, and subsequently, the hydraulic ensemble.

Upstream impacts: The construction of the Gotvand Dam upstream on the Karun River has been blamed for increasing the river's salinity in the Khuzestan province, which can accelerate the corrosion and decay of the ancient system.

Modern dams: Modern water management projects, including new dams built for irrigation and power, have altered the river's flow and impacted the functionality of the historical system.

While the Shushtar system was designed to manage water resources, the modern water crisis—driven by factors like poor water management, dam construction, and population growth—has created new pressures that threaten its preservation and continued use.

Khuzestan - Social and human effects

Loss of livelihood and migration: Thousands of farmers and ranchers have lost their source of income due to dried-up rivers and wetlands, the death of livestock, and increased soil salinity. This has led to the depopulation of rural areas and internal migration to cities.

Widespread unrest: A critical catalyst for broader anti-government protests, the crisis has prompted mass demonstrations since at least 2021.

Public health crisis: Residents in both urban and rural areas suffer from a lack of clean drinking water, with some areas having to resort to buying bottled water. The prevalence of dust storms causes respiratory and other health problems for thousands of people.

Exacerbated inequality: The crisis disproportionately affects marginalised communities, particularly the Arab Ahwazi minority, who have seen their livelihoods and cultural heritage damaged.

Power shortages: Low water levels in hydroelectric dams have caused power blackouts, which exacerbate the water crisis by disrupting pumps and are especially dangerous during extreme heat waves.

Khuzestan - Economic effects

Collapse of agriculture: The agricultural economy has been devastated by drought and mismanagement, forcing farmers to abandon their land and livestock. Over 260 hectares of farmland in the Hoor-al-Azim Wetland area alone have become unusable due to increased soil salinity.

Strain on the national economy: The loss of agricultural production and other damages from the crisis, combined with mismanagement, contribute to high inflation and poverty in the province.

Costly water projects: Mismanaged infrastructure projects, particularly dam construction, have worsened the crisis and in addition alternative water-saving methods have been ignored despite their lower cost.

Khuzestan - Environmental effects

Dried-up wetlands: Decades of damming rivers like the Karun and Karkheh have dried up vital wetlands, including the internationally recognised Hoor-al-Azim and Shadegan marshes.

Intense dust storms: The dried-out wetlands and riverbeds have become sources of sand and fine sediment. Wind picks up these particles, causing frequent, paralysing dust storms that damage infrastructure and endanger public health.

Soil and water salinity: The overuse of groundwater and reduced river flows have led to increased salt concentrations in the remaining water and soil, further degrading agricultural land and water resources.

Threatened biodiversity: Pollution from the oil and petrochemical industries, combined with water scarcity, threatens the biodiversity of the region's wetlands, which serve as crucial habitats for diverse species.

Khuzestan - Contributing factors to the crisis

Mismanagement: Experts cite decades of poor water management, destructive infrastructure projects like dam construction and inter-basin water transfers, and a lack of foresight as primary causes.

Industrial overconsumption: Water-intensive industries and the oil sector have been prioritised, diverting water away from the province's population and agricultural needs.

Climate change and drought: Reduced rainfall and more extreme heat have exacerbated the crisis, particularly in a region already prone to drought.

Rapid agricultural expansion: Despite decreasing water availability, the agricultural sector, which consumes over 90% of Iran's water, has expanded, and inefficient practices persist.

Khuzestan Demographic indicators

Population: Khuzestan is the fifth most populous province in Iran.

- In 2021–2022, the province's population was nearly 5 million, and estimates from 2016 place the population around 4.7 million.
- The provincial capital is Ahvaz.

Ethnic composition: The province has a significant Arab minority, who make up a substantial portion of the population. Other ethnic groups include Persians and Bakhtiaris.

Migration: The province has experienced significant emigration due to a lack of opportunities and harsh environmental conditions, with at least 200,000 people leaving in the five years leading up to 2021. The province also has a sizeable migrant worker population from other parts of Iran.

Poverty: The province has higher poverty rates than the national average.

- A 2022 report indicated Khuzestan ranked 17th out of 31 provinces for worst poverty rates.
- In 2022, nearly one-third of the population lived in poverty.
- In 2021, official statistics showed that 24.5% of the population in the city (unspecified) was in absolute poverty.

Khuzestan Economic indicators

GDP contribution: Despite its economic challenges, Khuzestan is a major contributor to Iran's economy.

- It generates nearly 15–16% of Iran's gross national product (GNP) when oil revenue is included, ranking it second after Tehran Province.
- Without oil revenue, its contribution places it fourth among Iranian provinces.

Energy industry: Khuzestan is central to Iran's energy sector.

- It is home to an estimated 80% of Iran's onshore oil reserves and more than a third of its petrochemical plants.
- Oil was first discovered here in 1908, and the province has numerous oil fields and refinery facilities.

Unemployment: The province's unemployment rates are significantly higher than the national average.

- An official rate of 12.6% was reported for 2021–2022, but the real number is believed to be higher.
- In 2021, the youth unemployment rate was 34.4%.

Key industries: In addition to oil and gas, other major industries include:

- Agriculture, producing a high percentage of the country's wheat and other crops.
- A steelmaking industry.
- Shipping and trade via key seaports like Imam Khomeini and Mahshahr.

E. Sistan and Baluchestan Province

Sistan and Baluchestan is Iran's largest and most deprived province, consistently ranking lowest on national development indices for key economic and social indicators. High poverty, unemployment, and low incomes are widespread, fuelled by a lack of investment and infrastructure and compounded by the challenges of living in a border region.

Demographic indicators

Population: The last complete census was conducted in 2016, putting the population at 2,775,014. The most populous cities are Zahedan, Zabol, and Iranshahr.

Ethnic and religious groups: The Baloch people constitute the majority, forming between 70% and 76% of the population. The Sistani Persian minority is the second-largest ethnic group. The majority of the Baluchi population are Sunni Muslims, while the Sistani Persians are mostly Shia.

Youth population: Roughly 60% of the residents are under 30 years old, creating a large youth demographic with limited economic prospects.

Economic indicators

Lowest economic contribution: Despite its large area, the province's share of Iran's economy is less than 1.4%, and it has the lowest urbanisation rate in the country.

Widespread poverty: As of 2022, unofficial reports claim that as many as two-thirds of the population lived in poverty, making it the most impoverished province in Iran.

Highest income inequality: The province has the highest level of income inequality in its urban areas, with a Gini coefficient of 0.49% in 2021.

High unemployment:

2025: The province ranked second-highest in the country for unemployment, with a rate of 12.2%.

Youth unemployment: The youth unemployment rate (ages 15 to 24) was 30.6% in 2023–2024, ranking fifth-highest in the country.

Low income: In 2023, average rural household income was just over $900 annually, which was 55.3% lower than the national rural average. Urban household income was nearly $2,200 annually, representing a 35.4% deficit compared to the national urban average.

Dependence on informal labour: Due to high unemployment, residents, including children, often resort to high-risk informal labour, such as fuel smuggling to Pakistan, to survive.

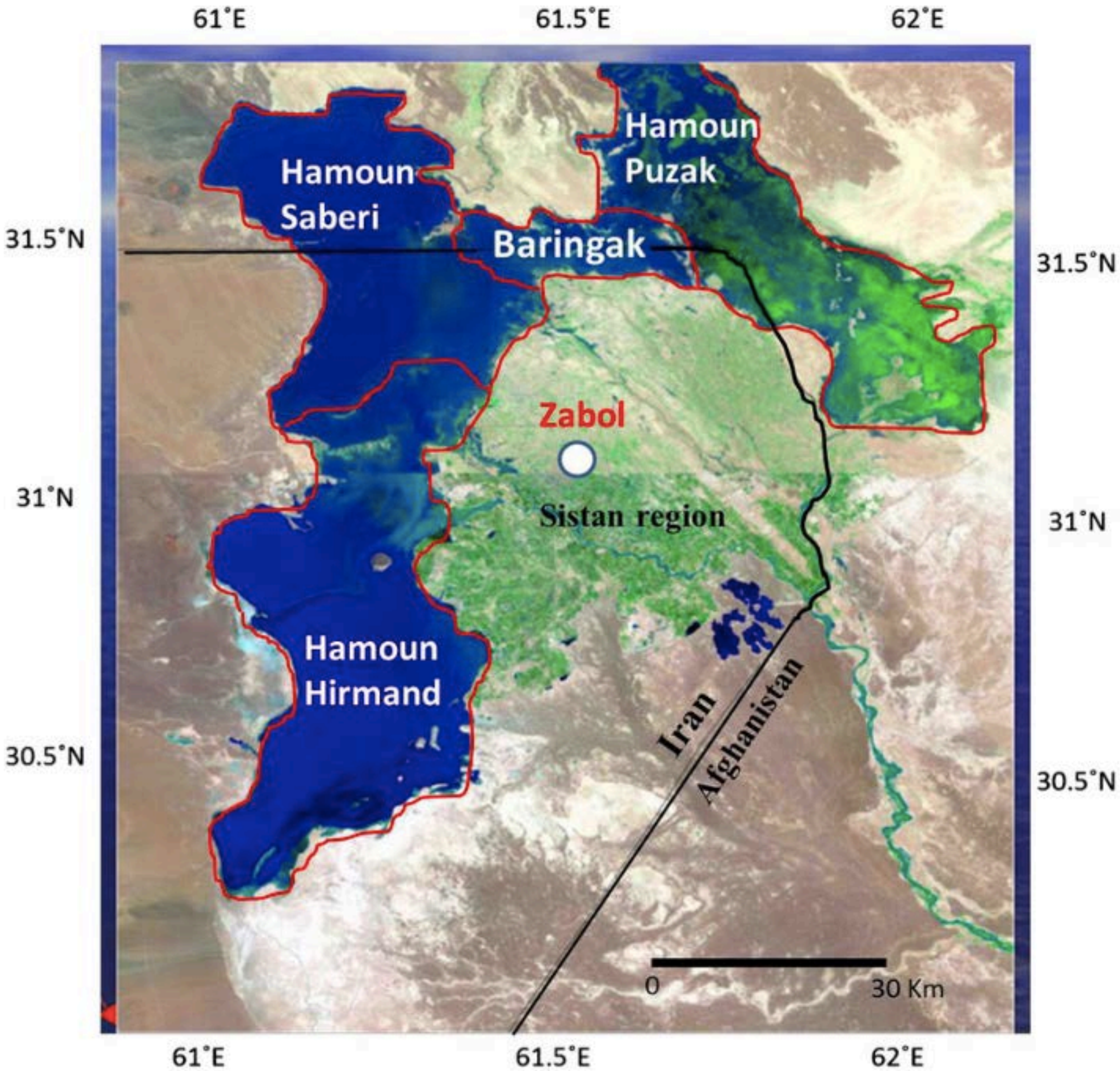
Social and human development indicators

Lowest Human Development Index: Sistan and Baluchestan consistently ranks at the bottom of Iran's provinces for human development, with an index score of 0.688. In 2009, its HDI was 0.608.

Highest illiteracy rate: In 2022, unofficial reports indicated that the illiteracy rate in the province was 90 times higher than the national average. In 2016, the illiteracy rate was 18.7% for men and 29.1% for women, the highest in the country at that time.

Highest number of school dropouts: The province has the highest rate of educational deprivation and school dropouts in Iran, with more than 145,000 individuals reportedly deprived of an education in 2021–2022.

Lowest access to services: Basic infrastructure and services, including clean drinking water, natural gas, and proper healthcare, are severely lacking, especially in rural areas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Water crisis in Sistan and Baluchestan province

The water crisis in Iran's Sistan and Baluchestan province has devastating economic and social effects, exacerbated by climate change and government mismanagement. The province, already one of the poorest in Iran, is experiencing desertification, population displacement, and severe economic hardship, with costs reflected in lost agricultural productivity, increased poverty, and growing social unrest.

Effects of the water crisis

Social effects

Forced migration: Water scarcity forces rural residents, primarily farmers, to abandon their lands and migrate to cities, contributing to urban overpopulation and pressure on limited infrastructure. Influxes of poorly educated and unskilled migrants add to the urban unemployment rate.

Increased poverty: The most marginalised people, including the Baluch, are disproportionately affected by the water shortage. Many are forced to purchase expensive potable water from companies with ties to the government.

Health issues: Dust storms, intensified by the drying of wetlands and lakes, cause respiratory and cardiovascular problems.

Economic effects

Agricultural collapse: The province's agriculture sector has been devastated by drought and depleted water resources. With a staggering 94% of the region's water used for agriculture and significant waste, aquifers have dried up.

Industrial decline: Water and electricity shortages cripple industry, contributing to Iran's issues with unemployment and inflation.

Depleted groundwater: Excessive pumping of groundwater for irrigation has led to the depletion of underground water resources and saltwater contamination.

Environmental degradation: Desertification threatens agricultural land, and dust storms cause damage to crops and transportation infrastructure.

Costs of the water crisis

Direct costs

Lost productivity: The cost is reflected in lost agricultural output and halted industrial production.

Public health impacts: Inadequate and unsafe water supplies increase healthcare costs.

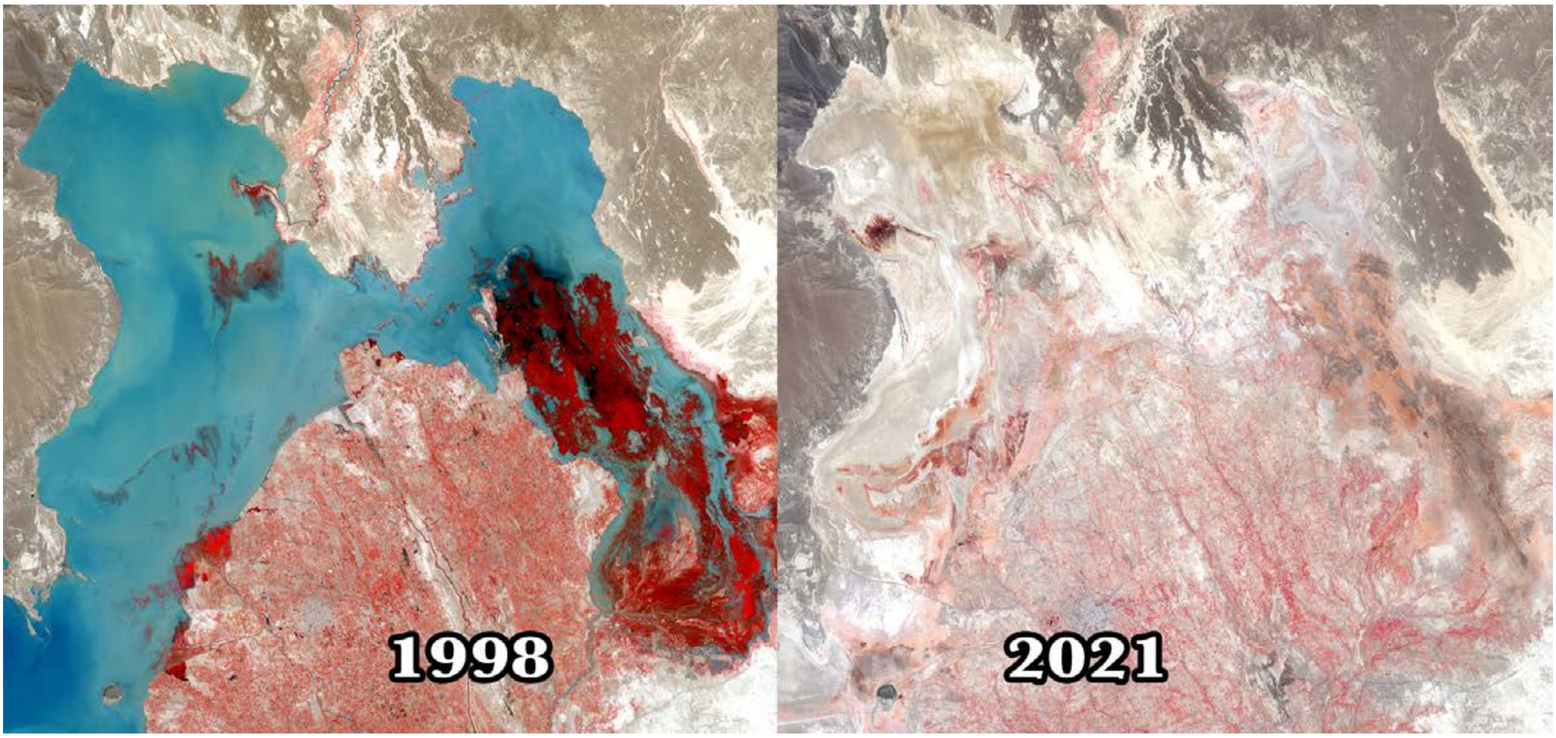
Infrastructure damage: The province has experienced ground subsidence due to groundwater depletion, posing a threat to infrastructure.

Indirect costs

Government spending on water projects: The government has invested public funds into developing water infrastructure, though some projects have been criticised for mismanagement and environmental harm.

Social and political instability: The economic and social toll contributes to resentment toward the government and broader political challenges. The unequal distribution of water in provinces like Sistan and Baluchestan can spark hydro-political conflict.

Hamoun Wetlands

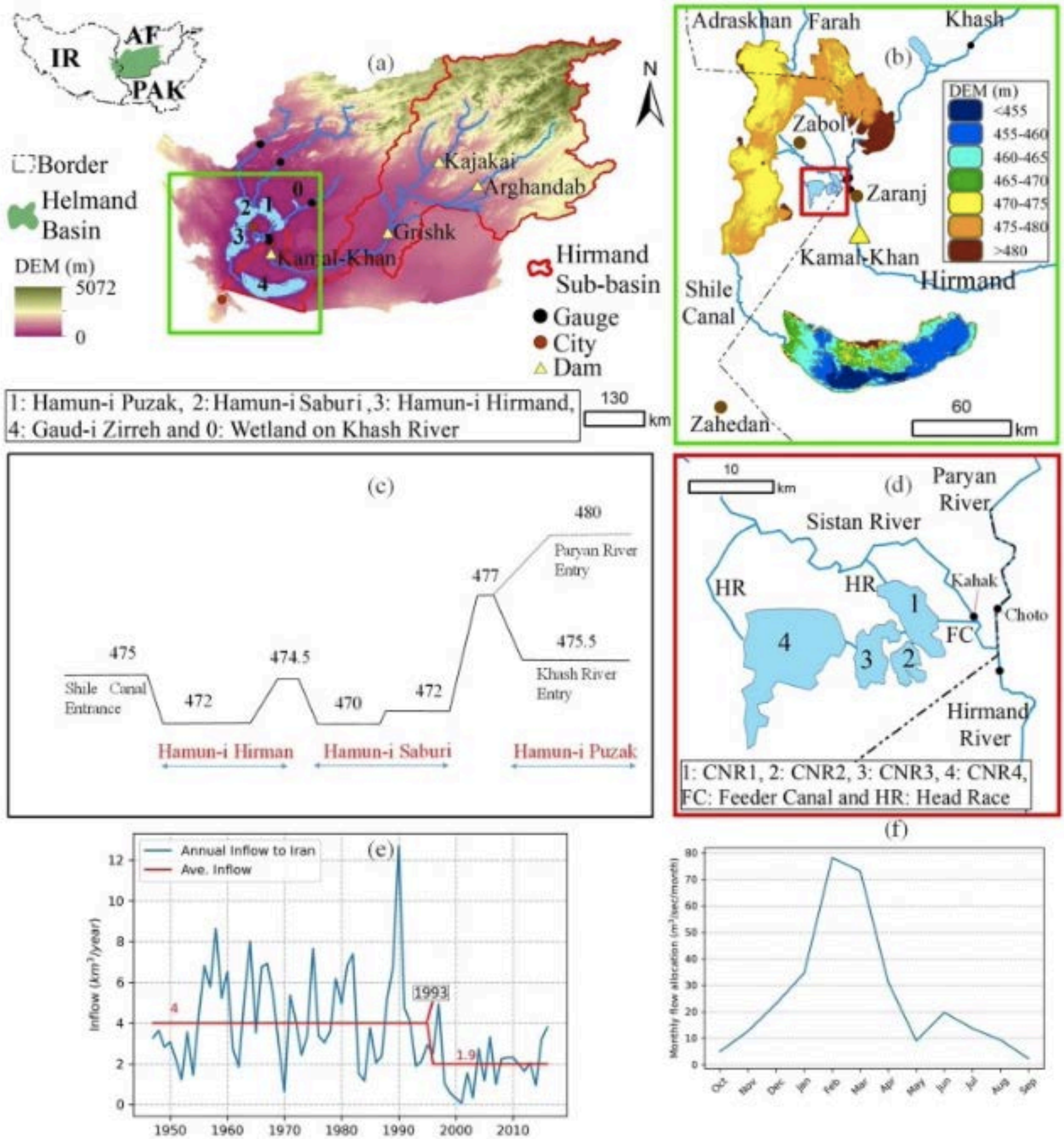


The Lake Hamoun area is classified as freshwater wetlands. Because Hamoun is a closed basin, it's more of an inland delta. About 60,000 hectares of the wetlands in the Hamoun region in Iran are protected under the Ramsar Convention. The Hamoun region on the Afghanistan side is not protected under the Ramsar Convention even though it represents more area that is permanently inundated and vegetated.

The Hamoun wetlands have a normal wet and dry cycle. The water level typically rises in the spring and falls from April to January. Large areas dry up regularly. But during prolonged dry periods, birds migrate elsewhere, and fishing is not possible.

The annual precipitation in this extremely dry basin is only about 50 millimetres. The average depth of the lake, even at its highest water level, is only 3 meters. That means the area is vulnerable to major changes in water level that happen naturally. When in addition people alter the water flow, the changes are more pronounced. Irrigation expansion has made the lakes more vulnerable to drought. The once thriving wetlands are now mostly lifeless salt flats.

As of late 2025, Lake Hamoun is almost entirely dry, having mostly vanished due to persistent drought and upstream water mismanagement in Afghanistan. The severe desiccation has triggered a major environmental and humanitarian crisis for the Sistan region, located on the border between Iran and Afghanistan.



Key aspects of the waters crisis locally

Widespread desiccation: Experts reported in September 2025 that over 85% of the Hamoun wetlands have disappeared, turning the area into a dust bowl. While some water may temporarily appear during heavy rainfall, it quickly evaporates.

Humanitarian disaster: The drying of the lake has devastated the livelihoods of local communities who once relied on fishing and farming. This has led to mass displacement, with thousands of households migrating from the Sistan region.

Intense dust storms: The exposed lakebed is a massive source of dust, sand, and salt, which are picked up by strong winds. These dust storms, which now occur more than 200 days a year, have blanketed villages, destroyed crops, and caused widespread respiratory illness.

Ecological collapse: The loss of the wetlands has wiped out local fish and wildlife populations and ended the presence of migratory birds that once used the lake as a stopover.

Water management disputes: A primary cause of the lake's desiccation is the reduced flow from the Helmand River, which originates in Afghanistan and is the Hamun's main water source. Iranian officials accuse Afghanistan of violating water agreements by diverting the river with extensive dam construction, including the Kamal Khan Dam completed in 2021.

Political tension: The water dispute has escalated tensions between Iran and the Taliban-led government of Afghanistan. It has also fuelled protests within Iran from residents in the Sistan and Baluchestan province, demanding that the government secure Iran's water rights.

Desiccation of the Transboundary Hamoun Lakes between Iran and Afghanistan
M. Akbari, A. Mirchi, A. Roozbahani et al. Journal of Great Lakes Research 48 (2022) 876–889

Hamoun Lakes consist of three connected Lakes (Hamun-i Puzak, Hamun-i Saburi and Hamun-i Hirmand) above Shile Canal and a deeper terminal lake (Gaud-i Zirreh). The first three cascading lakes are very shallow, and they respond rapidly to monthly Hirmand River inflow variation.

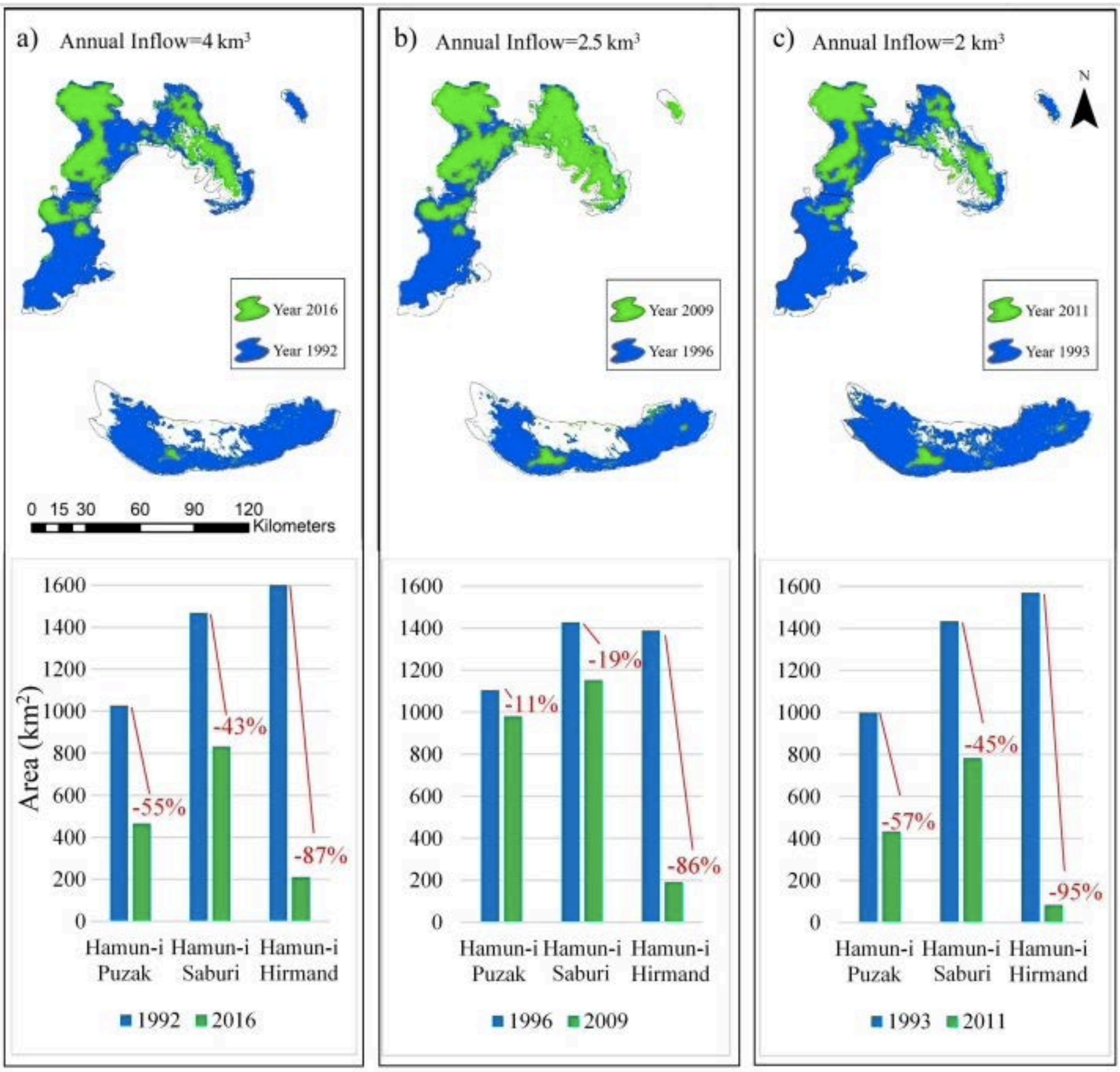
A shift in upstream regulations of the Hirmand River in Afghanistan has changed post-2004 water deliveries at the international border. From 1960 to 2003, Standardised Discharge Index (SDI) and Standardised Precipitation Index (SPI) were highly correlated (70%), meaning high river flow was expected to feed the lakes due to high precipitation over the Hirmand River sub-basin. However, the correlation changed to 0.13 in the periods 2004–2016 indicating a drastic decline in the Hirmand River flow downstream despite large amounts of upstream precipitation over its sub-basin. This gap kept increasing and SPI-SDI correlation became negative (0:63) between 2010 and 2016.

Upstream regulations are the main cause of inflow delivery reduction to the lakes. The construction of Chah Nimeh Reservoir 4 (capacity of 0.81 km3 for domestic and agricultural use in a socio-economically disadvantaged region of Iran) and Kamal-Khan Dam (capacity 0.05 km3) has aggravated the situation. The decline of the socio-ecological system due to unsustainable water management in this transboundary region is expected to have detrimental impacts on the condition of the residents (e.g., dust storms). Therefore, revisiting the 1973 treaty between riparian countries to share the Hirmand River inflow considering the environmental right of the lakes is recommended to improve the condition of the region.

Normalised Difference Spectral Indices using satellite images from 1987 to 2021 to observe monthly areal change of the lakes. The results show that the major cause of desiccation is upstream water regulation which severely reduced the Hirmand River inflow delivery to the lakes. Constructed reservoirs near the lakes by Iran in 2008, compounded the effect of Afghanistan water regulation to aggravate the situation.

There is a discernible shift in the relation between the Hirmand River flow at the border and upstream precipitation before and after 2004. In 1960–2003, high Hirmand River inflows were expected due to high precipitation, while the flow declined after 2004 despite large amounts of upstream precipitation.

Although a long period of drought from 1998 to 2004 decreased the lakes' area, the lake system is primarily falling victim to anthropogenic flow reduction recently. Increased regulation of flows and use of water for irrigation in Afghanistan and Iran underscores the necessity of bilateral dialogues between the two countries to consider environmental flow for the lakes. The lakes' shrinkage places socio-economic stress on an already-vulnerable region with public health implications as the exposed lake beds turn into major sources of dust storms.



F. Tehran

Based on 2025 estimates, Tehran, Iran's capital and largest city, has a population of around 9.8 million people. As the country's main commercial hub, the city's economy is centred on services, industry, and trade. However, high inflation and a significant gap between wages and the cost of living present serious challenges for residents.

Demographic indicators

Population: The city of Tehran has a population of approximately 9.8 million in 2025. The wider metropolitan area, which includes the entire Tehran Province, has an estimated population of 16.8 million. This makes it the most populous metropolitan area in Iran and Western Asia.

Ethnicity: Tehran is ethnically diverse. In 2009, an official survey found that the major ethnic groups in Tehran Province included Persians (56.9%), Azari (56.9%), and Northern Iranian peoples such as Mazani, Gilak, and Talish (30.3%).

Age and workforce: Iran's population is relatively young, with half of the country's population under 39 as of 2025. The average age of the Iranian population is 32 years. The labor market faces challenges, including a high unemployment rate among university graduates.

Literacy: Iran ranks 119th in education expenditures, a key indicator of literacy.

Economic indicators (2025)

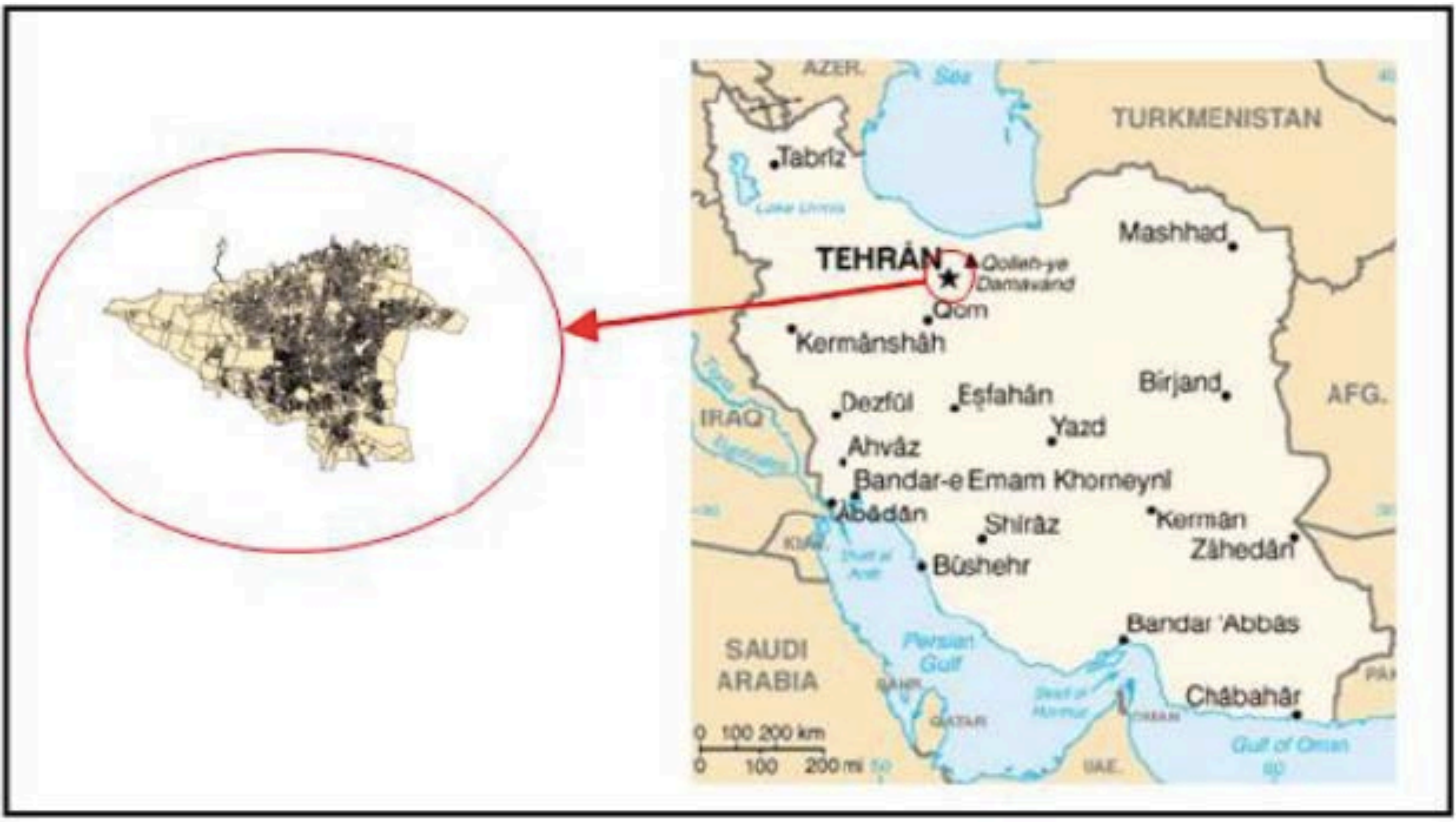
Gross Domestic Product (GDP): Iran's total GDP is projected to be around $451 billion by the end of 2025. However, the IMF reported that based on purchasing power parity, the country's GDP per capita saw a slight decline from $17,222 in 2024 to $17,103 in 2025. The Tehran Province itself constitutes about 30% of Iran's total economy.

Main economic sectors: The services sector is the largest component of Iran's GDP, making up 51% of the total. This is followed by oil production (23%), manufacturing and mining (13%), and agriculture (10%). Tehran Province is a significant industrial hub, containing 26% of all industrial units in Iran.

Unemployment: The International Monetary Fund (IMF) projects that Iran's unemployment rate will increase to 9.5% in 2025. University graduates face a higher rate of unemployment than the national average.

Inflation and cost of living: Inflation is a major issue, projected to reach 43.3% in 2025. The cost of living in Tehran has risen sharply, and the minimum wage covers only a fraction of the monthly expenses for a family. In September 2025, food prices had risen by 57.9% over the past year.

Housing: Housing is a significant financial burden for many residents of Tehran, with some families spending over 70% of their income on rent.



Tehran's Water Crisis

•In October 2025 Time magazine published the following article under the heading 'Iran's Water Crisis Is Its Greatest Threat'

Iran is a warning to every society that treats water as infinite. Over the summer, Iran's water crisis turned into an emergency. Wells collapsed and some reservoirs ran dry. Taps went dry for half a day in Tehran, and state media warned that the city of about 10 million people could hit "Day Zero," the point at which water resources can no longer meet demand, within weeks.

Temperatures rose above 100 degrees Fahrenheit, air conditioners droned, and power cuts followed. Millions of Iranians baked in the punishing heat. In a rare admission of failure, Masoud Pezeshkian, the Iranian president offered 100 billion tomans (about a million dollars) to anyone who could solve the crisis.

Iran isn't facing a mere drought. Iran faces water bankruptcy, with demand far outstripping supply. The collapse of water security in Iran has been decades in the making and is rooted in a mania for mega projects—dam building, deep wells, and water transfer schemes—that ignored the fundamentals of hydrology and ecological balance.

For millennia, qanats—ingenious underground aqueducts—balanced survival with scarcity across the central plateau of Iran. Those traditional systems are now collapsing alongside aquifers, and ancient settlements in Yazd in central Iran, Kerman in southeast Iran, and Khorasan in northeastern Iran have been abandoned as Qanats dried up, aquifers caved in, and land subsided. Satellite imagery and field surveys show entire farming communities disappearing because their groundwater sources failed.

Successive Iranian rulers believed that dams, deep wells, and inter-basin transfers could outsmart geography and climate. The mismanagement of resources by the Islamic Republic compounded the crisis. Political hubris and mismanagement have reduced one of the oldest water civilisations to a parable of collapse.

The water crisis in Tehran, exacerbated by prolonged drought and poor management, has devastating economic, social, and environmental consequences. Financial losses are in the billions of dollars annually, and the crisis has fuelled public discontent, migration, and environmental degradation. In October 2025, an official warned that Tehran's five main reservoirs held only around 13% of their capacity.

Economic and infrastructure costs

Billions in economic losses: Annual economic damage from inadequate and unsafe water supplies, groundwater depletion, and erosion has amounted to approximately 3% of Iran's GDP. This cost is comparable to the country's losses from international sanctions.

Energy and industry costs: Water shortages restrict hydropower production, leading to power outages that cost the industrial sector billions of dollars a year. Industries dependent on water face production disruptions.

Agricultural decline: Water-intensive agriculture is highly inefficient and a primary driver of the crisis, consuming more than 90% of the country's water. This has led to reduced crop yields, livestock losses, and threats to food security.

Infrastructure strain: Tehran loses nearly a third of its water through leaky pipes. Inefficient irrigation and inadequate infrastructure have also increased the reliance on unsustainable groundwater extraction.

High costs for alternatives: Proposed solutions, such as costly water transfer projects and desalination, are environmentally damaging and expensive. The government is also fast-tracking projects like a ring pipeline for redistribution and expanding wastewater recycling.

Impact on businesses: Frequent water and electricity cutoffs disrupt operations, forcing businesses to close during peak work hours. This was demonstrated in August 2025, when authorities temporarily closed government offices in Tehran and other cities to save power.

Social and political costs

Growing inequality: Water access is highly unequal in Tehran, with impoverished districts experiencing hazardous water quality and inadequate supply. Meanwhile, affluent neighbourhoods with elite government connections face fewer shortages and maintain private luxuries like swimming pools and green spaces.

Displacement and depopulation: An estimated 70% of Iran's villages are at risk of being abandoned due to water shortages. Between 2002 and 2017, over 12,000 villages were completely deserted.

Health and quality of life: Deteriorating water quality in Tehran poses a public health risk, particularly in poorer areas. Water pressure reductions mean high-rise buildings may not receive water.

Environmental consequences

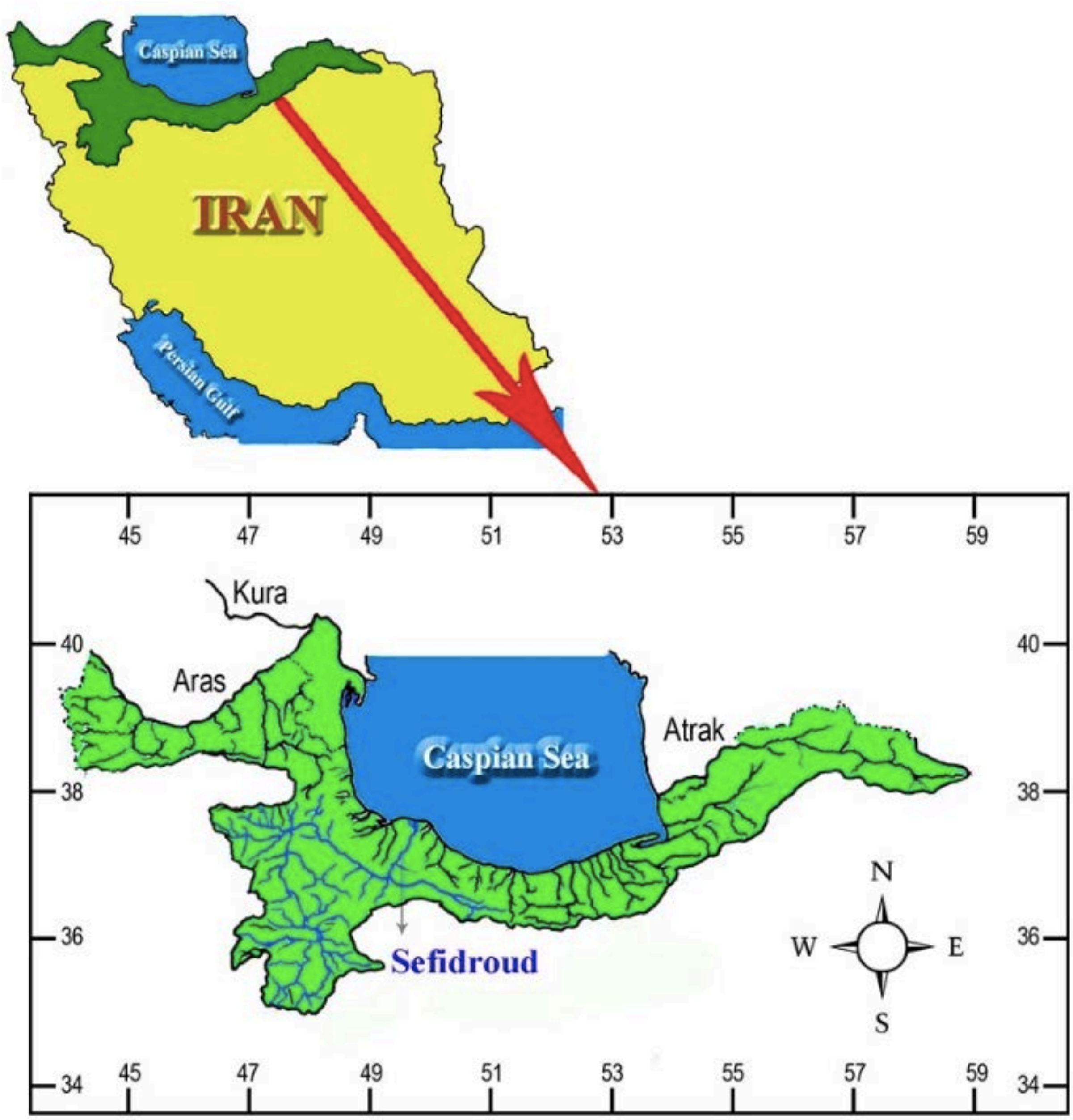
Land subsidence: Excessive groundwater pumping to compensate for surface water shortages is causing the land to sink in and around Tehran. Research cited by Iranian institutes shows parts of Tehran subsiding at a rate of over 10 centimetres a year, threatening infrastructure.

Groundwater depletion: Iran's rate of groundwater depletion is among the worst in the world, with levels dropping at an alarming rate. Over the last two decades, Iran has lost approximately 211 ± 34 km^3 of its water storage, more than double its annual consumption.

Hazardous pollution: Water pollution is a major problem, with most collected municipal sewage discharged untreated into groundwater. Increased salinity in over-irrigated soil also reduces fertility.

Desertification and dust storms: Dwindling water supplies worsen desertification, which fuels dust storms. These storms damage crops, disrupt transportation, and pose a severe public health hazard, contributing to respiratory and cardiovascular problems.

G. Caspian Sea coast



The Caspian Sea coast in Iran, known as northern Iran or "Shomal," is a popular destination characterised by a temperate, wet climate, dense forests, and coastal plains backed by the Alborz Mountains. This region is divided into three provinces: Gilan, Mazandaran, and Golestan. It is known for its lush scenery and is a major domestic tourist spot, featuring beaches, mountains, and cultural landmarks.

Geography and climate

Provinces: The coastal area is made up of the provinces of Gilan, Mazandaran, and Golestan.

Climate: It is the only temperate climatic zone in Iran, with some areas receiving over one meter of rain annually and having no dry season.

Landscape: The coastal plains are forested and rise sharply into the Alborz Mountains.

Tourism and culture

Tourist destination: The coast is a top destination for domestic tourism due to its greenery and tropical climate, which is a stark contrast to much of Iran's arid interior.

Beaches: The region offers sandy beaches, and while they can be crowded in summer, it is possible to find quieter spots.

Historical sites: Notable landmarks include the Gonbad-e Qabus tower in Golestan province and the Great Wall of Gorgan (Red Snake Wall), which is a UNESCO tentative site.

Economy and environment

Agriculture: The provinces are major agricultural centres.

Wetlands: The area is ecologically significant, with the Ramsar Convention on wetlands having been signed in the coastal city of Ramsar, Iran, in 1971.

Conditions: The narrow plain along the Caspian Sea is a sharp contrast to the rest of the country. Blocked from the interior by the Elburz Mountains, it features a fertile, subtropical climate.

Temperature: Summers are hot and humid, with temperatures reaching around 38°C (100°F) and humidity approaching 100%. Frosts are extremely rare in winter.

Precipitation: This is the wettest region of Iran, with heavy annual rainfall that can exceed 1,980 mm (78 inches).

Vegetation: The area is known for its lush forests, swamps, and rice paddies.

Mountainous regions (Zagros and Elburz)

Conditions: The mountainous areas, particularly the Zagros in the southwest and the Elburz in the north, experience a distinct cold, dry mountain climate.

Temperature: Winter temperatures can be far lower than expected for the country's latitude, often dropping below freezing. Temperatures of -20°C (-4°F) are common, and -30°C (-22°F) has been recorded in the northwest. Many peaks remain snow-covered until late spring.

Seasons: These northern and western parts of Iran typically have four distinct seasons.

Southern coastal areas (Persian Gulf and Gulf of Oman)

Conditions: This region has a more moderate climate than the interior, but it is still quite hot.

Temperature: Summer days are hot, ranging from 25–35°C (77–95°F), while winter days are mild, from 15–25°C (59–77°F).

Precipitation: Most rainfall occurs during the winter and spring.

Seasonal overview

Summer (April–October): A long, hot, and very dry season across most of the country, with the exception of the humid Caspian coast.

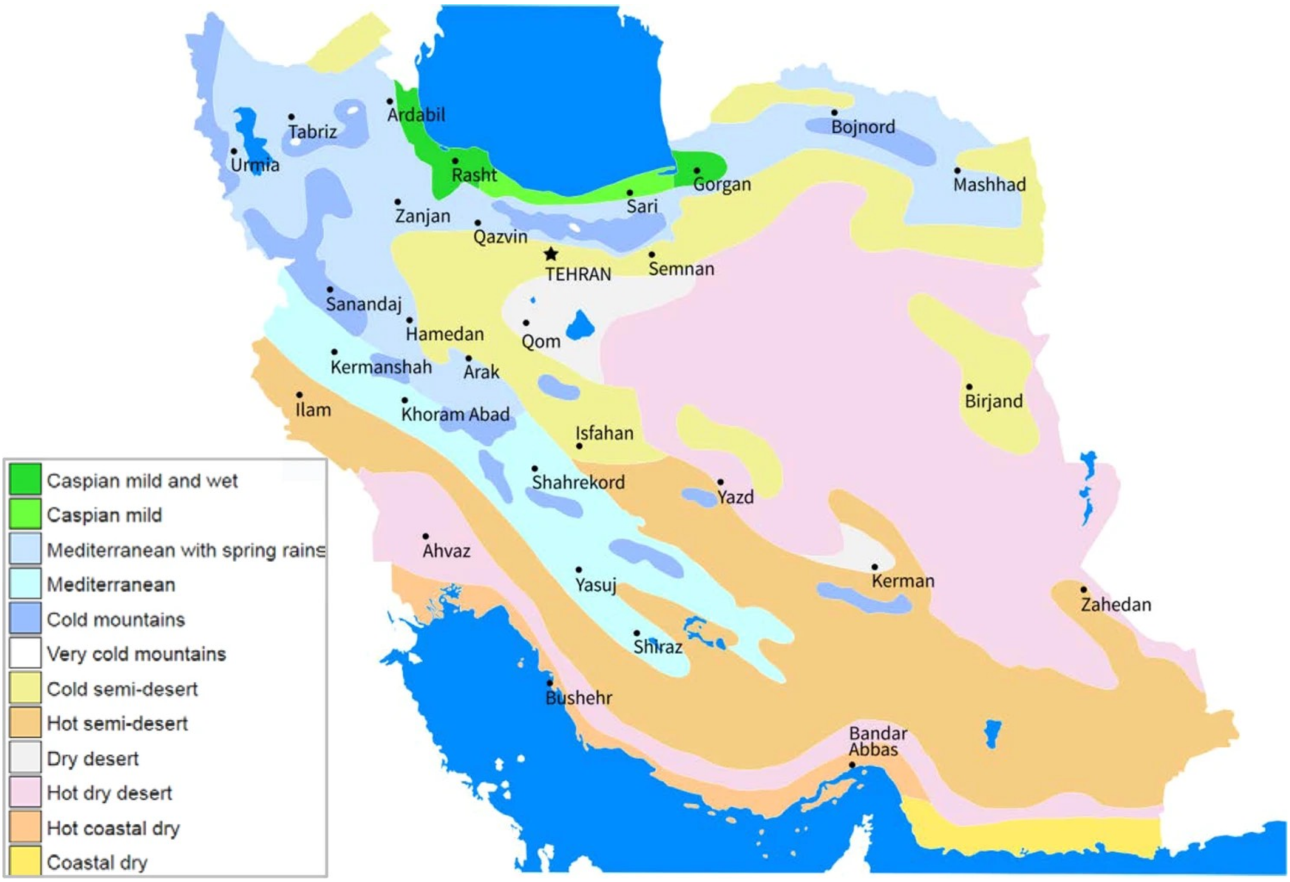
Winter (November–March): The main rainy season. Most of the country's annual precipitation falls during this three-month period.

Spring and autumn: These seasons become increasingly short towards the south and east, eventually merging into the area of hot summers and mild winters

Prescipation

Rainfall in Iran varies significantly by region, with the highest amounts found near the Caspian Sea and mountainous areas, and the lowest amounts in the central and eastern deserts. The country has a diverse climate, influenced by topography and proximity to moisture sources.

XI. Climate Variations of the Islamic Republic of Iran



Iran's climate is one of great extremes, with a diverse range of climate zones due to its varied geography and topography. The climate can be broadly categorised, moving from extremely arid conditions in the interior to a fertile, humid subtropical climate along the Caspian Sea.

Climate zones

Arid and semi-arid interior plateau

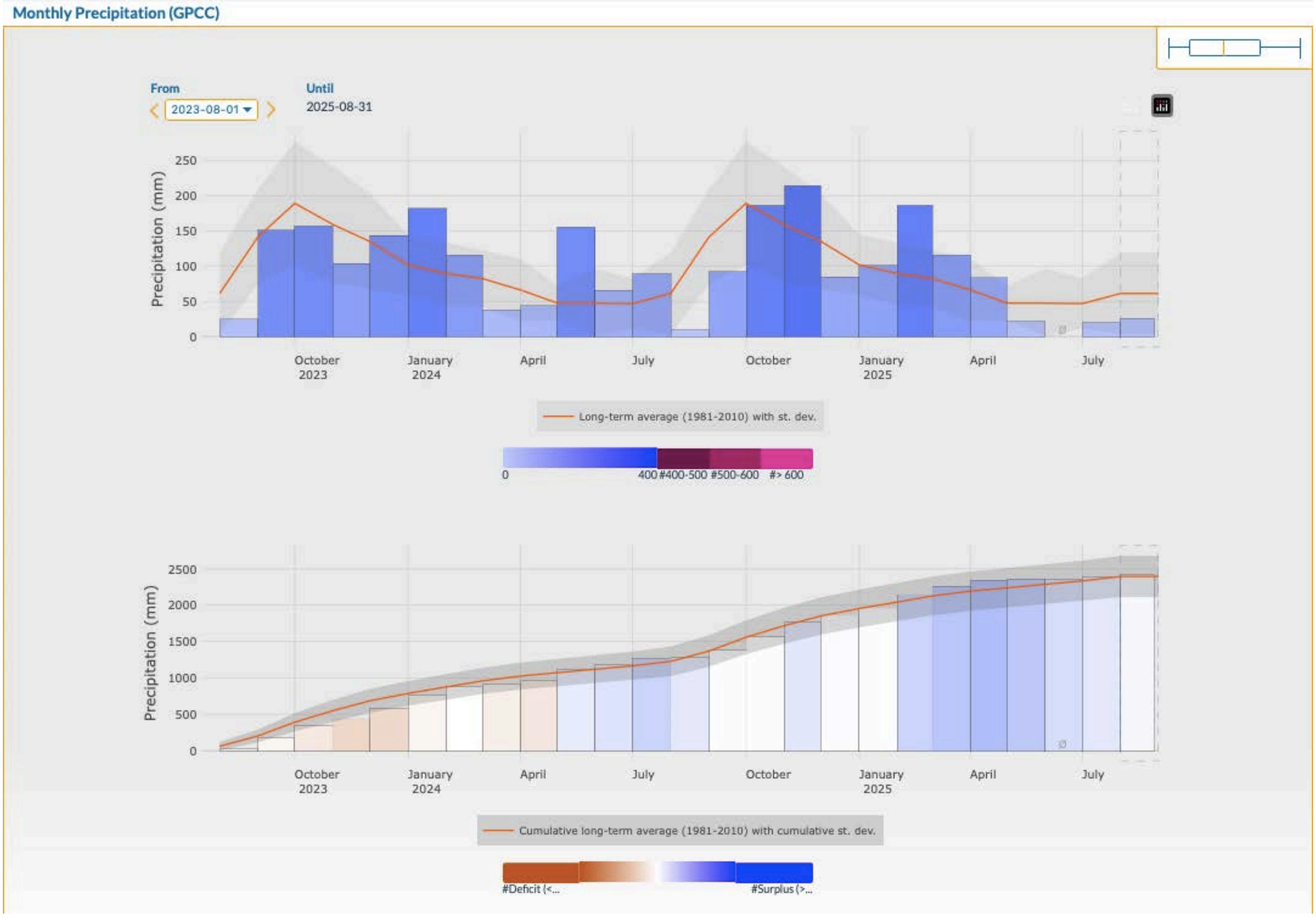
Conditions: The central and eastern parts of the country are dominated by a high-altitude, sparsely populated desert plateau. This includes the Dasht-e Kavir and Dasht-e Lut deserts, which are known for extremely high summer temperatures.

Temperature: Summers are extremely hot, with temperatures sometimes rising above 55°C (131°F). Winters are cold, but temperatures are less extreme than in the mountains.

Precipitation: This region receives very little rainfall, often less than 50 mm (2 inches) per year.

Vegetation: Vegetation is sparse and adapted to desert conditions.

XII. Monthly Rainfall in Iran

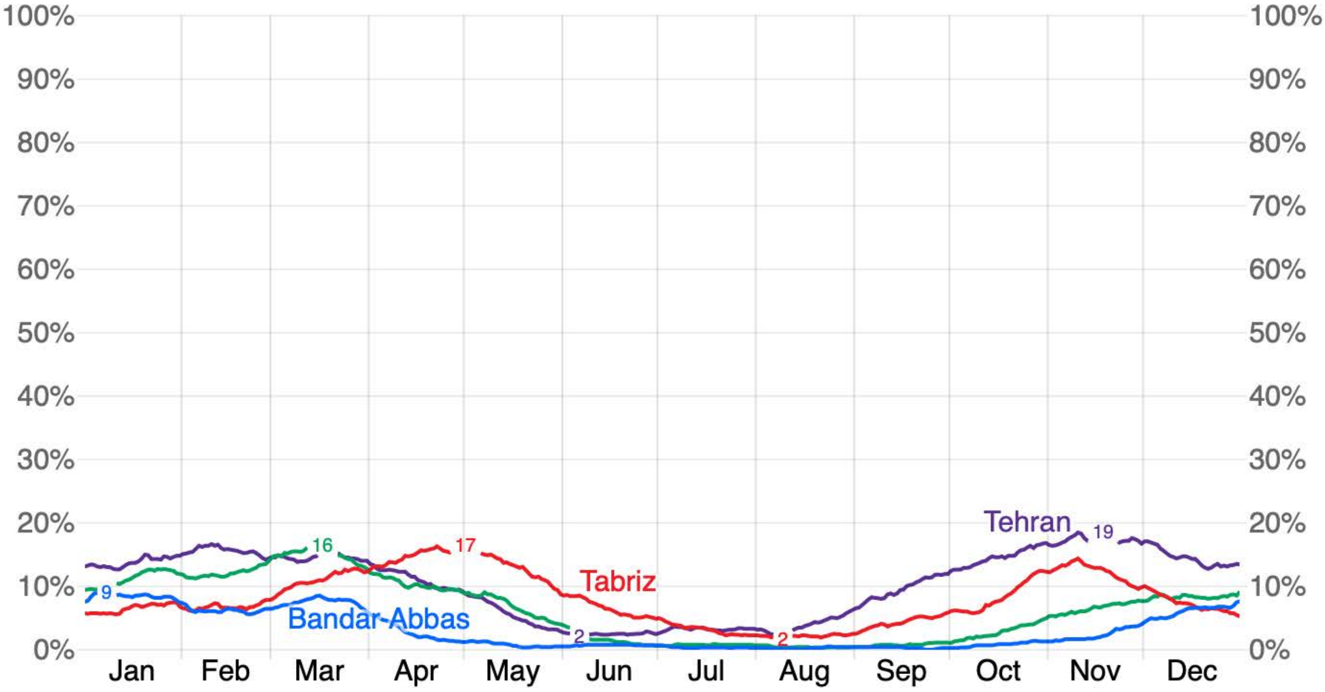


Rainfall	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Tehran	16.0mm	17.7mm	20.4mm	16.6mm	7.4mm	2.9mm	4.1mm	4.6mm	12.0mm	23.9mm	28.8mm	20.2mm
Mashhad	9.4mm	13.6mm	19.9mm	15.7mm	8.5mm	1.7mm	0.7mm	0.6mm	1.4mm	3.4mm	7.8mm	9.9mm
Tabriz	4.8mm	6.4mm	13.4mm	22.9mm	19.6mm	8.3mm	4.7mm	2.8mm	6.2mm	12.9mm	18.0mm	7.7mm
Bandar Abbas	25.3mm	17.1mm	18.6mm	7.3mm	1.9mm	4.4mm	1.3mm	0.7mm	0.6mm	2.6mm	6.3mm	18.3mm

The average rainfall accumulated over the course of a sliding 31-day period centred on the day in question. © WeatherSpark.com. https://weatherspark.com

Precipitation in Iran averaged 227.80 mm from 1901 until 2024, reaching an all time high of 344.36 mm in 1957 and a record low of 128.50 mm in 2021. source: Worldbank

XIII. Daily Chance of Precipitation in Iran



The percentage of days in which precipitation is observed, excluding trace quantities
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Days of Precip.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Tehran	4.3d	4.4d	4.5d	3.3d	1.7d	0.7d	1.0d	1.3d	2.9d	4.6d	5.2d	4.4d
Mashhad	3.5d	3.4d	4.6d	3.1d	2.0d	0.5d	0.2d	0.1d	0.2d	0.9d	2.0d	2.6d
Tabriz	2.0d	1.9d	3.5d	4.5d	4.0d	1.9d	1.0d	0.7d	1.3d	2.7d	3.7d	2.2d
Bandar Abbas	2.6d	1.7d	2.3d	0.8d	0.2d	0.2d	0.1d	0.1d	0.1d	0.3d	0.7d	1.9d

High rainfall regions

These regions receive the most precipitation in Iran, often exceeding 600 mm and sometimes over 1,500 mm annually.

Southern Caspian Sea Coast: This region has the highest annual precipitation, characterised by a mild and humid climate.

Northern and Western Zagros Mountains: The western slopes of this mountain range receive substantial annual rainfall.

Alborz Mountains: The northern slopes of these mountains also receive significant rainfall, with higher altitudes seeing snow.

Moderate rainfall regions

These areas receive moderate precipitation, with rainfall often concentrated in the winter and spring months.

Western Iran: This area has a cool and sub-humid climate, with maximum precipitation occurring in winter.

Northwestern Iran: Characterised by a cold and temperate semi-arid climate, it experiences its highest precipitation in spring.

Northeastern Iran: With a cool and arid climate, this region also receives more rainfall during the winter.

Low rainfall regions

Large parts of Iran consist of desert and steppe areas with very low annual rainfall, often less than 300 mm.

Central, Eastern, and Southeastern Iran: These regions have warm, arid, and hyper-arid climates, with low average precipitation.

Central Plateau Basins: Some basins in this area receive 100 mm of precipitation or less annually.

Seasonal variations

Precipitation patterns also shift throughout the year, depending on the region.

Autumn: The southern coast of the Caspian Sea sees its maximum precipitation during this season.

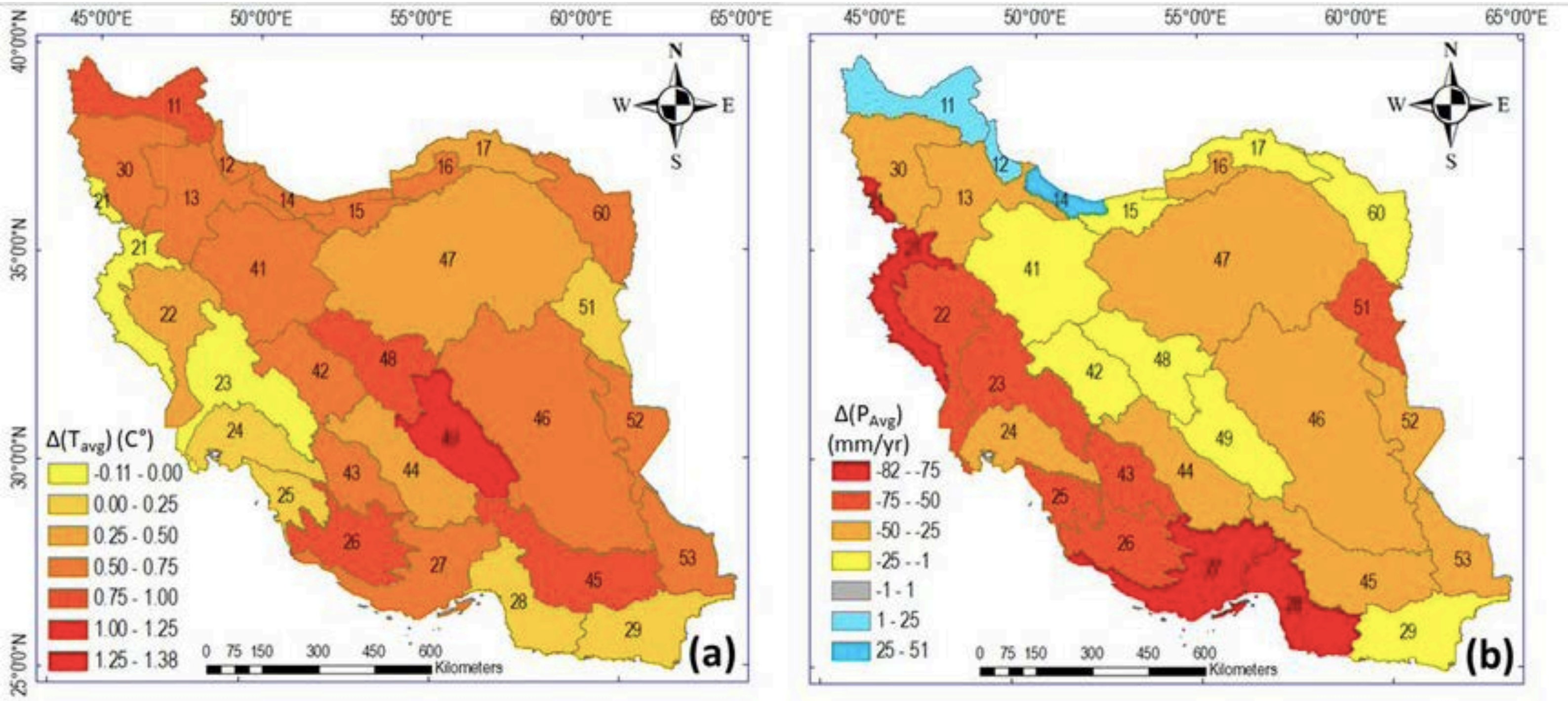
Winter: This is the rainiest season for most of Iran, including the western, southwestern, northeastern, southeastern, and central regions.

Spring: Northwestern Iran experiences its highest precipitation in spring.

Summer: Most of Iran is hot and dry in the summer, with minimal precipitation.

XIV. Average temperatures

Iran's average temperature varies significantly depending on the region and the time of year, ranging from very cold winters in the mountains to extremely hot summers in the deserts and southern plains. The country has a diverse climate, mainly arid or semi-arid, with a mild, humid area along the Caspian Sea.



Change in (a) average temperature (T) and (b) average precipitation (P) in the 30 main basins in Iran between two 15-year sub-periods (1986–2000 and 2001–2016), The maps in this Figure are drawn by ArcGIS 10.6 (https://desktop.arcgis.com/en/arcmap).

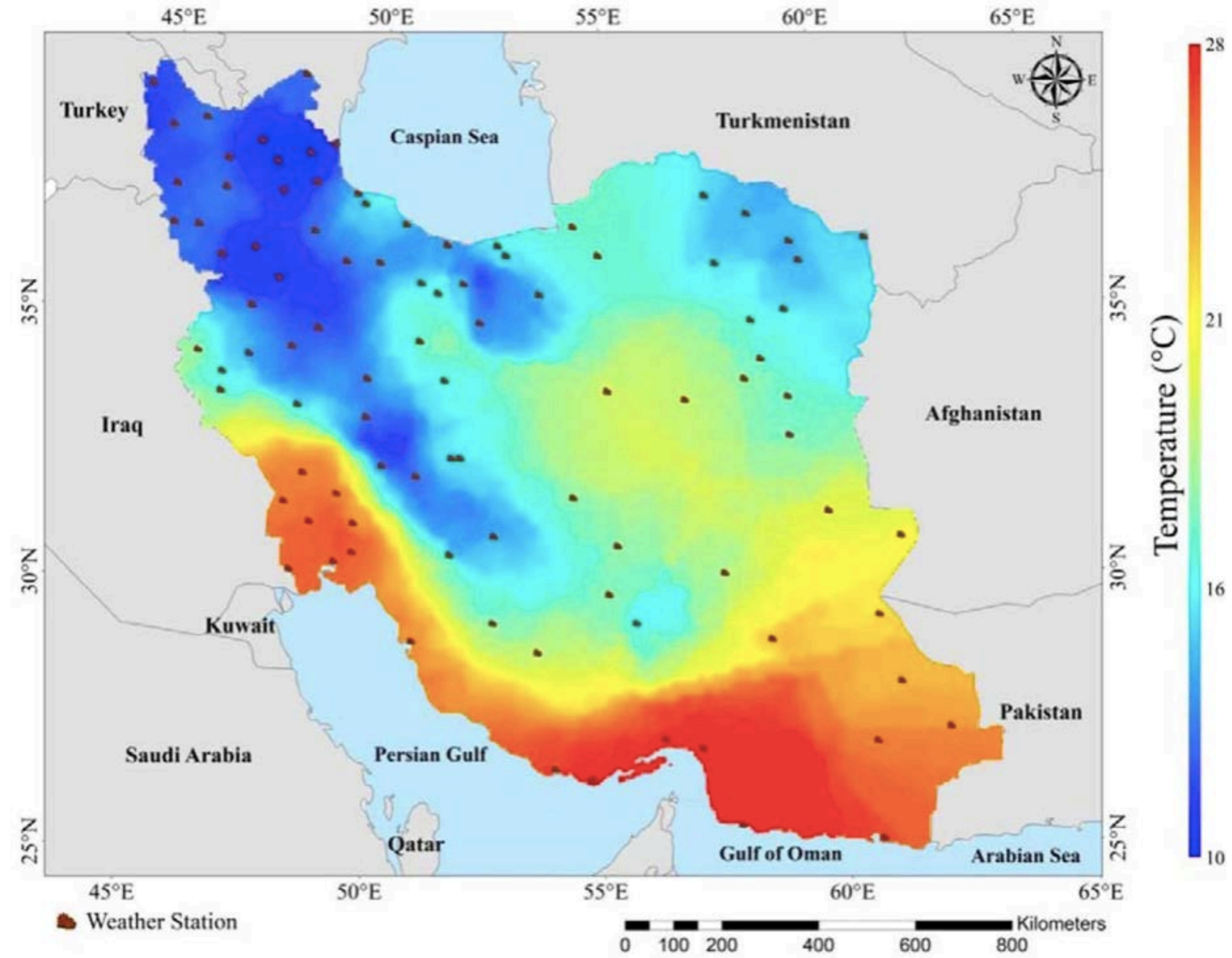
Regional temperature averages

Northern and northwestern Iran: The Alborz and Zagros mountain ranges in the north and west experience cold winters with heavy snowfall and sub-freezing temperatures. Cities like Tabriz have average January lows of 23°F (-5°C) and average July highs of 90°F (32°C). The coastal area along the Caspian Sea has a milder, semi-humid climate.

Central and southeastern Iran: These areas are dominated by desert climates, including the Dasht-e Lut, one of the hottest places on Earth. Central cities like Yazd and Isfahan have hot, dry summers and cool winters.

Southern Iran: The south experiences mild winters and very hot summers, with average daily highs exceeding 100°F (38°C) in July. The summer heat is accompanied by high humidity in the Khuzestan Plain. In the Persian Gulf coastal regions, temperatures can vary from an average high of 73°F (23°C) in January to 105°F (40.5°C) in July.

XV. Seasonal temperature patterns



Location of the study area and distribution of 95 synoptic stations

Iran's seasonal temperature patterns vary geographically but are generally characterised by hot, dry summers and cold, dry winters, with exceptions for Caspian coastal regions and high mountain areas. The highest monthly temperatures are in July, and the coldest months are in January. Summers are characterised by intense heat, especially in the Persian Gulf region, while winters see cold conditions and snow in the mountains. Spring and autumn offer milder temperatures and are often considered the best times to visit.

Summer (June - August)

Hot & Dry: Summers are generally hot and dry, particularly across the central plateau and desert areas, with temperatures often exceeding 40°C.

Coastal Humidity: The southern coastal regions of the Persian Gulf experience high humidity in addition to the extreme heat.

Caspian Coast: A contrast to the rest of the country, the northern Caspian coast has milder summers.

Winter (December - February)

Cold & Dry: Winters are typically cold and dry in most of the country.

Mountain Snow: Mountainous areas, such as the Alborz range, experience cold temperatures with significant snowfall.

Coastal Areas: The Caspian coast has relatively milder winters, while the south remains warmer.

Spring (March - May)

Mild & Green: Spring is generally a pleasant time with mild temperatures and a green landscape.

Variable Conditions: While generally mild, conditions can vary, with precipitation often concentrated in this period.

Autumn (September - November)

Mild Temperatures: Autumn brings milder temperatures to much of the country.

Precipitation: This season can see significant rainfall, especially in the southern Caspian coastal areas.

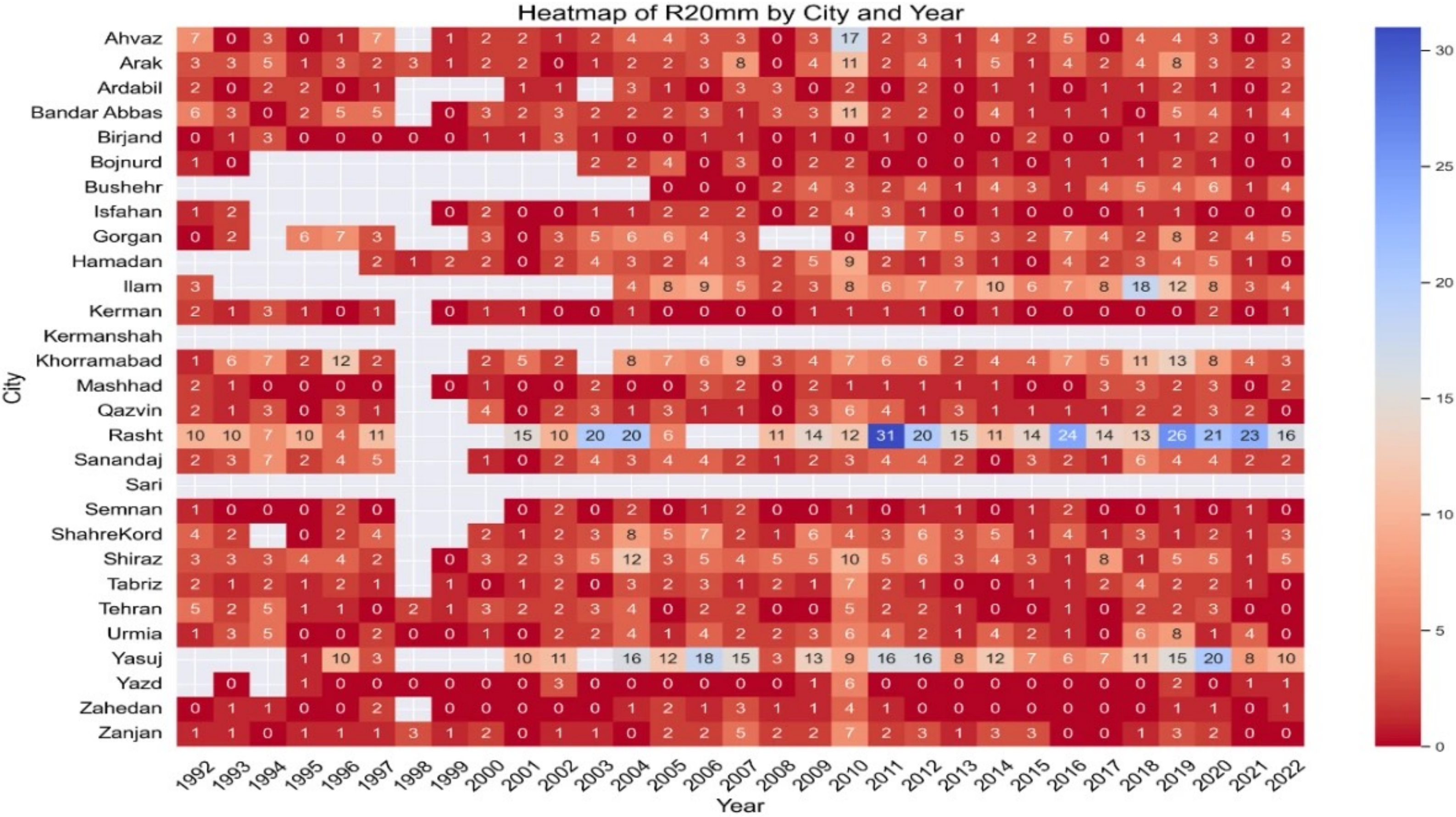
Key Factors Influencing Patterns

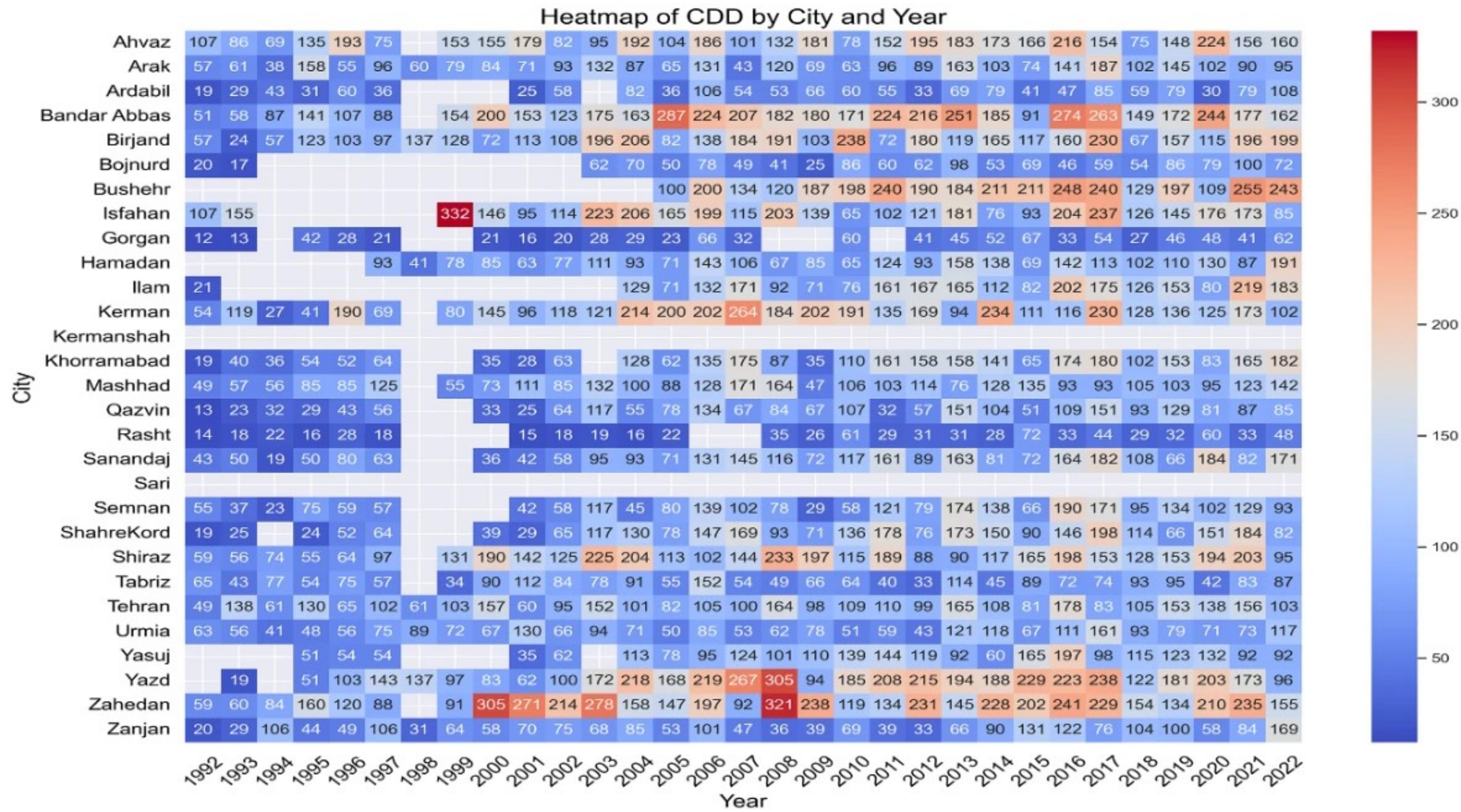
Geography: Iran's location between arid desert areas and the humid Mediterranean, coupled with its dominant mountain ranges (Alborz and Zagros) and high plateau, creates significant climatic diversity.

Continental Influence: The climate is largely continental, leading to significant differences between summer and winter temperatures.

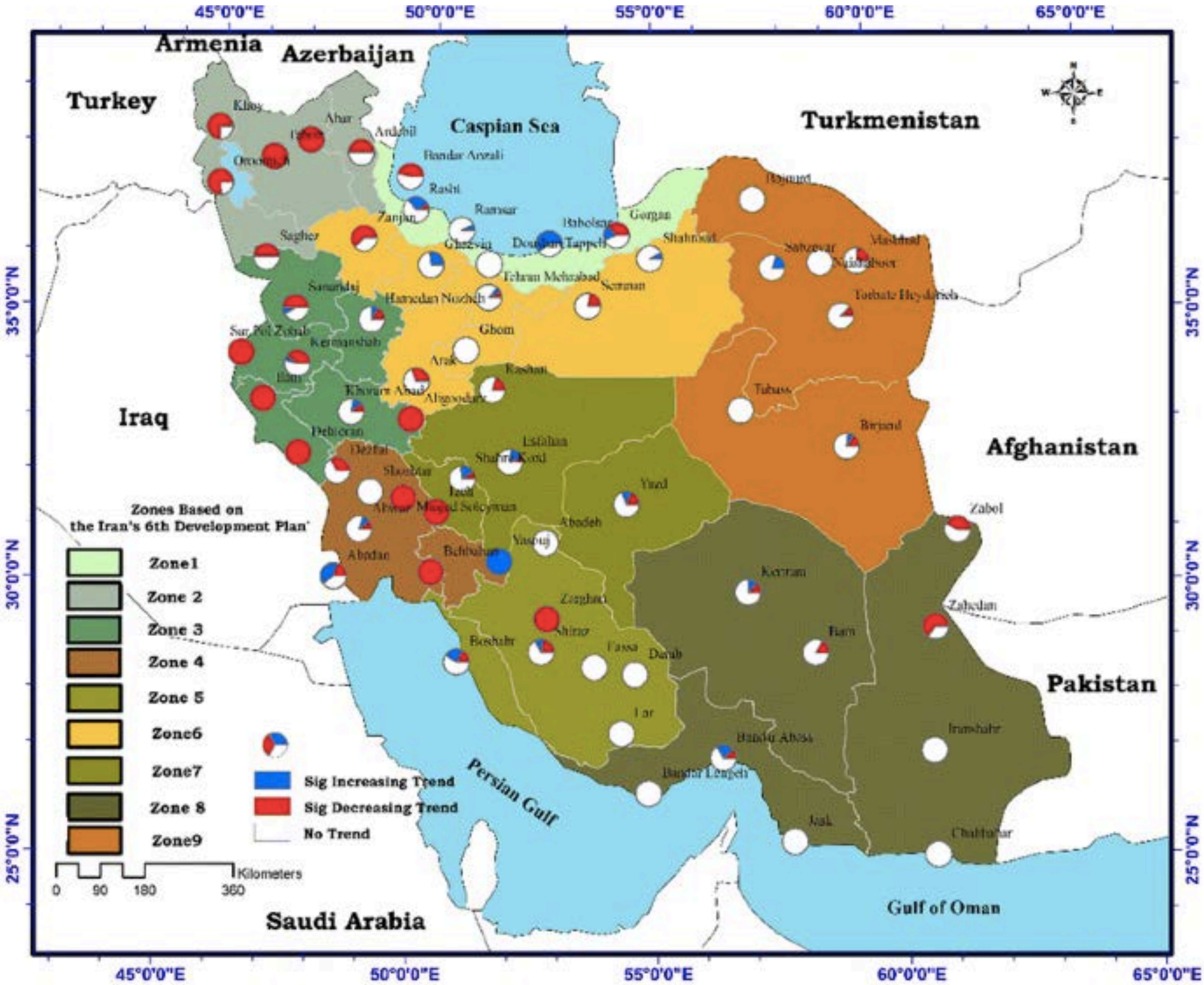
Average temperatures have risen, with maximum temperatures projected to increase by up to 5°C by the end of the century.

XVI. Iran - Heatmap by City and Year





XVII. Climate Change Impacts



Climate change has severely impacted Iran, primarily through increased temperatures and decreased precipitation, leading to widespread water scarcity, droughts, desertification, and floods. These changes threaten the country's environment, economy, and social stability, specifically:

Increased temperatures: Average temperatures have risen, with maximum temperatures projected to increase by up to 5°C by the end of the century.

Water scarcity and drought: Climate change has led to increased water scarcity and severe droughts, which affect agriculture and water resources.

Extreme weather: The country is experiencing more frequent and intense heatwaves, flash floods, and sand and dust storms.

Sea level change: While the Caspian Sea has been shrinking, the southern coast is expected to see a rise in sea level.

Environmental impacts

Drought and climate change have worsened environmental conditions in Iran, leading to widespread water shortages, land degradation, and increased dust storms across the country. Decades of mismanagement, including excessive dam construction and inefficient agricultural practices, have depleted surface and groundwater reserves, exacerbating the impact of low rainfall and rising temperatures.

Consequences for water resources and land

Water scarcity: After five consecutive years of drought and mismanagement, Iran's water resources are rapidly depleting.

Reservoirs are at critical levels: In early 2025, Tehran's five main reservoirs held only about 13% of their capacity, with the vital Lar Dam near empty. Inflow to dam reservoirs nationwide was down 28% compared to the previous year.

Groundwater depletion: Iran has one of the highest rates of groundwater depletion globally, having lost an estimated 70% of its reserves over the past five decades. This is largely due to over-extraction by thousands of illegal wells.

Vanishing water bodies: Iconic rivers and lakes have dried up, often revealing cracked, parched beds.

Lake Urmia: Once the Middle East's largest saltwater lake, it has largely collapsed into a salt desert. The exposed salt flats threaten to unleash massive salt storms across northwestern Iran.

Zayandeh Rud River: A lifeline for the city of Isfahan, the river has frequently run dry, contributing to water rationing and extensive damage to agriculture.

Land degradation: The over-extraction of groundwater has caused widespread land subsidence, with cities like Tehran and Isfahan sinking at alarming rates.

Desertification and soil salinisation: Declining rainfall and loss of vegetation cover have accelerated desertification. As water bodies dry and groundwater is depleted, soil salinisation intensifies, damaging agricultural productivity and rendering once-fertile land unusable.

Impact on air quality

Dust and salt storms: The combination of prolonged drought, degrading soil, and dry lakebeds has led to more frequent and intense dust and salt storms.

Health and infrastructure risks: These storms spread dust and corrosive salt particles, exacerbating respiratory and cardiovascular illnesses. In Khuzestan, the dust problem has caused hospitalisations and strained infrastructure.

Air pollution: Many Iranian cities, including Tehran, rank among the world's most polluted due to vehicle emissions and the burning of low-quality mazut fuel. In winter, atmospheric inversion layers trap this pollution, creating dangerous smog.

Social and health impacts

Drought in Iran has severe social and health impacts, primarily by depleting water resources and damaging the agricultural sector. The consequences disproportionately affect low-income, rural, and agricultural communities, leading to forced migration, increased social stress, and a range of physical and mental health issues.

Social impacts

Forced migration: As rural agricultural livelihoods disappear, many people are forced to leave their villages for urban areas or city outskirts in search of work. This massive internal migration disrupts social networks, causes overcrowding, and increases the water scarcity problems in destination cities.

Reduced quality of life: The economic hardship caused by drought significantly lowers household income and purchasing power. Studies in provinces like Kerman show that this has led to a decrease in the overall well-being and life satisfaction of families.

Social conflicts: Competition for increasingly scarce water and land resources can fuel conflict within communities and between different user groups.

Breakdown of community and family: The stress from financial problems and resource scarcity leads to increased tension and conflict within families. Some studies report reduced marital relations and social isolation, with individuals withdrawing from community activities due to shame or lack of resources.

Exacerbated gender inequality: Women often bear an increased burden during droughts, as they are tasked with the difficult and time-consuming work of collecting water from distant or unsafe sources. Drought also increases their workload in the agricultural sector and intensifies economic insecurity.

Decreased social security: The poverty and desperation caused by drought can contribute to social harm, including increased theft and substance abuse, which participants in some studies link to nervousness and despair over water scarcity.

Health impacts

Waterborne diseases: The reduced availability of clean water, combined with contaminated water sources, increases the risk of waterborne illnesses such as cholera and dysentery.

Malnutrition and food insecurity: Drought-induced crop and livestock losses cause food shortages and raise food prices, leading to food insecurity and malnutrition, especially among children and vulnerable populations.

Airborne and respiratory diseases: Dry soil and desertification contribute to increased dust waves and sandstorms. These lead to respiratory problems and other health issues in affected areas.

Mental health issues: The profound stress, anxiety, and hopelessness resulting from livelihood loss, economic hardship, and future uncertainty have led to increased mental distress. Some reports also link severe long-term drought to increased drug abuse and, in some cases, suicide.

Physical health problems: The strenuous manual labor of fetching water and coping with poor living conditions can lead to physical ailments. Participants in one study reported back pain, hand pain, and even uterine prolapse from repeatedly carrying heavy water containers.

Reduced access to healthcare: Families experiencing poverty from drought often lack the funds to seek proper medical care, delaying or forgoing treatment for chronic illnesses.

Impact and costs of Iran's desertification and water crisis

The exacerbating problem of desertification, fuelled by climate change, unsustainable agricultural practices, and mismanagement of water resources has led to widespread environmental degradation and significant socio-economic impacts across the country.

Environmental effects

Drying Rivers and Lakes: Iconic water bodies like the Zayandeh Rud and Lake Urmia have significantly shrunk or even dried up for much of the year, impacting ecosystems and biodiversity. Lake Urmia, once the Middle East's largest saltwater lake, has shrunk by over 80%.

Declining Groundwater Levels: Over-extraction, largely driven by agricultural needs, has led to a significant decrease in groundwater levels and aquifer depletion. Iran is estimated to lose 5 billion cubic meters of groundwater annually due to over-extraction. Over the past 50 years, Iran has depleted around 70% of its groundwater reserves.

Land Subsidence: The depletion of groundwater has resulted in land subsidence in various regions, including Tehran, which is subsiding at a rate of up to 25 cm per year. Cities like Isfahan, Khashan, and Yazd are also experiencing land subsidence, posing a risk to infrastructure.

Salinisation: Overexploitation of groundwater has led to salinisation of soil and freshwater aquifers, reducing soil fertility and rendering land unproductive. Around 50% of irrigated land in Iran is affected by salinity.

Desertification and Dust Storms: Drying lake beds and wetlands, combined with soil erosion and land degradation, have intensified desertification and resulted in more frequent and severe dust storms, particularly impacting areas like Khuzestan and Sistan-Baluchestan.

Water Quality Degradation: Untreated industrial and municipal wastewater, along with agricultural runoff, contribute to the pollution of surface and groundwater resources, impacting water quality and potentially posing health risks.

Socio-economic effects and costs

Agricultural Damage: The agriculture sector, a significant source of employment and GDP, has been severely affected by water shortages, leading to reduced crop yields, livestock losses, and declining agricultural productivity. The estimated annual economic losses due to desertification in Iran are around US $1 billion.

Rural-to-Urban Migration: Water scarcity and the collapse of agricultural livelihoods in rural areas have triggered widespread migration to urban centres, particularly from provinces like Khuzestan, Sistan-Baluchestan, and Isfahan. It is estimated that more than 70% of Iran's villages are at risk of being abandoned due to drought and water scarcity. Between 2002 and 2017, over 12,000 villages were completely deserted.

Strain on Urban Infrastructure and Services: The influx of migrants has put immense pressure on urban areas, exacerbating existing problems like housing shortages, air pollution, and traffic congestion, and straining access to essential services like clean water and sanitation.

Social and Political Tensions: Water shortages and the perception of inequitable water distribution have led to social unrest and protests in various regions, fuelling ethnic tensions and distrust, according to the University of Exeter.

Impact on Human Health: Dust storms and contaminated water can worsen respiratory problems and pose other health risks to the population. Air pollution is a serious concern, with over 40,000 deaths annually attributed to it in Tehran alone.

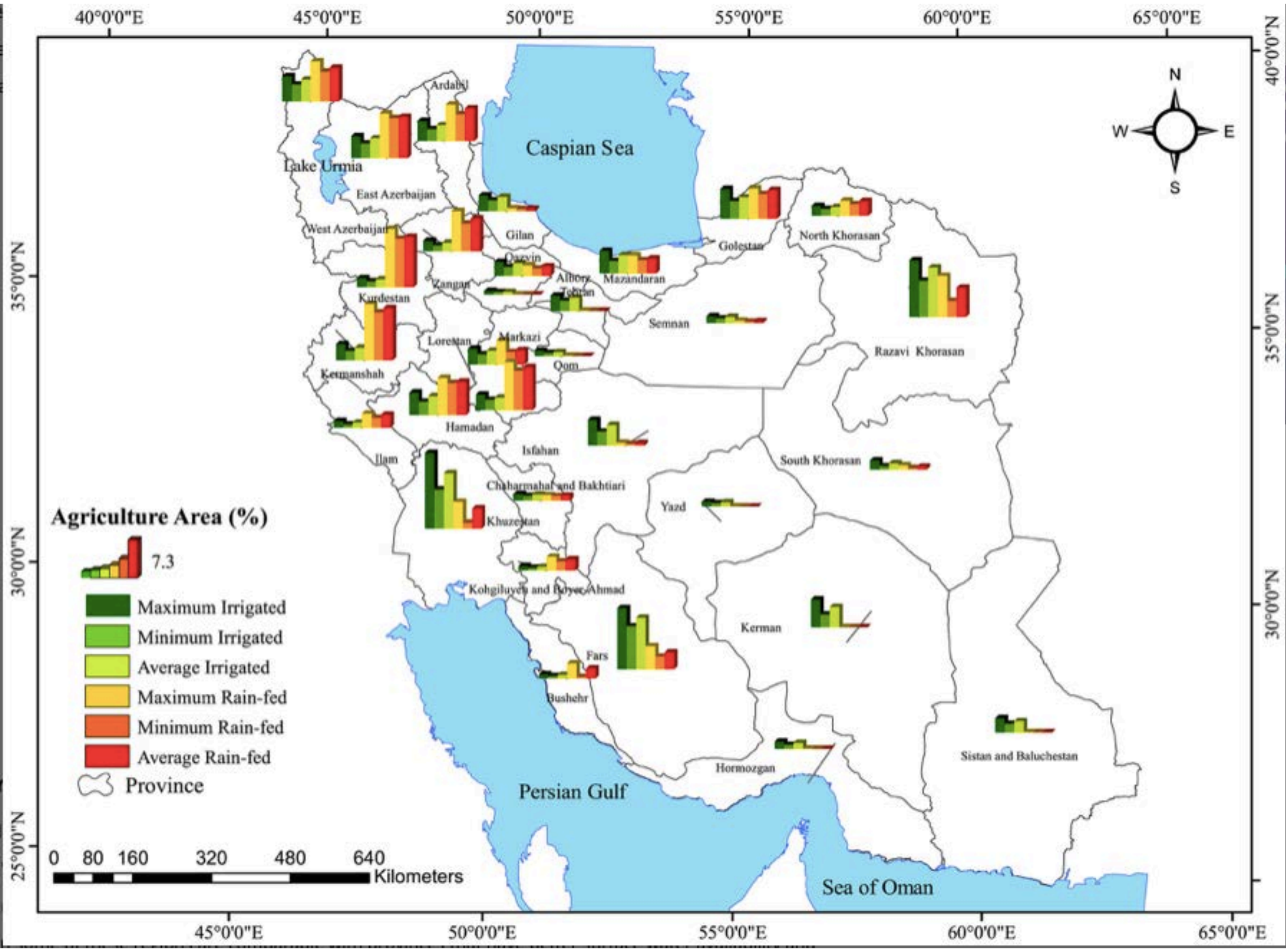
Economic Losses and Costs: Beyond the direct impact on agriculture, the water crisis poses broader economic consequences, including potential revenue losses for the government, increased unemployment, credit risk for financial institutions, and potentially hindering the development of other sectors like industry and energy. Implementing sustainable water management solutions, such as artificial recharge and spate irrigation, would come with significant upfront costs, according to the Atlantic Council.

Energy Sector Impacts: Water shortages directly impact energy production, particularly hydropower, potentially leading to electricity shortages and exacerbating social tensions.

In summary, Iran's desertification and water crisis represent a complex challenge with far-reaching environmental and socio-economic consequences.

The impacts include environmental degradation, agricultural losses, mass migration, social unrest, and significant economic costs, demanding urgent and comprehensive interventions to ensure the country's long-term sustainability and stability.

XVIII. Economic impact on the Agricultural Sector



The agriculture sector, which is the largest consumer of water, is hit hardest by drought.

The ongoing drought in Iran poses significant economic challenges to the agricultural sector, impacting production, employment, and food security. The situation is exacerbated by excessive water consumption, especially in agriculture, and water resource mismanagement.

Key impacts

Production Decline and Costs:

- Agricultural production, particularly wheat, has significantly decreased, leading to higher food prices.

- One study suggests that a severe drought, similar to the one in 1999-2000, could impose a direct cost of $1.605 billion USD, representing 30.3% of the cropping sector's total value added.
- Such a drought could reduce overall GDP by approximately 4.4% and lead to decreased non-oil exports, increased food imports, and higher inflation.
- The government's guaranteed wheat purchases have decreased by 35% compared to the previous year due to reduced production.
- Drought has affected 150,000 hectares of agricultural land in Sistan and Baluchestan province alone.

Employment and Livelihoods:

- Reduced agricultural productivity directly impacts farmers' income and can lead to job losses in rural areas.
- This hardship can lead to migration from rural areas to already strained urban areas.

Water Management and Practices:

- Agriculture accounts for 80-90% of Iran's water consumption, often using traditional, inefficient irrigation methods.
- Over-extraction of groundwater for farming has resulted in severe land subsidence and sinkholes in cities and agricultural areas.
- Despite declining water availability, irrigated agricultural production and area increased between 1981-2013, indicating unsustainable development through over-abstraction of water resources.
- Iran has lost approximately 211 ± 34 BCM of its total water storage over the past two decades.

Government Response and Policy:

- The Iranian government has expanded grain imports to address production shortfalls.
- Import needs are expected to rise to approximately 4.5 million tons in the current year.
- There are calls to reform water management policies and agricultural practices to mitigate the impacts of drought.

Market data

Agricultural sector outlook

- The Iranian agricultural market reached $70 billion USD in 2025 and is projected to reach $82 billion USD by 2030, growing at a 3.21% CAGR.
- Cereals and grains held the largest market share at 41.20% in 2024, supported by government price guarantees and subsidies.
- Fruits and vegetables are the fastest-growing segment, with a projected CAGR of 5.70% through 2030.
- Aquifer depletion and reservoir shortages are estimated to exert a -1.2% drag on the market's CAGR, forcing shifts in cropping patterns and irrigation methods.
- Iran is increasing exports of fruits and vegetables to Persian Gulf states, generating significant revenue. This strategy is supported by government subsidies on water, fertilisers, and energy, but contributes to the country's water crisis.

XIX. Persian Qanat System

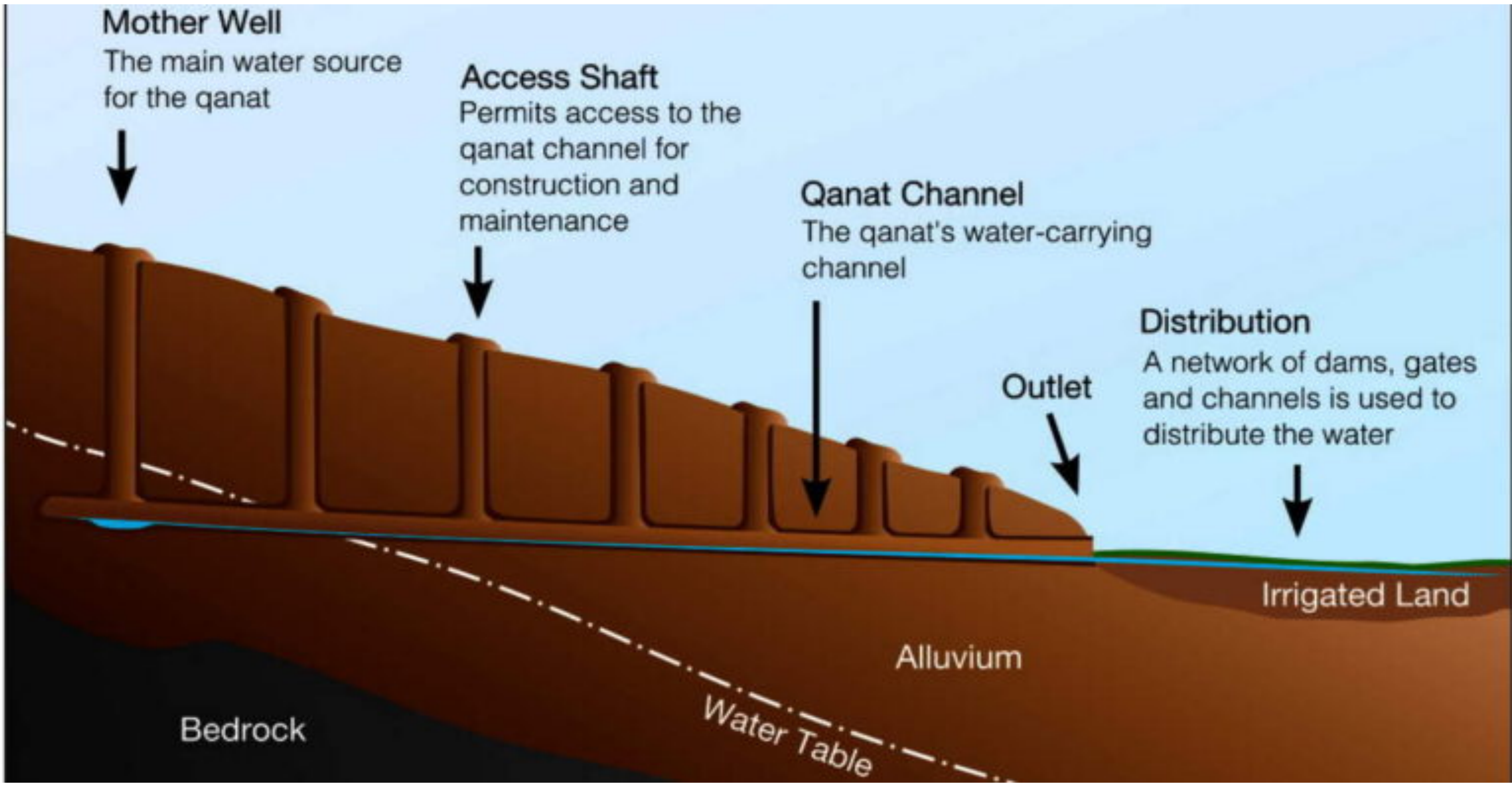
In the arid regions of Iran, where water is scarce and precious, lies a remarkable ancient invention that has sustained civilisations for millennia: the Persian Qanat. This ingenious underground water management system not only provided communities with a reliable source of water for drinking, irrigation, and agriculture but also shaped the landscape and cultural heritage of the region.

Dating back over 3,000 years, the Persian Qanat is a testament to human ingenuity and engineering prowess. Consisting of a series of underground tunnels, shafts, and channels, the qanat system taps into groundwater sources located at higher elevations and transports water through gravity to lower-lying areas, where it is accessed through surface wells or underground reservoirs.

Several cities in Iran are renowned for their ancient qanat systems, which have been designated as UNESCO World Heritage Sites. Cities such as Yazd, Kashan, and Gonabad boast well-preserved Qanats that not only serve as functional water sources but also offer unique tourist attractions. Visitors can explore underground qanat tunnels, visit historic qanat monuments, and learn about the cultural significance of these water management systems.

This traditional water management system is found throughout Iran. The system was crucial for agricultural and urban development in Iran and other parts of the world.

Qanat Key features



Core components of a Qanat

Mother well: This initial, and often deepest, vertical shaft is dug into an alluvial fan until it penetrates the water table and reaches the primary groundwater source.

Qanat channel (Gallery): This is the gently sloping, underground tunnel that is hand-dug from the mother well down to the surface outlet, allowing water to flow via gravity.

Vertical access shafts: Bored at regular intervals along the qanat channel, these serve multiple purposes, including providing ventilation for workers during construction and maintenance, and allowing for the removal of excavated soil.

Outlet (Mazhar): This is the point where the underground tunnel finally reaches the surface, releasing the water for use by the community.

Key Qanat engineering features

Precision slope: The underground channel requires a carefully calculated gradient—gentle enough to prevent erosion from high-speed water flow, but steep enough for the water to travel continuously by gravity.

Gravity-fed: The entire system operates without the need for mechanical pumps or energy, relying solely on gravity to move water over long distances.

Reduced water loss: By keeping the water underground, the qanat system prevents significant water loss from evaporation, a major concern in hot, arid regions.

Practical and social benefits

Reliable and sustained water supply: Qanats tap into stable groundwater sources, providing a continuous flow of fresh water that is less susceptible to seasonal and year-to-year rainfall variations than surface water.

Resilience: The underground system is resistant to damage from natural disasters like floods and earthquakes, and is protected from wartime destruction.

Foundation for settlement: The reliable water source from Qanats has been critical for the development of permanent settlements and agriculture in desert areas for thousands of years.

Community management: The construction and maintenance of Qanats encouraged social collaboration and the creation of traditional water management systems to ensure equitable water sharing.

Architectural applications: Beyond water supply, Qanats have been integrated with other structures for cooling and refrigeration. For example, some homes and cisterns use airflow from a qanat in conjunction with wind-catchers (badgirs) to provide a form of natural air conditioning.

Associated structures

Badgir (Wind-catchers)

A wind-catcher or 'Badgir' in the Persian language is the traditional and ancestral feature of Persian architecture. It is built as a creative system meant to create passive ventilation inside the buildings.

They consist of a tall, chimney-like structure, rising up from a corner of the roofs. It somehow looks like a small tower, but with tiny vertical openings on one or several sides. From these openings enters the wind, which is directed downward to refresh the interior of the house. With the pressure difference inside the column, the hot airflow naturally goes up, while the cold one gets down.

Nowadays, Badgirs are one of the most famous and picturesque features of Persian cities. They can be found in many places in Iran, particularly in the cities close to the central deserts and all along the Persian Gulf. Yazd counts an incredible number of beautiful Badgirs, that's why it is known as "The city of Wind-catchers”. It's also in its Unesco-listed garden, Dowlat Abad which stands as the tallest Badgir in the world, up to 34 meters

How Badgirs work

Badgirs work in a few ways: The first and most common is to cool the inside of a building. The tower has openings that are facing the wind and trap it inside creating a nice breeze inside the building, much like the way you feel in a wind tunnel between skyscrapers. When used with the qanat, the air is pulled down, reaches the water and is drawn up the Badgir to be dispersed in the building.

It traps the itinerant wind to bring fresh air to the living rooms of houses in dry climate regions of the Iranian plateau. This high adobe-brick tower has vents at the top up to eight and mostly chill the space cooperating with stored water built beneath it.

When there is no wind, the Badgirs are like a chimney, letting the hot air rise and escape. When the hot air can rise, flow is created and it escapes out of the chimney.

Various Badgir designs

Uni-directional

If wind tends to blow from one side only, then it will be built with one downwind opening, without openings in any other directions.

Bi-directional

These Badgir tend to be more efficient for airflow circulation and have better performance. They serve two functions – to blow and suck air into a building.

Multi-directional

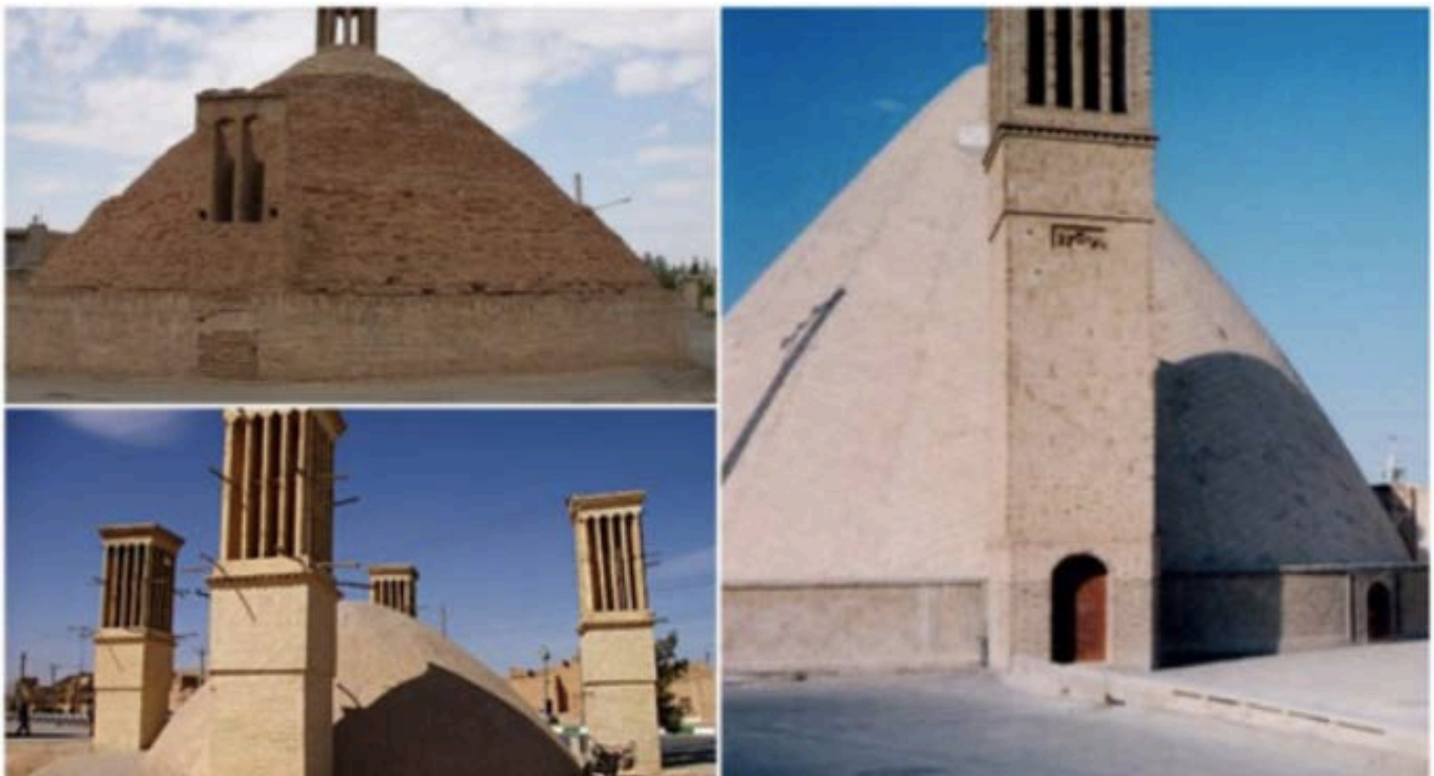
These tend to be either four, six or eight-sided Badgirs, and are bigger and taller than the two types above. The exact height and structure of each opening depend upon the specific region's climate.

Extraordinary Engineering

This extraordinary engineering system still inspires architects today, as it's a perfect example of a remarkable and environmentally friendly cooling system. Studies have shown that Badgir can reduce the indoor temperature by around 10 degrees.

That's why in ancient Persia, they were always built upon water reservoir and 'Yakhchal', an ancient ice storage room, which is the forefather of our modern fridge. Badgir would allow people to keep freshwater, meats and sometimes food, during the hot months of summer in the absence of a fridge in the past.

Ab Anbar (Cistern)



An Ab Anbar is a type of underground water reservoir, or cistern, that is a significant feature of Iran's traditional architecture and water management systems, particularly in arid regions. These structures collect and store rainwater and water from Qanats (underground channels) to provide a vital water supply for urban residents and travellers, especially during hot, dry seasons. Ab Anbars often feature sophisticated engineering, including thick, water-resistant walls, specialised mortar, cooling systems, and wind-catchers for natural ventilation.

Purpose and Function

Water Storage: Their primary purpose is to store water from seasonal rainfall or Qanat systems, ensuring a consistent supply when other sources diminish.

Survival in Arid Climates: Ab Anbars are crucial for the survival and prosperity of settlements in desert and semi-arid regions where water is scarce.

Public and Private Use: They served communities, with many built by vaqfs (religious endowments) for public use within towns and on trade routes, while private homes might also have their own cisterns.

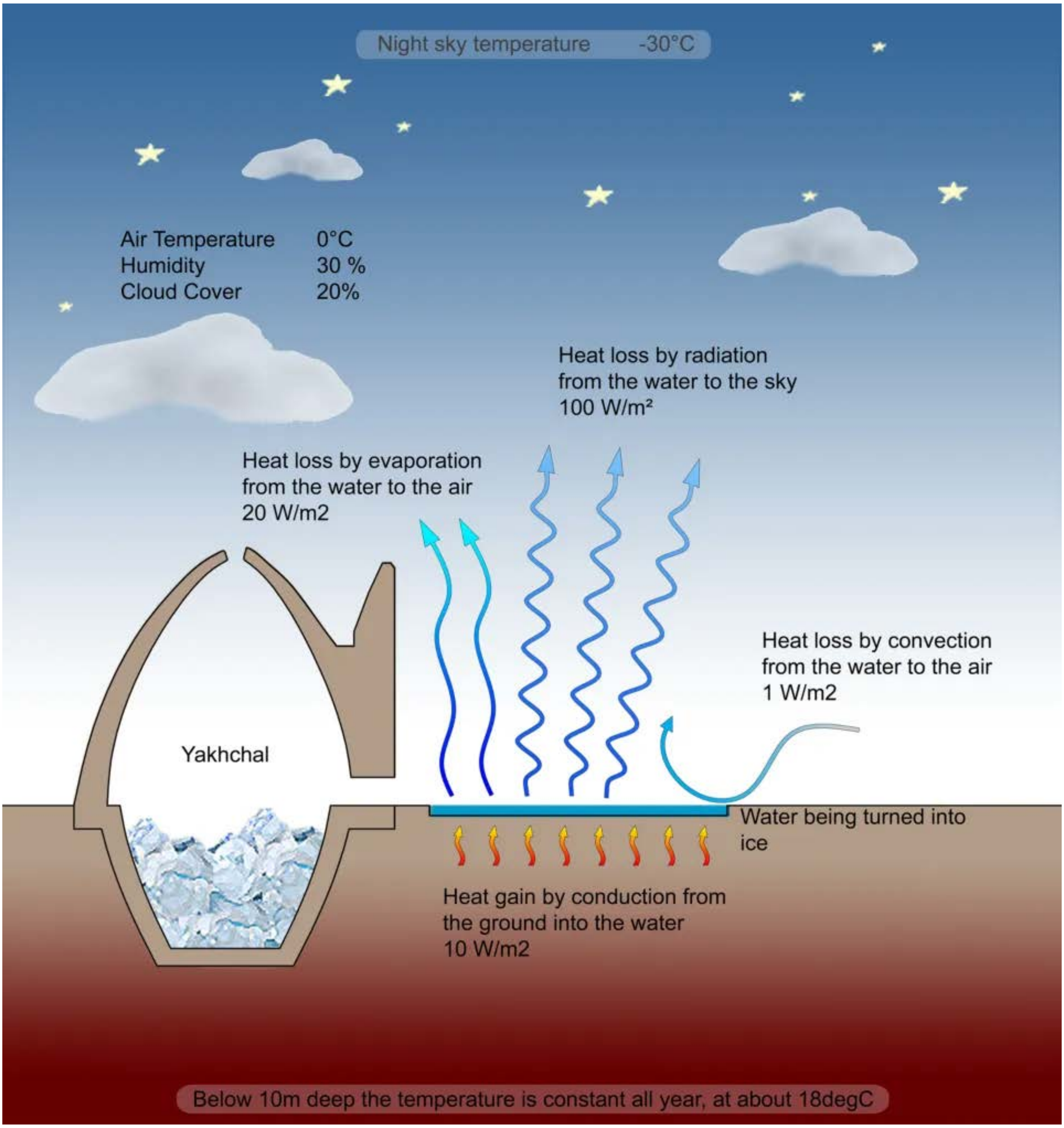
Ice Houses (Yakhchals)

Yakhchāls are ancient Iranian ice houses built to store ice for year-round use in hot, arid climates. These structures used a combination of clever design and construction, often featuring a domed roof and thick, insulating walls made of a special mortar called sarooj, to store ice harvested from winter freezing or nearby mountains. The buildings also served to create ice through evaporative cooling and to store food.

How they work

Ice production: Shallow ponds were filled with water overnight from a qanat (underground canal). A tall "shade wall" shielded the ponds from the sun during the day, and a phenomenon called radiant sky cooling allowed the water to freeze efficiently at night.

Ice harvesting and storage: Once ice was harvested in winter, it was transported to the yakhchāl's subterranean storage chamber. The ice was stored in layers, separated by straw for insulation.



Preservation: The yakhchāl's design, including its thick, heat-resistant walls and conical shape, maintained low internal temperatures, preserving the ice for use in the summer. The dome's shape helped the hottest air rise to the top, where it could escape, while the coolest air stayed at the bottom with the ice.

Insulation:

Walls: The walls were made from a unique, water-resistant mortar called sarooj, which was a mix of sand, clay, lime, goat hair, egg whites, and ash.

Dome: The dome-shaped roof helped the hottest air rise and escape. Some yakhchāls had a small aperture at the top, covered by a piece of marble that allowed light in but blocked the escape of cool air.

Watermills

Qanat watermills in Iran are systems that combine an ancient underground aqueduct (qanat) with watermills to harness water power for grinding grain. The Qanat system uses gravity to channel water from an underground source through a tunnel, and the falling water then turns a watermill wheel to perform work. Examples like the Rigareh Underground Water Mill in Nain show how this ingenious technology provided both irrigation and power in arid regions for centuries.

How Qanat watermills work

Water source: A "mother well" is dug to a sufficient depth to tap into an underground aquifer.

Underground aqueduct (Qanat): A gently sloping tunnel is dug from the mother well, using gravity to move water along the tunnel to the surface.

Watermill: The qanat tunnel is directed to an elevated point above a watermill. The water is released from the tunnel to turn the mill's wheel.

Power generation: The turning watermill can then be used to grind grain or perform other mechanical tasks.

Significance of the system

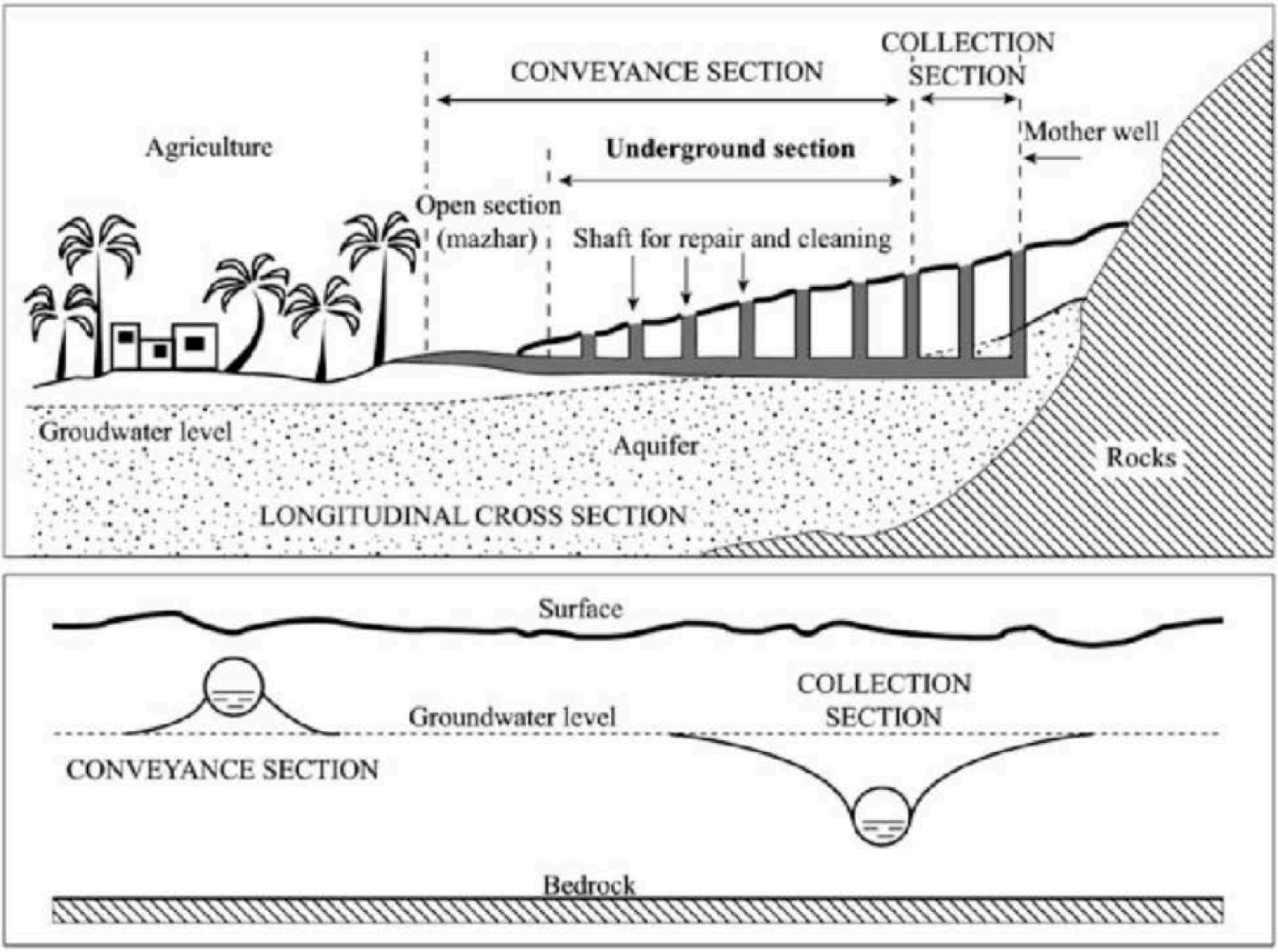
- **Ancient technology**: The qanat system is an ancient Iranian invention dating back to the Iron Age, and it allowed agriculture and cities to flourish in desert environments.

- **Sustainable power:** These watermills are a form of renewable energy, relying entirely on gravity and water flow, with no need for fossil fuels or external power sources.

- **Cultural heritage:** Many qanat watermills are considered important cultural and historical sites, demonstrating the ingenuity of past engineers and societies.

- **Wide application:** The qanat technology spread from Iran to other arid regions, and watermills are found in various locations, including the Rigareh mill in Nain.

Qanat Key Architectural and Engineering Features



- **Underground Construction:** Most are built underground to withstand water pressure and provide stability against earthquakes.

- **Construction Materials:** They are built with durable materials, including special, tough bricks (Ajor Ab anbari) and a strong, waterproof mortar called sarooj.

- **Cooling and Ventilation:** Sophisticated ventilation systems, often using wind-catchers (badgirs), are used to bring in cool air and circulate it within the reservoir, keeping the water fresh and cool.

- **Stairways and Entrances:** Complex staircases lead down into the reservoirs, often featuring a distinctive arched entrance known as a sardar.

- **Water Delivery:** Water was delivered via special channels from the water source and controlled by sluice gates, with faucets providing access to the stored water.

Noteworthy Qanats in Iran

- **Gonabad:** The Qasabeh Qanat is one of the oldest and largest in the world, dating back to the Achaemenid Empire (700–500 BCE). It still supplies water to nearly 40,000 people and features a well depth of over 360 meters and a length of 45 kilometers. It is one of 11 Qanats in Iran designated as a UNESCO World Heritage Site.

- **Yazd:** Yazd is known for its extensive qanat system, which is still in use today. The longest qanat in the world, the Zarch Qanat, is in Yazd province, stretching for 80 km.

- **Isfahan:** Isfahan province features unique qanats, including the double-decked Moun Qanat and the Vazvan Qanat, which uses an underground dam.

- **Kerman:** The region around Kerman is also known for its dependence on an extensive Qanat system. The Qanat of Gowhar-riz is also a UNESCO site.

- **Kashan:** Archaeological research shows that Qanats in the Kashan region have supported settlements for thousands of years.

Cultural and practical significance

- **Sustainability:** Qanats are powered by gravity, requiring low operational costs. When properly managed, they can provide a reliable water source indefinitely.

- **Agriculture:** This system enabled agriculture and settlements to thrive in Iran's arid climate by providing a consistent water supply for irrigation.

- **Cooling and storage:** Qanats were also used in conjunction with wind towers to provide air conditioning and to help store ice in yakhchals (ice pits) during the summer

Water crisis impact on Qanats

The Iranian water crisis significantly harms Qanats by reducing their water flow as groundwater tables decline, a problem worsened by over-extraction through deep wells, causing Qanats to dry up. This leads to a high cost for rural communities who rely on these ancient systems, as they must now bear the expense of maintaining the now ineffective Qanats and may face water scarcity despite past water abundance. While Qanats themselves are a low-cost, sustainable, gravity-fed system, the ongoing water crisis elevates the cost for communities through potential loss of their traditional water source and the need for expensive modern alternatives, with some areas experiencing further costs due to land subsidence.

Depletion and abandonment

Declining water tables: Decades of excessive groundwater extraction through deep and semi-deep wells have lowered water tables, cutting off the water sources that feed shallower Qanats. Annual groundwater withdrawal by Qanats reportedly decreased by 50% between 2006 and 2011.

Reduced Water Flow: As the groundwater table drops, the gravity-powered flow of water in the Qanats diminishes, making the system less effective and potentially unusable for agriculture and other needs.

Climate change and drought: Long-term drought and climate change exacerbate the effects of over-extraction, with many Qanats in arid regions like southern and northern Khorasan running dry.

Physical collapse: As the water table falls and the soil dries out, the ground can subside, causing ancient qanat shafts and tunnels to lose their structural integrity and collapse. For instance, a study of the Mashhad plain found that only 5.59% of Qanat shafts from 1961 were still intact in 2021.

Cost of the crisis on Qanats

Restoration costs

High and unaffordable maintenance: While Qanats have relatively low operational costs, repairs are expensive and difficult to organise among their multiple owners. In Yazd province, one study showed that saving a litre per second of water flow cost US $1,187.50, an amount individual owners could not afford.

Government spending: In recent years, the Iranian government has allocated budgets for restoration efforts, such as the US $250 million earmarked for the broader Lake Urmia restoration program, which includes replacing old irrigation systems. However, this may not be sufficient for the immense scale of the problem across the country.

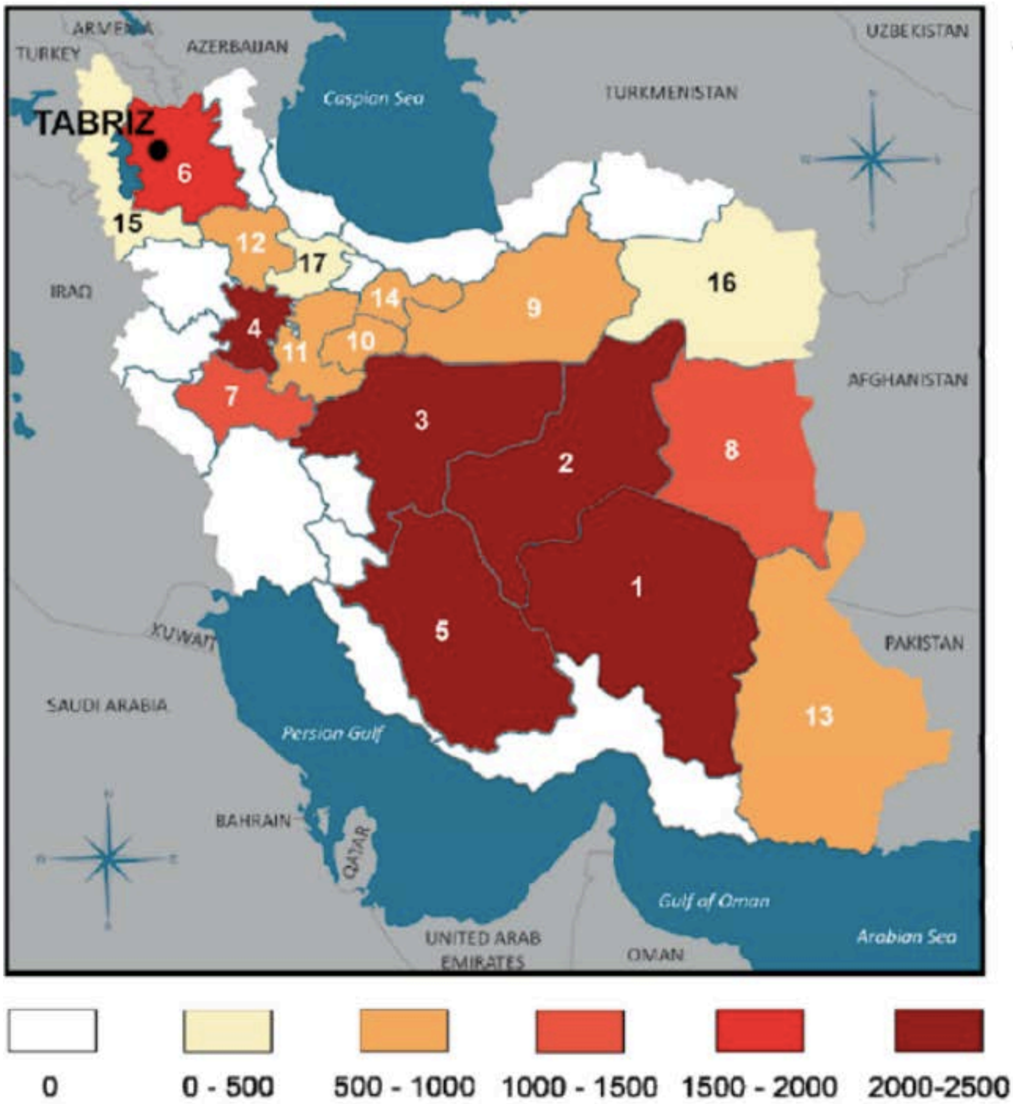
Long-term economic costs

Increased agricultural costs: The decline of the self-sustaining qanat system forces a reliance on modern, energy-intensive methods like deep wells for irrigation. These alternatives increase operational costs and dependency on external resources.

Loss of a Sustainable Resource: The traditional qanat system is a sustainable, gravity-fed method that requires no fuel and has low operational costs. The crisis effectively removes this low-cost resource, forcing reliance on less sustainable and more expensive technologies.

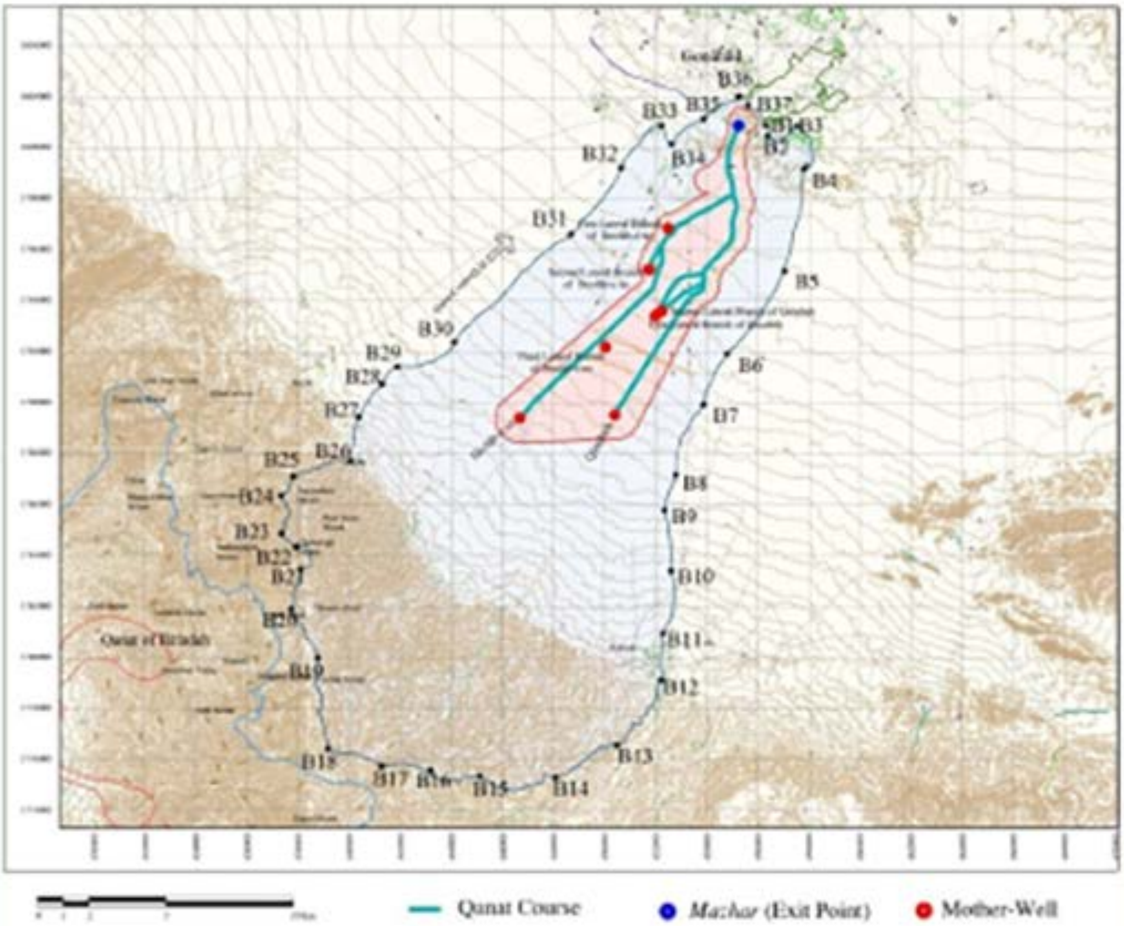
Irrecoverable damage: The over-exploitation of groundwater can cause irreversible damage to aquifers and land. Reversing these effects is either impossible or extremely expensive. This includes the high costs of dealing with land subsidence, which causes infrastructure damage.

Social and Economic Hardship: The loss of water and traditional water systems can lead to reduced agricultural productivity, crop damage, and widespread socio-economic hardship for rural communities.



No.	QANATS	REGION
1	2277	Kerman
2	2260	Yazd
3	2246	Isfahan
4	2198	Hamedan
5	2044	Fars
6	1920	East-Azerbaijan
7	1334	Lorestan
8	1131	South-Khorasan
9	857	Semnan
10	737	Qom
11	685	Markazi
12	625	Zanjan
13	547	Sistan-Baluchestan
14	536	Tehran
15	486	West-Azerbaijan
16	319	Razavi-Khorasan
17	308	Qazvin

Qasabeh Qanat
Buffer Zone



Zone	Area
Core Zone	4492 ha
Buffer Zone	25905 ha
Agricultural Demand Area	509 ha

Geographical coordinates of Buffer Zone

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Regulation

Buffer Zone of Qanat is the area specified for protecting the qanat and its water-supplying system against possible natural, environmental, cultural and landscape damages.

Its limits include the watershed (which affects feeding the water table), the hydraulic and quality boundaries of qanat as well as the waterways. Buffer zone is delineated by taking into account body, environmental, natural and landscape values.

Note: in regions where the qanat course passes through urban fabric and residential areas, 50 meters on either side of qanat axis (a total width of 100m) has been considered as the buffer zone.

1. Any activities endangering qanat life such as digging deep or semi-deep water wells, intervention in the watershed system also harming the natural, cultural-historical landscape and habitat of the region is strictly banned.

2. Construction of industrial and semi-industrial facilities as well as expansion and addition of attachments to existing structures depends on obtaining permit from ICHHTO

3. Body development of towns and villages located within the buffer zone must be based on regional programs, pilot projects as well as on detailed and master plans.

4. Gathering garbage, construction debris, wastewater, pollutants as well as industrial trash, agricultural residues and livestock droppings is forbidden.

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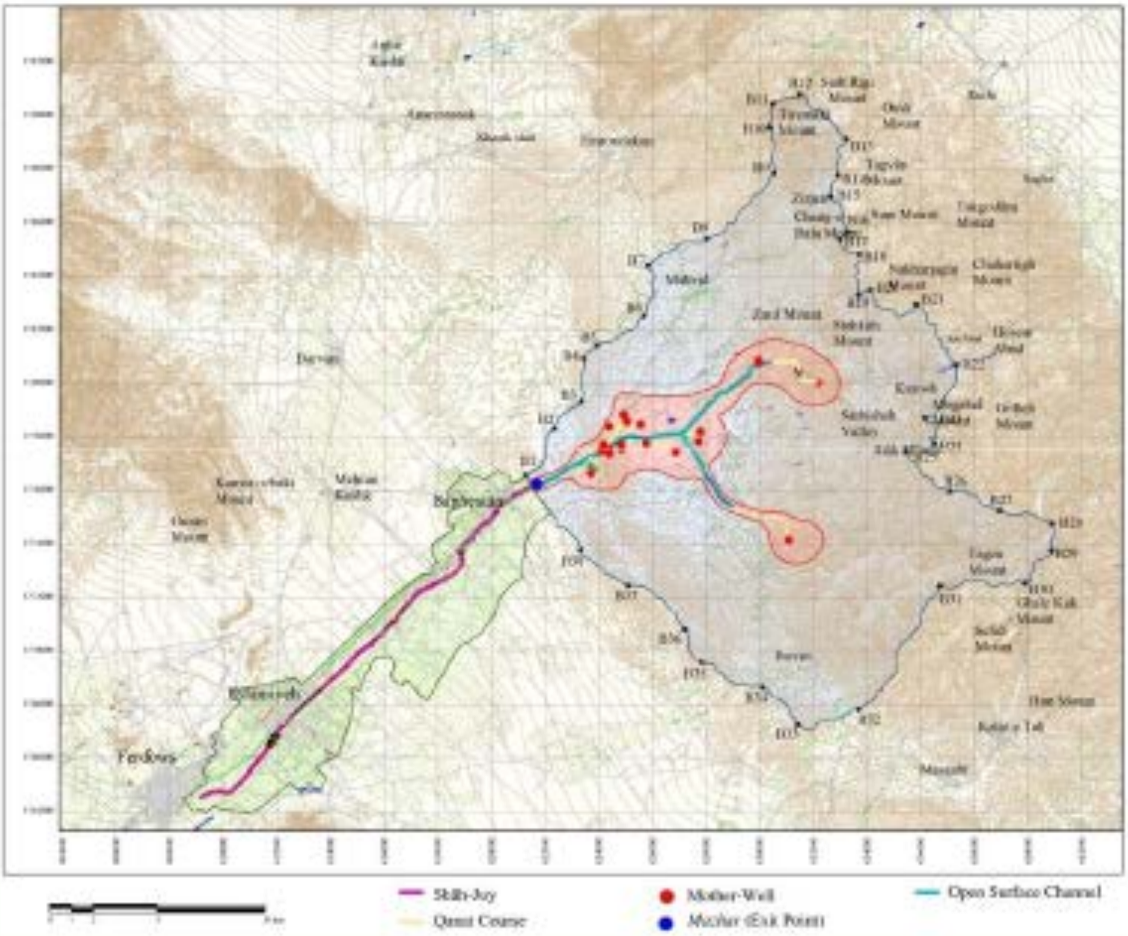
Map 1-8. Qasabeh Qanat Buffer Zone

Qanat of Baladeh
Buffer Zone



Zone		Area
Core Zone		2757 ha
Buffer Zone		19321 ha
Agricultural Demand Area		4957 ha

Geographical coordinates of Buffer Zone

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Regulation

Buffer Zone of Qanat is the area specified for protecting the qanat and its water-supplying system against possible natural, environmental, cultural and landscape damages.

Its limits include the watershed (which affects feeding the water table), the hydraulic and quality boundaries of qanat as well as the waterways. Buffer zone is delineated by taking into account body, environmental, natural and landscape values.

Note: in regions where the qanat course passes through urban fabric and residential areas, 50 meters on either side of qanat axis (a total width of 100m) has been considered as the buffer zone.

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4. Gathering garbage, construction debris, wastewater, pollutants as well as industrial trash, agricultural residues and livestock droppings is forbidden.

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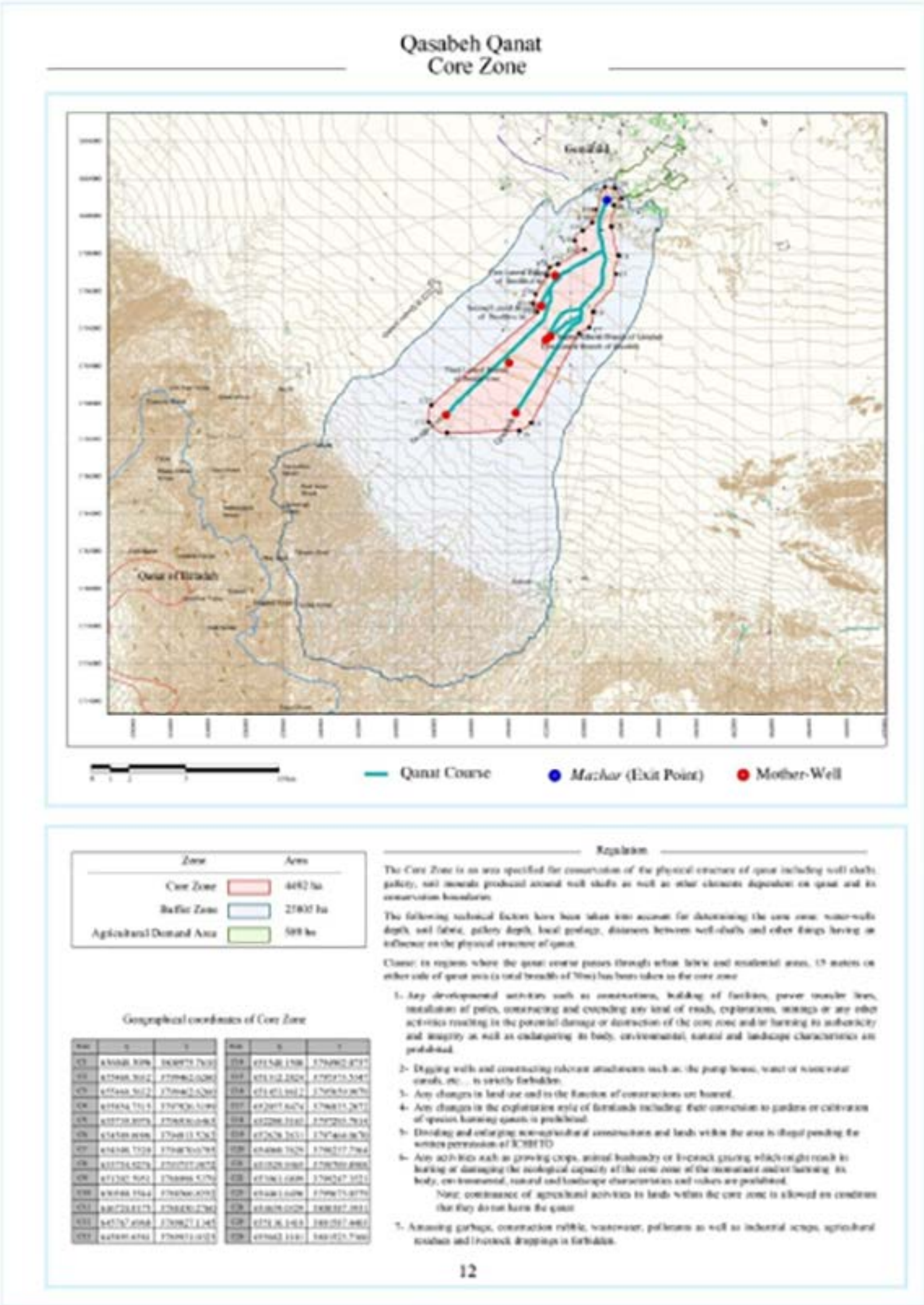
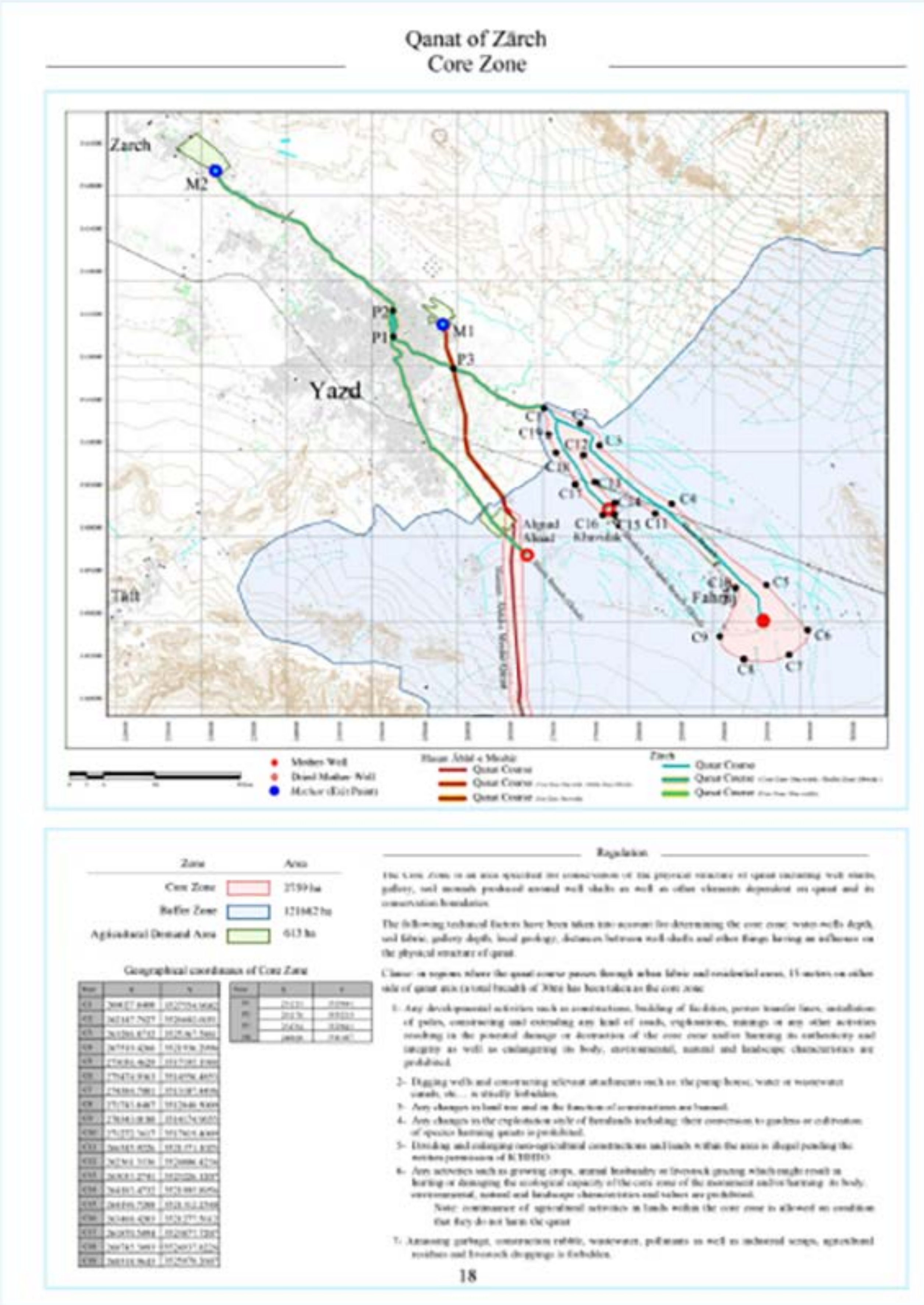
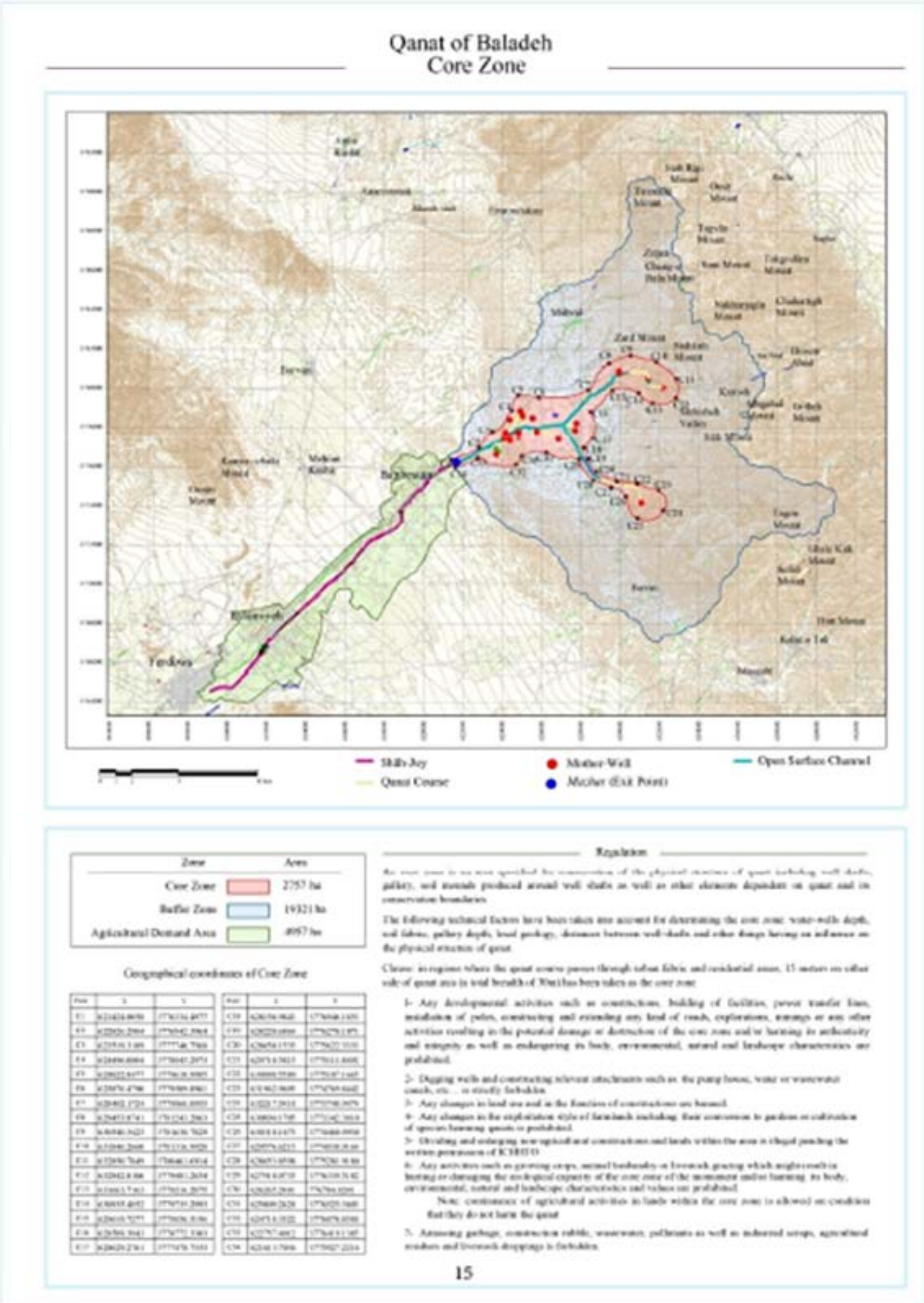
Map 1-11. Qanat of Baladeh Buffer Zone



Map 1-9. Qasabeh Qanat Core Zone

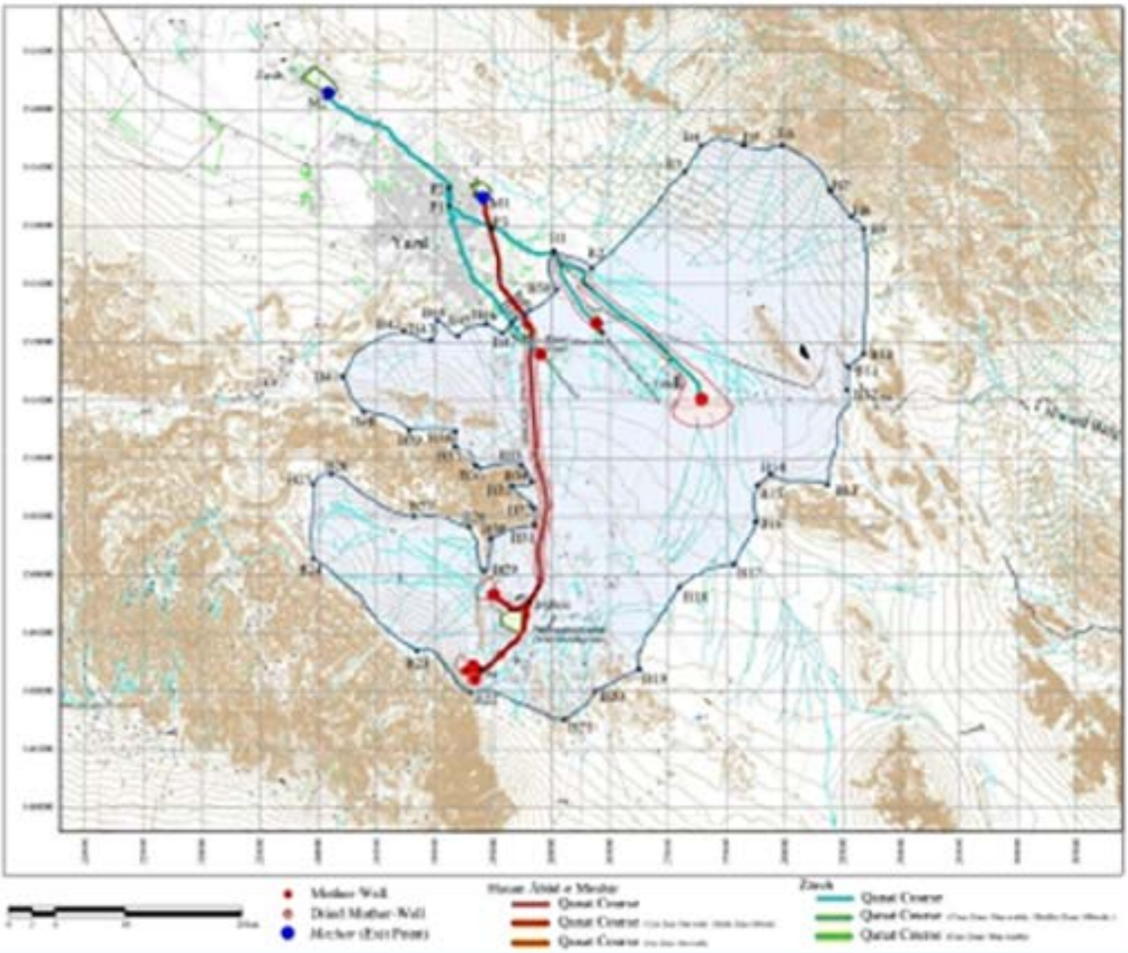


Map 1-15. Qanat of Zārch Core Zone



Map 1-12. Qanat of Baladeh Core Zone

Qanat of Zārch
Buffer Zone



Zone	Area
Core Zone	3084 ha
Buffer Zone	125162 ha
Agricultural Demand Area	344 ha

Geographical coordinates of Buffer Zone

Regulation

Buffer Zone of Qanat is the area specified for protecting the qanat and its water-supplying system against possible natural, environmental, cultural and landscape damages.

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Note: in regions where the qanat course passes through urban fabric and residential areas, 50 meters on either side of qanat axis (a total width of 100m) has been considered as the buffer zone.

1. Any activities endangering qanat life such as digging deep or semi-deep water wells, intervention in the watershed system also harming the natural, cultural-historical landscape and habitat of the region is strictly banned.

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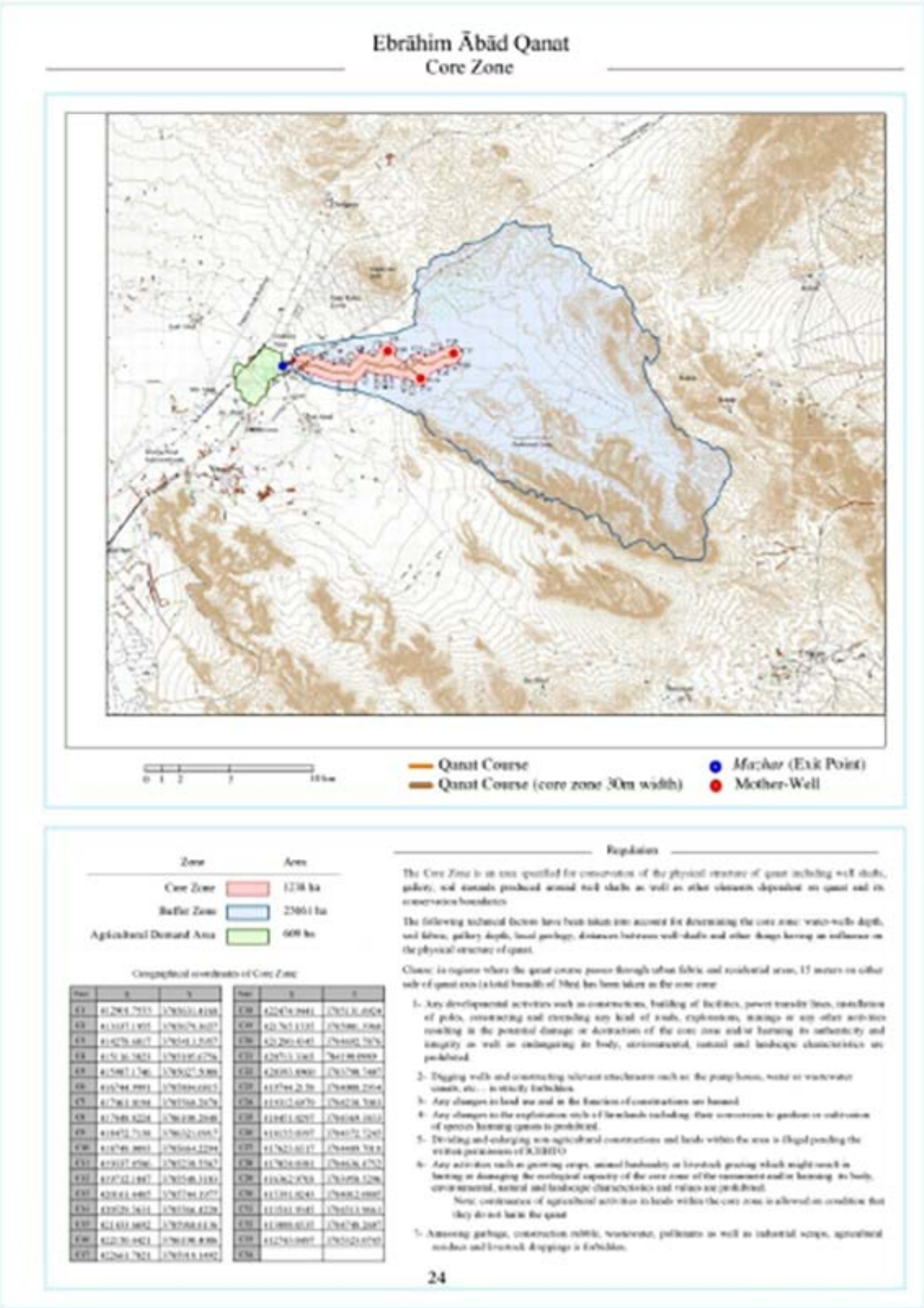
3. Body development of towns and villages located within the buffer zone must be based on regional programs, pilot projects as well as on detailed and master plans.

4. Gathering garbage, construction debris, wastewater, pollutants as well as industrial trash, agricultural residues and livestock droppings is forbidden.

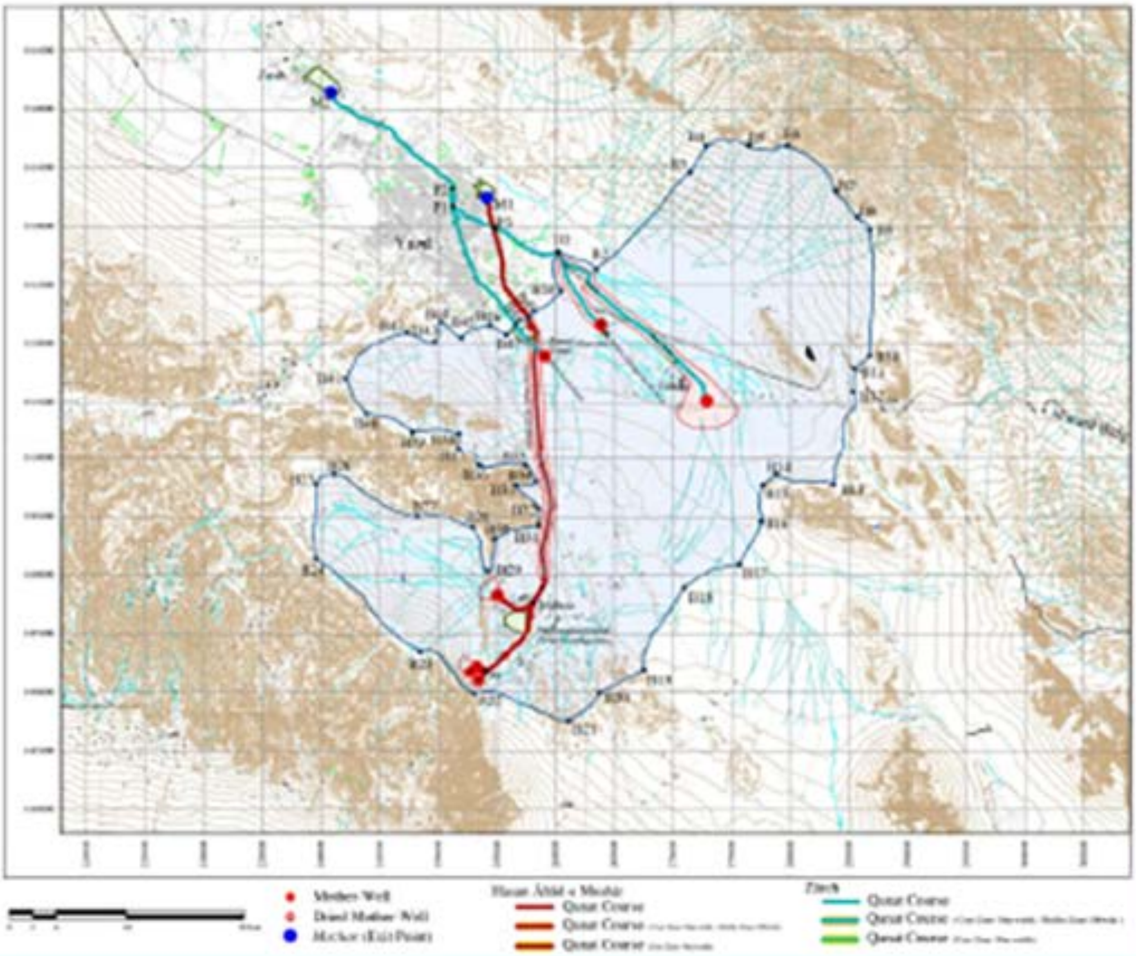
17

Map 1-14. Qanat of Zārch Buffer Zone



Map 1-21. Ebrāhim Ābād Qanat Core Zone

Hassan Ābād-e Moshir Qanat
Buffer Zone



Zone	Area
Core Zone	2739 ha
Buffer Zone	121662 ha
Agricultural Demand Area	615 ha

Geographical coordinates of Buffer Zone

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Regulation

Buffer Zone of Qanat is the area specified for protecting the qanat and its water-supplying system against possible natural, environmental, cultural and landscape damages.

Its limits include the watershed (which affects feeding the water table), the hydraulic and quality boundaries of qanat as well as the waterways. Buffer zone is delineated by taking into account body, environmental, natural and landscape values.

Note: in regions where the qanat course passes through urban fabric and residential areas, 50 meters on either side of qanat axis (a total width of 100m) has been considered as the buffer zone.

1. Any activities endangering qanat life such as digging deep or semi-deep water wells, intervention in the watershed system also harming the natural, cultural-historical landscape and habitat of the region is strictly banned.

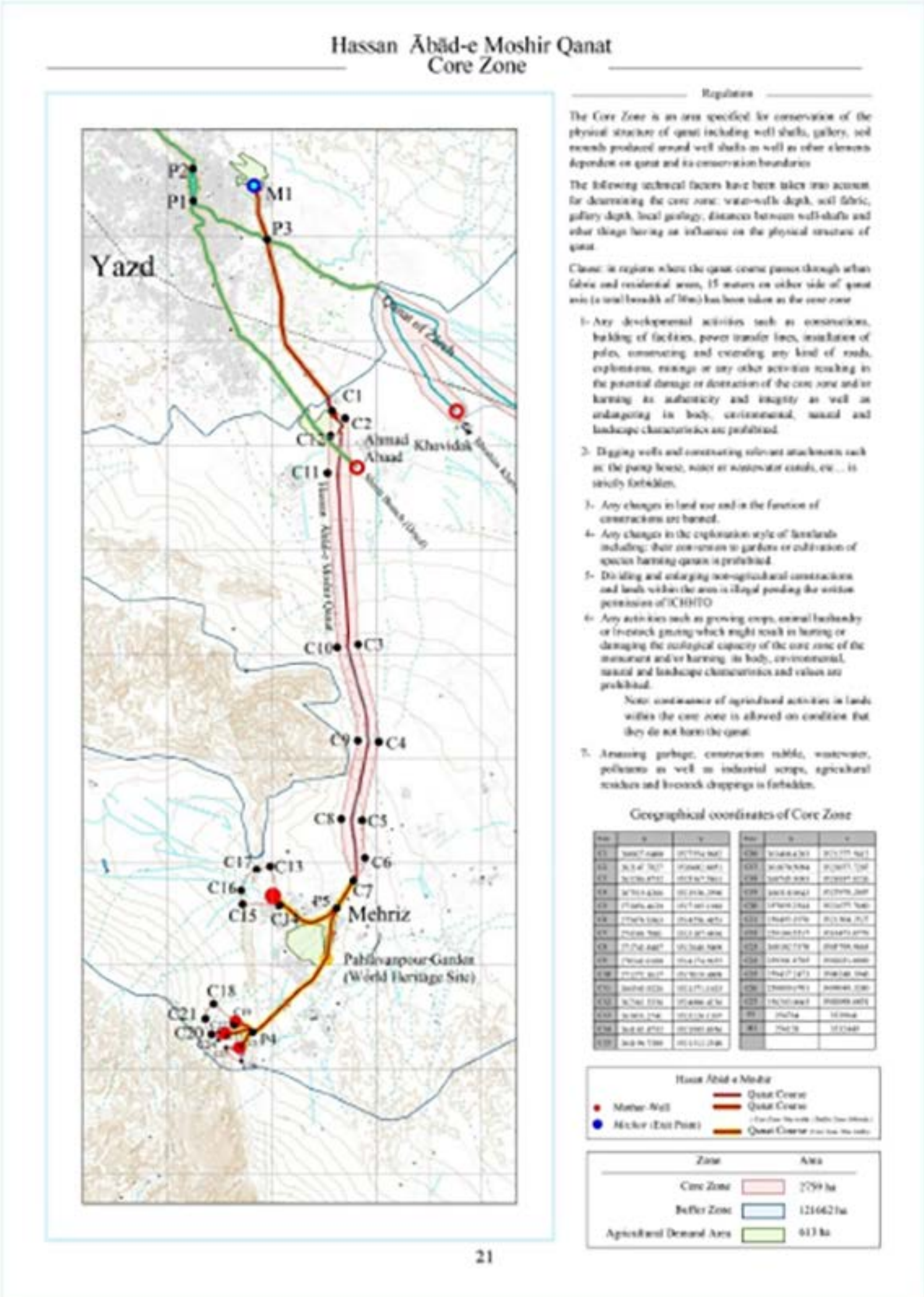
2. Construction of industrial and semi-industrial facilities as well as expansion and addition of attachments to existing structures depends on obtaining permit from ICHHTO

3. Body development of towns and villages located within the buffer zone must be based on regional programs, pilot projects as well as on detailed and master plans.

4. Gathering garbage, construction debris, wastewater, pollutants as well as industrial trash, agricultural residues and livestock droppings is forbidden.

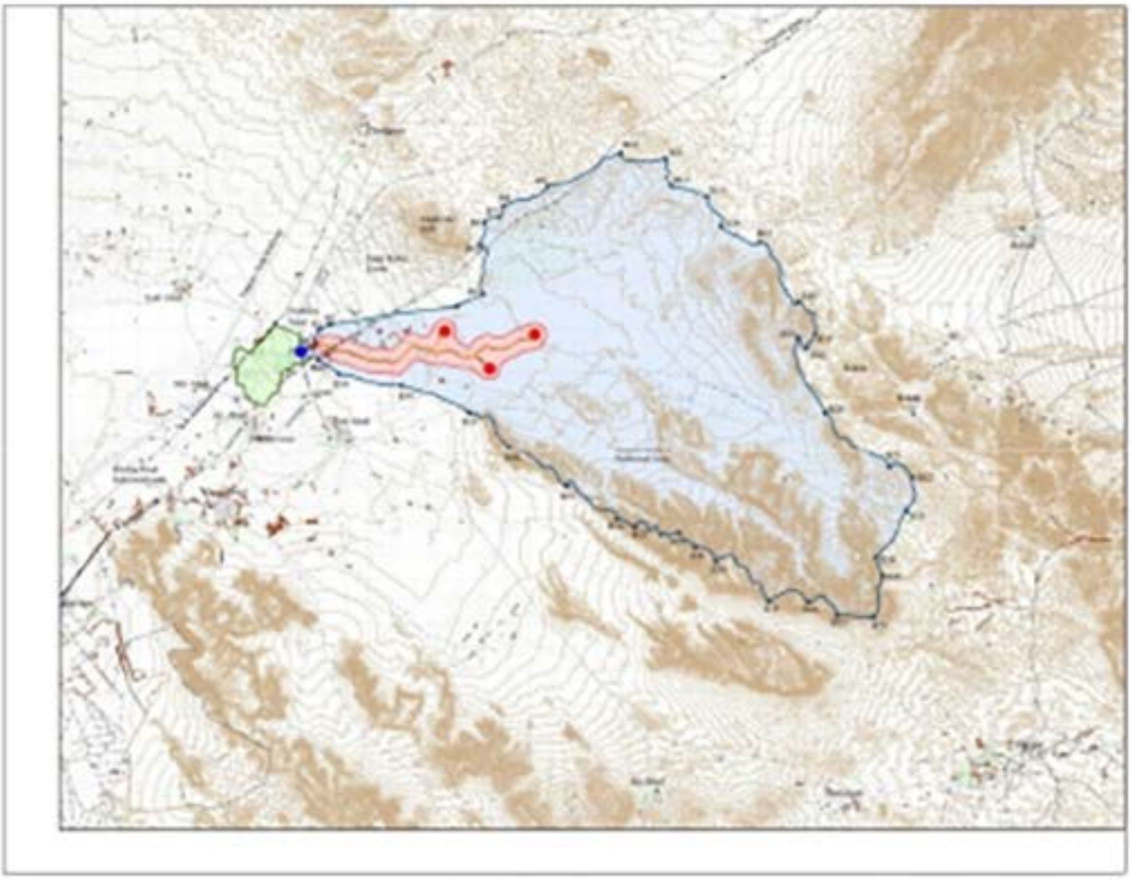
20

Map 1-17. Hassan Ābād-e Moshir Qanat Buffer Zone



Map 1-18. Hassan Ābād-e Moshir Qanat Core Zone

Ebrāhim Ābād Qanat
Buffer Zone



0 1 2 5 10 km

- Qanat Course
- Qanat Course (core zone 30m width)
- *Mazhar* (Exit Point)
- Mother-Well

Zone	Area
Core Zone	1238 ha
Buffer Zone	23051 ha
Agricultural Demand Area	609 ha

Geographical coordinates of Buffer Zone

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Regulation

Buffer Zone of Qanat is the area specified for protecting the qanat and its water-supplying system against possible natural, environmental, cultural and landscape damages.

Its limits include the watershed (which affects feeding the water table), the hydraulic and quality boundaries of qanat as well as the waterways. Buffer zone is delineated by taking into account body, environmental, natural and landscape values.

Note: in regions where the qanat course passes through urban fabric and residential areas, 50 meters on either side of qanat axis (a total width of 100m) has been considered as the buffer zone.

1. Any activities endangering qanat life such as digging deep or semi-deep water wells, intervention in the watershed system also harming the natural, cultural-historical landscape and habitat of the region is strictly banned.

2. Construction of industrial and semi-industrial facilities as well as expansion and addition of attachments to existing structures depends on obtaining permit from ICHHTO

3. Body development of towns and villages located within the buffer zone must be based on regional programs, pilot projects as well as on detailed and master plans.

4. Gathering garbage, construction debris, wastewater, pollutants as well as industrial trash, agricultural residues and livestock droppings is forbidden.

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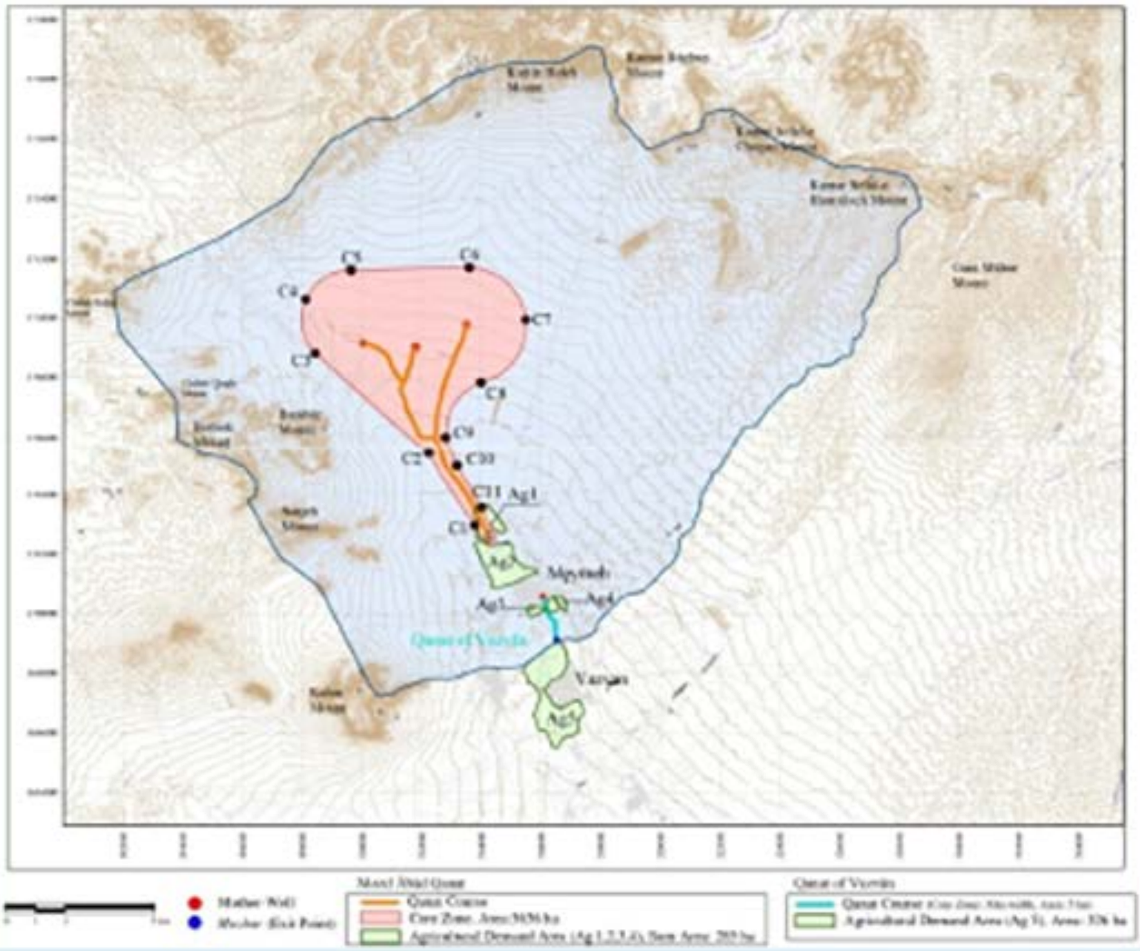
Map 1-20. Ebrāhim Ābād Qanat Buffer Zone

Mozd Ābād Qanat
Core Zone



Zone		Area
Collective Buffer Zone		29631 ha

Geographical coordinates of Core Zone

Point	X	Y
C1	513782.9740	3702956.3230
C2	512239.7040	3705408.2980
C3	508444.9725	3708829.3080
C4	508123.7192	3710646.0017
C5	509639.4261	3711633.9838
C6	513606.6483	3711719.5301
C7	515492.1002	3709958.7115
C8	513999.9999	3707854.1813
C9	512813.5595	3705997.5960
C10	513193.4439	3704966.9147
C11	514020.4156	3703563.0881

Regulation

The Core Zone is an area specified for conservation of the physical structure of qanat including well shafts, gallery, soil mounds produced around well shafts as well as other elements dependent on qanat and its conservation boundaries.

The following technical factors have been taken into account for determining the core zone: mains wells depth, soil fabric, gallery depth, local geology, distances between well-shafts and other things having an influence on the physical structure of qanat.

Clause: in regions where the qanat course passes through urban fabric and residential areas, 15 meters on either side of qanat axis (a total breadth of 30m) has been taken as the core zone.

1- Any developmental activities such as constructions, building of facilities, power transfer lines, installation of poles, constructing and extending any kind of roads, explorations, minings or any other activities resulting in the potential damage or destruction of the core zone and/or harming its authenticity and integrity as well as endangering its body, environmental, natural and landscape characteristics are prohibited.

2- Digging wells and constructing relevant attachments such as the pump house, water or wastewater canals, etc… is strictly forbidden.

3- Any changes in land-use and in the function of constructions are banned.

4- Any changes in the exploitation style of farmlands including their conversion to gardens or cultivation of species harming qanats is prohibited.

5- Dividing and enlarging non-agricultural constructions and lands within the area is illegal pending the written permission of ICHHTO.

6- Any activities such as growing crops, animal husbandry or livestock grazing which might result in hurting or damaging the ecological capacity of the core zone of the monument and/or harming its body, environmental, natural and landscape characteristics and values are prohibited.

Note: continuance of agricultural activities in lands within the core zone is allowed on condition that they do not harm the qanat.

7- Amassing garbage, construction rubble, wastewater, pollutants as well as industrial scraps, agricultural residues and livestock droppings is forbidden.

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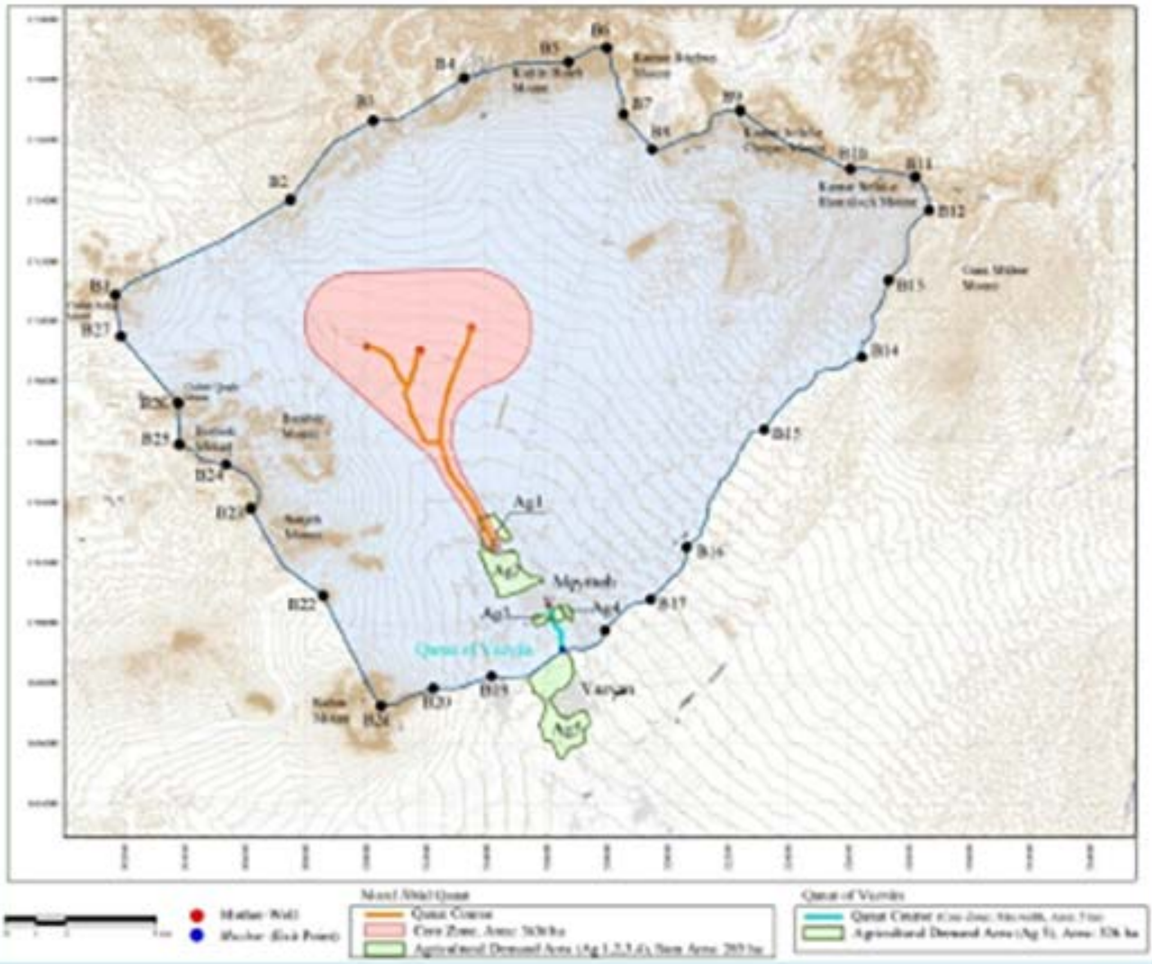
Map 1-26. Mozd Ābād Qanat Core Zone

Qanat of Vazvān and Mozd Ābād Qanat Buffer Zone



Zone		Area
Collective Buffer Zone		29631ha

Geographical coordinates of Buffer Zone

Point	X	Y	Point	X	Y
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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]			

Regulation

Buffer Zone of Qanat is the area specified for protecting the qanat and its water-supplying system against possible natural, environmental, cultural and landscape damages.

Its limits include the watershed (which affects feeding the water table), the hydraulic and quality boundaries of qanat as well as the waterways. Buffer zone is delineated by taking into account body, environmental, natural and landscape values.

Note: in regions where the qanat course passes through urban fabric and residential areas, 50 meters on either side of qanat axis (a total width of 100m) has been considered as the buffer zone.

1. Any activities endangering qanat life such as digging deep or semi-deep water wells, intervention in the watershed system also harming the natural, cultural-historical landscape and habitat of the region is strictly banned.

2. Construction of industrial and semi-industrial facilities as well as expansion and addition of attachments to existing structures depends on obtaining permit from ICHHTO

3. Body development of towns and villages located within the buffer zone must be based on regional programs, pilot projects as well as on detailed and master plans.

4. Gathering garbage, construction debris, wastewater, pollutants as well as industrial trash, agricultural residues and livestock droppings is forbidden.

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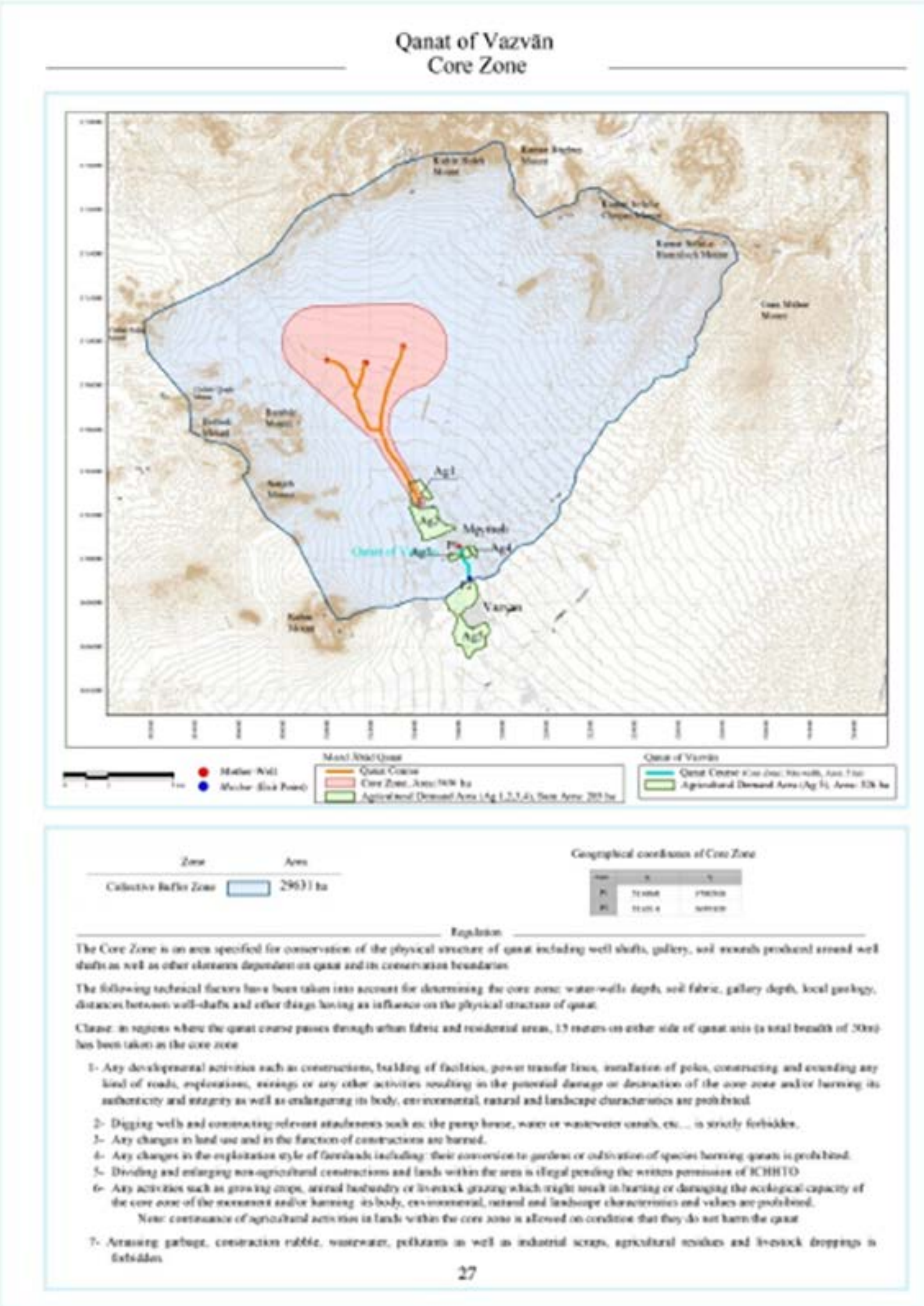
Map 1-23. Qanat of Vazvān & Mozd Ābād Qanat Buffer Zone



Qanat of Vazvān
Core Zone

Zone	Area
Collective Buffer Zone	29631 ha

Regulation

The Core Zone is an area specified for conservation of the physical structure of qanat including well shafts, gallery, soil mounds produced around well shafts as well as other elements dependent on qanat and its conservation boundaries.

The following technical factors have been taken into account for determining the core zone: water-wells depth, soil fabric, gallery depth, local geology, distances between well-shafts and other things having an influence on the physical structure of qanat.

Clause: in regions where the qanat course passes through urban fabric and residential areas, 15 meters on either side of qanat axis (a total breadth of 30m) has been taken as the core zone.

1- Any developmental activities such as constructions, building of facilities, power transfer lines, installation of poles, constructing and extending any kind of roads, explorations, minings or any other activities resulting in the potential damage or destruction of the core zone and/or harming its authenticity and integrity as well as endangering its body, environmental, natural and landscape characteristics are prohibited.

2- Digging wells and constructing relevant attachments such as: the pump house, water or wastewater canals, etc.... is strictly forbidden.

3- Any changes in land use and in the function of constructions are banned.

4- Any changes in the exploitation style of farmlands including: their conversion to gardens or cultivation of species harming qanats is prohibited.

5- Dividing and enlarging non-agricultural constructions and lands within the area is illegal pending the written permission of ICHHTO.

6- Any activities such as growing crops, animal husbandry or livestock grazing which might result in hurting or damaging the ecological capacity of the core zone of the monument and/or harming its body, environmental, natural and landscape characteristics and values are prohibited.

Note: continuance of agricultural activities in lands within the core zone is allowed on condition that they do not harm the qanat.

7- Amassing garbage, construction rubble, wastewater, pollutants as well as industrial scraps, agricultural residues and livestock droppings is forbidden.

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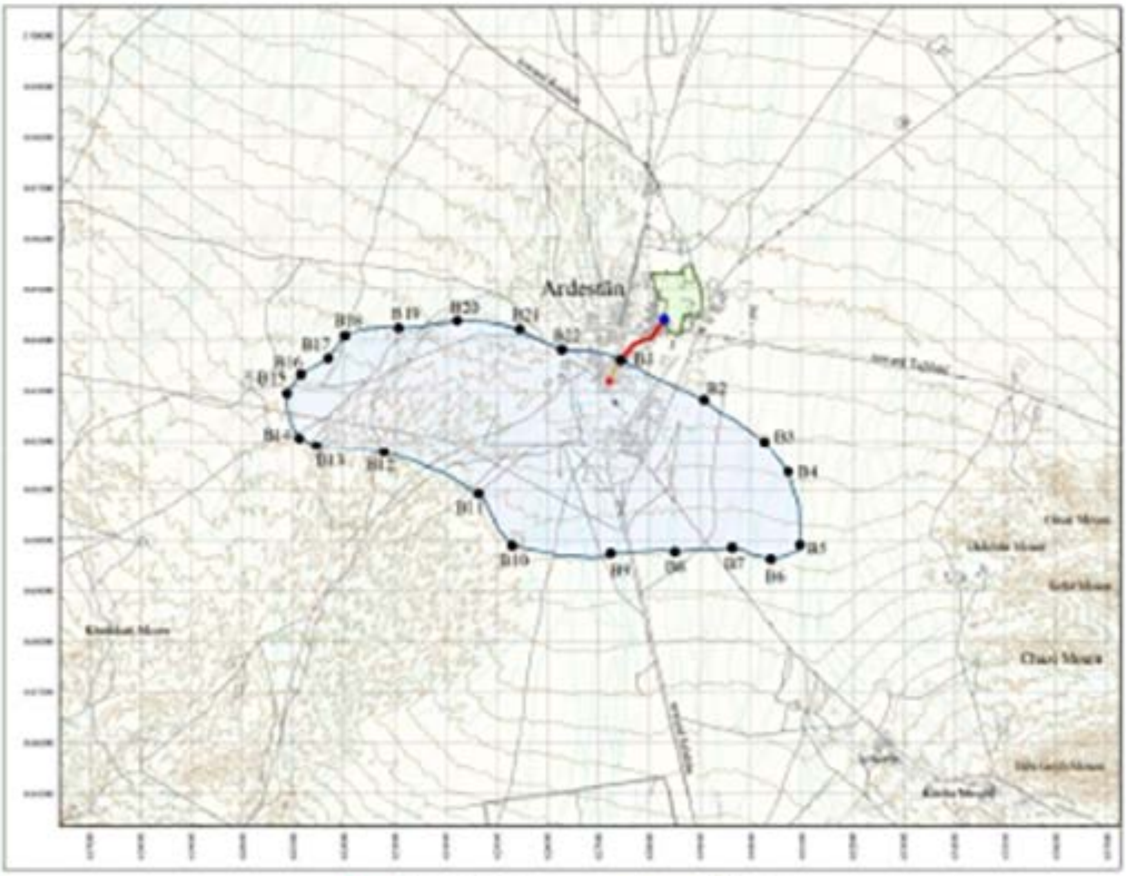
Map 1-24. Qanat of Vazvān Core Zone

Qanat of the Moon
Buffer Zone



- Mother-Well
- *Mazhar* (Exit Point)
- Qanat Course
- Qanat Course

Zone		Area
Core Zone		[illegible]
Buffer Zone		3647 ha
Agricultural Demand Area		811 ha

Geographical coordinates of Buffer Zone

Point	X	Y	Point	X	Y
B1	[illegible]	[illegible]	B12	[illegible]	[illegible]
B2	[illegible]	[illegible]	B13	[illegible]	[illegible]
B3	[illegible]	[illegible]	B14	[illegible]	[illegible]
B4	[illegible]	[illegible]	B15	[illegible]	[illegible]
B5	[illegible]	[illegible]	B16	[illegible]	[illegible]
B6	[illegible]	[illegible]	B17	[illegible]	[illegible]
B7	[illegible]	[illegible]	B18	[illegible]	[illegible]
B8	[illegible]	[illegible]	B19	[illegible]	[illegible]
B9	[illegible]	[illegible]	B20	[illegible]	[illegible]
B10	[illegible]	[illegible]	B21	[illegible]	[illegible]
B11	[illegible]	[illegible]	B22	[illegible]	[illegible]

Regulation

Buffer Zone of Qanat is the area specified for protecting the qanat and its water-supplying system against possible natural, environmental, cultural and landscape damages.

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Note: in regions where the qanat course passes through urban fabric and residential areas, 50 meters on either side of qanat axis (a total width of 100m) has been considered as the buffer zone.

1. Any activities endangering qanat life such as digging deep or semi-deep water wells, intervention in the watershed system also harming the natural, cultural-historical landscape and habitat of the region is strictly banned.

2. Construction of industrial and semi-industrial facilities as well as expansion and addition of attachments to existing structures depends on obtaining permit from ICHHTO

3. Body development of towns and villages located within the buffer zone must be based on regional programs, pilot projects as well as on detailed and master plans.

4. Gathering garbage, construction debris, wastewater, pollutants as well as industrial trash, agricultural residues and livestock droppings is forbidden.

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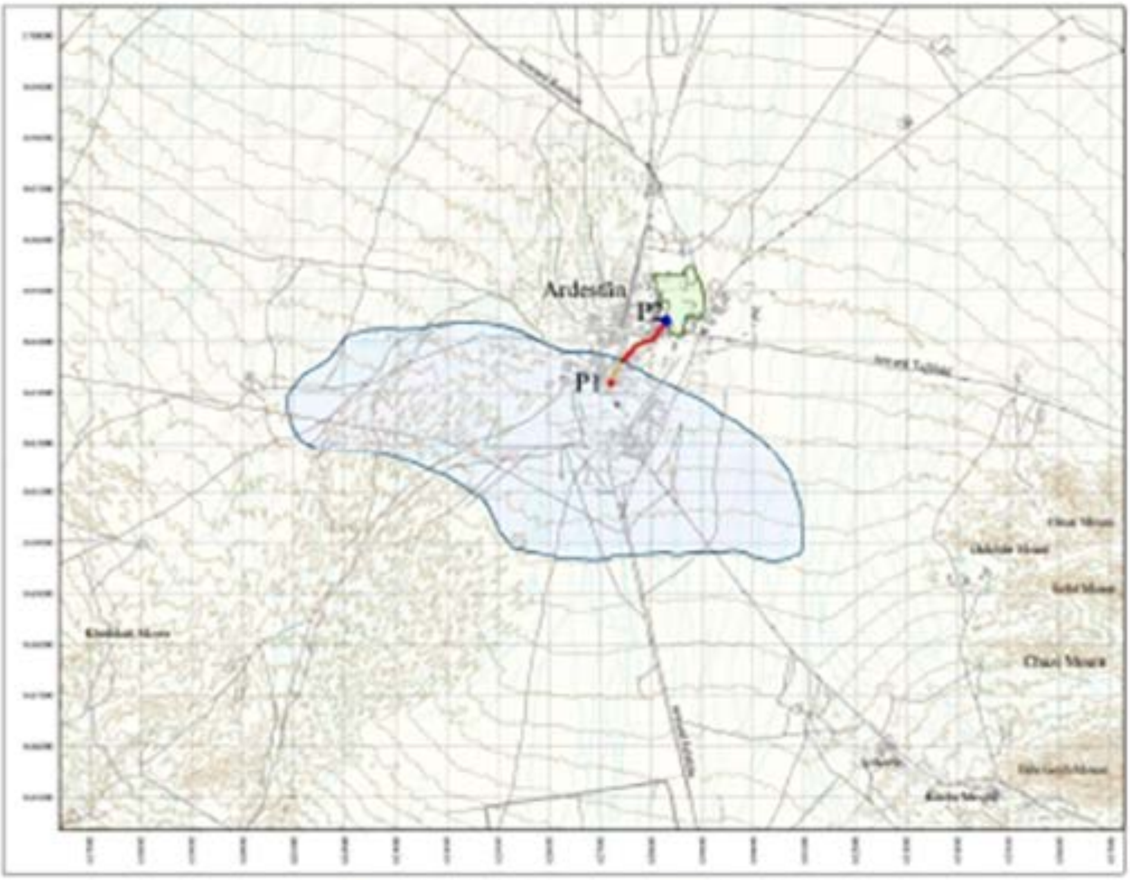
Map 1-28. Qanat of the Moon Buffer Zone

Qanat of the Moon
Core Zone



- Mother-Well
- *Mazhar* (Exit Point)
- Qanat Course
- Qanat Course

Zone		Area
Core Zone		5 ha
Buffer Zone		3047 ha
Agricultural Demand Area		811 ha

Geographical coordinates of Core Zone

Point	X	Y
P1	627223	3693186
P2	628289	3694412

Regulation

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Note: continuance of agricultural activities in lands within the core zone is allowed on condition that they do not harm the qanat.

7- Amassing garbage, construction rubble, wastewater, pollutants as well as industrial scraps, agricultural residues and livestock droppings is forbidden.

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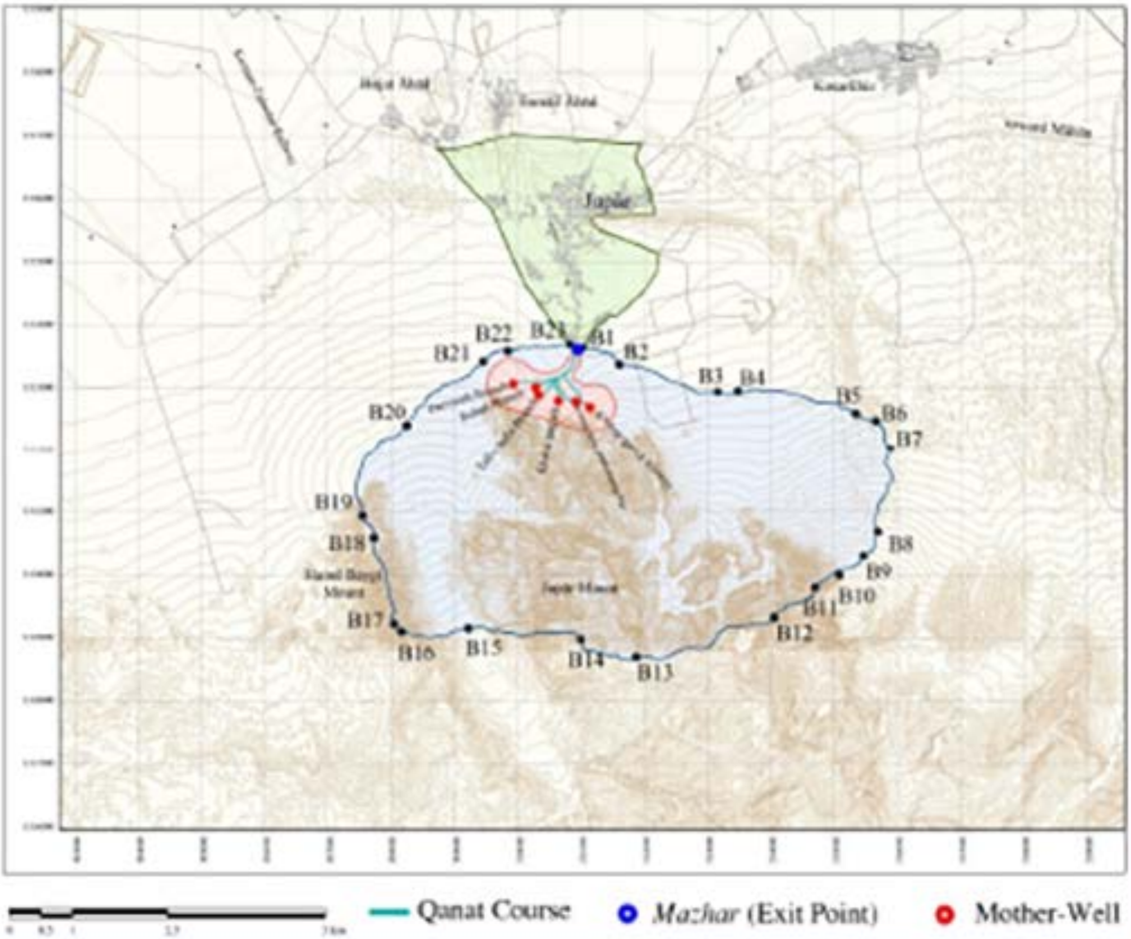
Map 1-29. Qanat of the Moon Core Zone

Qanat of Gowhar-riz
Buffer Zone



Qanat Course *Mazhar* (Exit Point) Mother-Well

Zone		Area
Core Zone		151 ha
Buffer Zone		2900 ha
Agricultural Demand Area		037 ha

Geographical coordinates of Buffer Zone

Point	X	Y
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

Point	X	Y
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]		

Regulation

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3. Body development of towns and villages located within the buffer zone must be based on regional programs, pilot projects as well as on detailed and master plans.

4. Gathering garbage, construction debris, wastewater, pollutants as well as industrial trash, agricultural residues and livestock droppings is forbidden.

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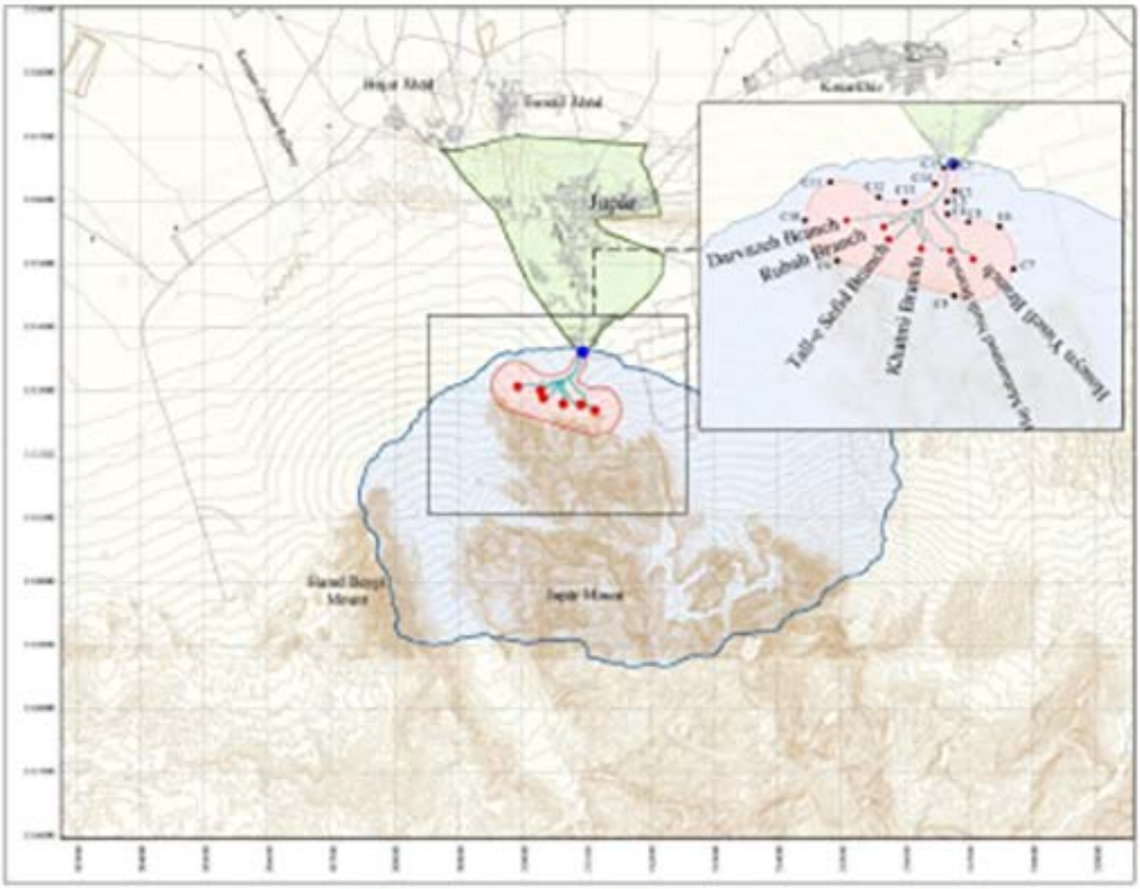
Map 1-31. Qanat of Gowhar-riz Buffer Zone

Qanat of Gowhar-riz
Core Zone



— Qanat Course ● *Mazhar* (Exit Point) ● Mother-Well

Zone		Area
Core Zone		151 ha
Buffer Zone		2980 ha
Agricultural Demand Area		657 ha

Geographical coordinates of Core Zone

Point	X	Y
C1	510950.4902	3323610.3552
C2	510958.0961	3323361.1345
C3	510887.3391	3323257.9964
C4	510991.8520	3323138.8988
C5	511091.6336	3323061.3739
C6	511388.3325	3323020.2187
C7	511523.7859	3322607.4289
C8	510954.7824	3322352.9777
C9	509831.3419	3322687.8838
C10	509521.8362	3323077.5229
C11	509766.4987	3323446.1287
C12	510230.2271	3323299.6630
C13	510481.5523	3323253.9660
C14	510773.7746	3323426.7137
C15	510835.7981	3323583.9200

Regulation

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7- Amassing garbage, construction rubble, wastewater, pollutants as well as industrial scraps, agricultural residues and livestock droppings is forbidden.

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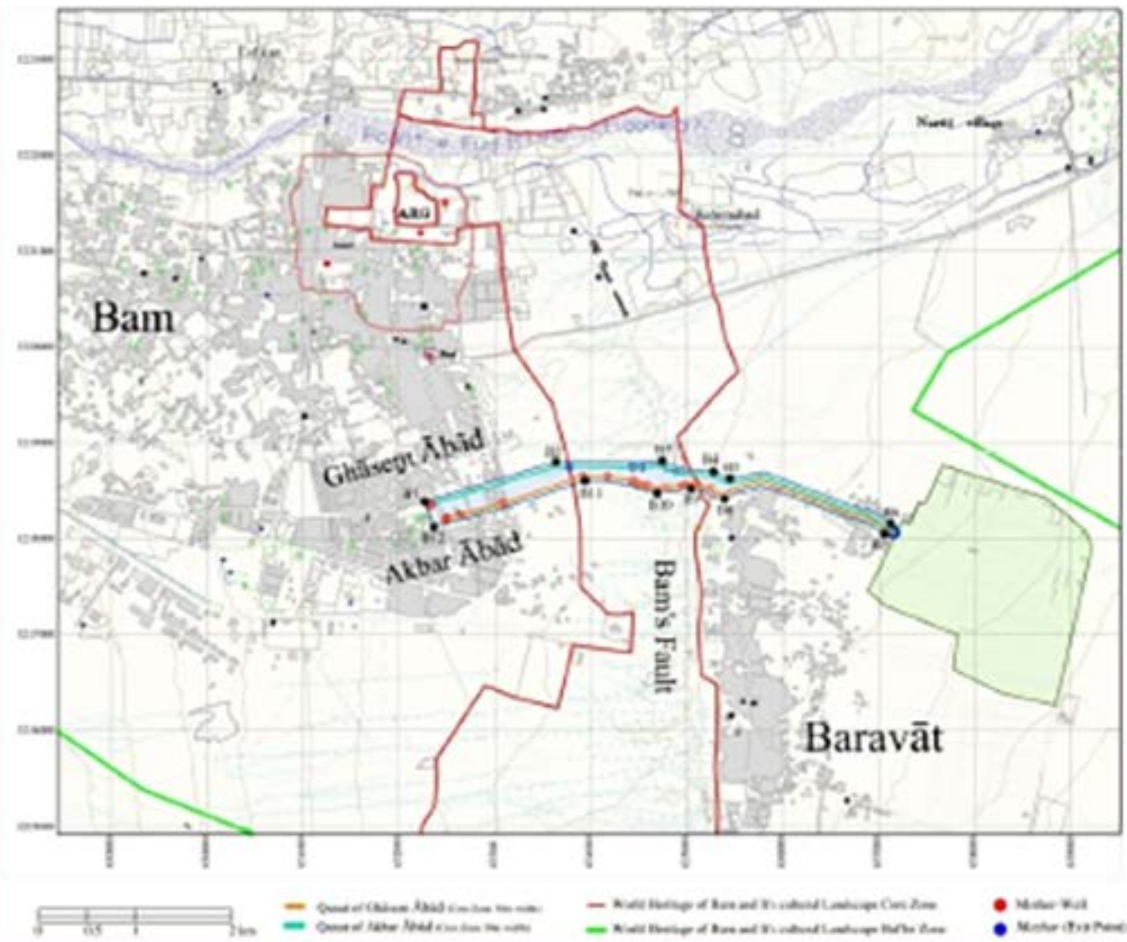
Map 1-32. Qanat of Gowhar-riz Core Zone

Qanat of Bam (Ghāsem Ābād & Akbar Ābād)
Buffer Zone



Zone		Area
Ghāsem Ābād Core Zone		15 ha
Ghāsem Ābād Core Zone		15 ha
CollectiveBuffer Zone		80 ha
Agricultural Demand Area		358 ha

Geographical coordinates of Buffer Zone

Point	X	Y
B1	[illegible]	[illegible]
B2	[illegible]	[illegible]
B3	[illegible]	[illegible]
B4	[illegible]	[illegible]
B5	[illegible]	[illegible]
B6	[illegible]	[illegible]
B7	[illegible]	[illegible]
B8	[illegible]	[illegible]
B9	[illegible]	[illegible]
B10	[illegible]	[illegible]
B11	[illegible]	[illegible]
B12	[illegible]	[illegible]

Regulations

Buffer Zone of Qanat is the area specified for protecting the qanat and its water-supplying system against possible natural, environmental, cultural and landscape damages.

Its limits include the watershed (which affects feeding the water table), the hydraulic and quality boundaries of qanat as well as the waterways. Buffer zone is delineated by taking into account body, environmental, natural and landscape values.

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2. Construction of industrial and semi-industrial facilities as well as expansion and addition of attachments to existing structures depends on obtaining permit from ICHHTO

3. Body development of towns and villages located within the buffer zone must be based on regional programs, pilot projects as well as on detailed and master plans.

4. Gathering garbage, construction debris, wastewater, pollutants as well as industrial trash, agricultural residues and livestock droppings is forbidden.

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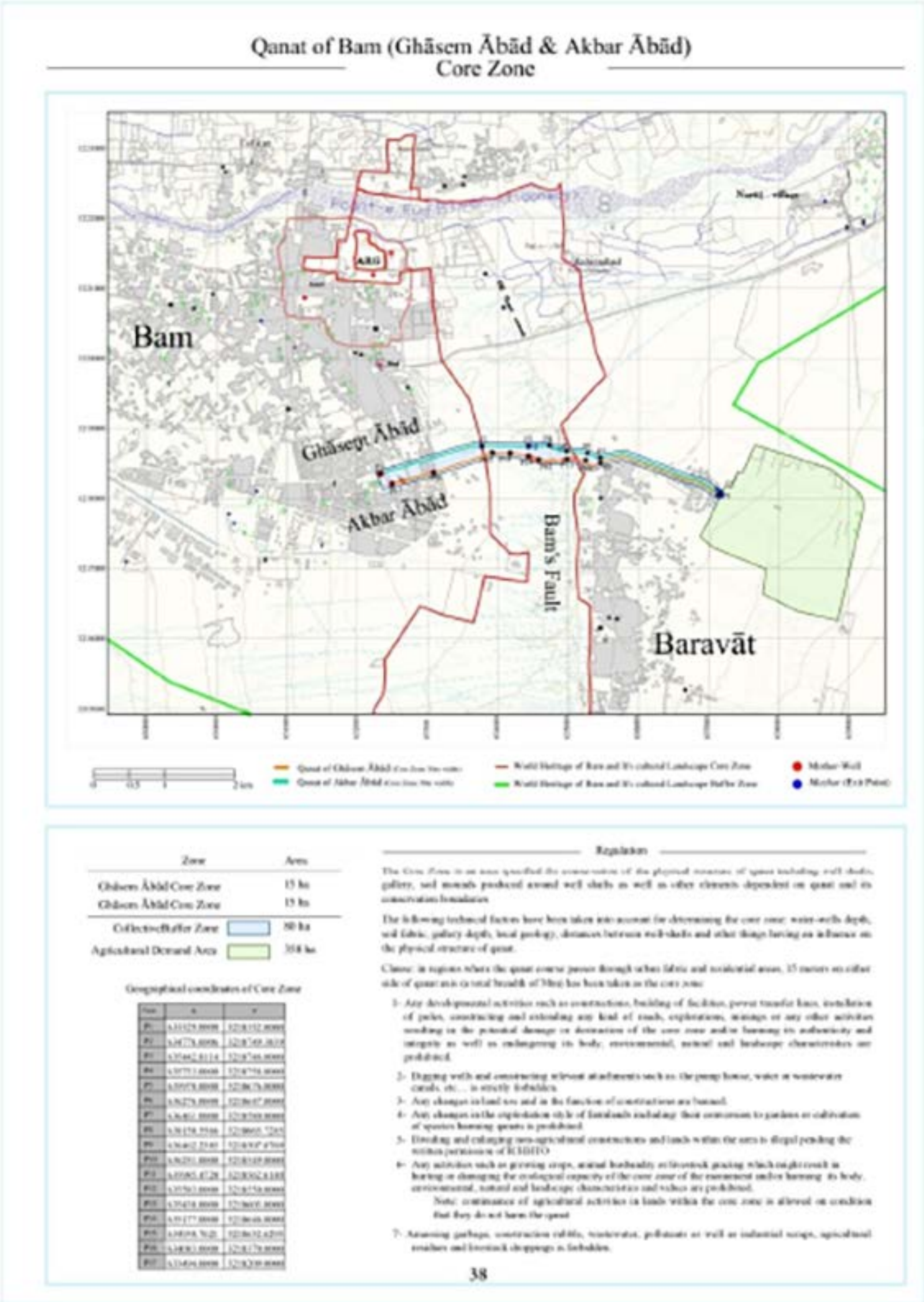
Map 1-34. Qanats of Bm (Ghāsem Ābād & Akbar Ābād) Buffer Zone



Zone	Area
Ghāsem Ābād Core Zone	15 ha
Ghāsem Ābād Core Zone	15 ha
Collective Buffer Zone	80 ha
Agricultural Demand Area	358 ha

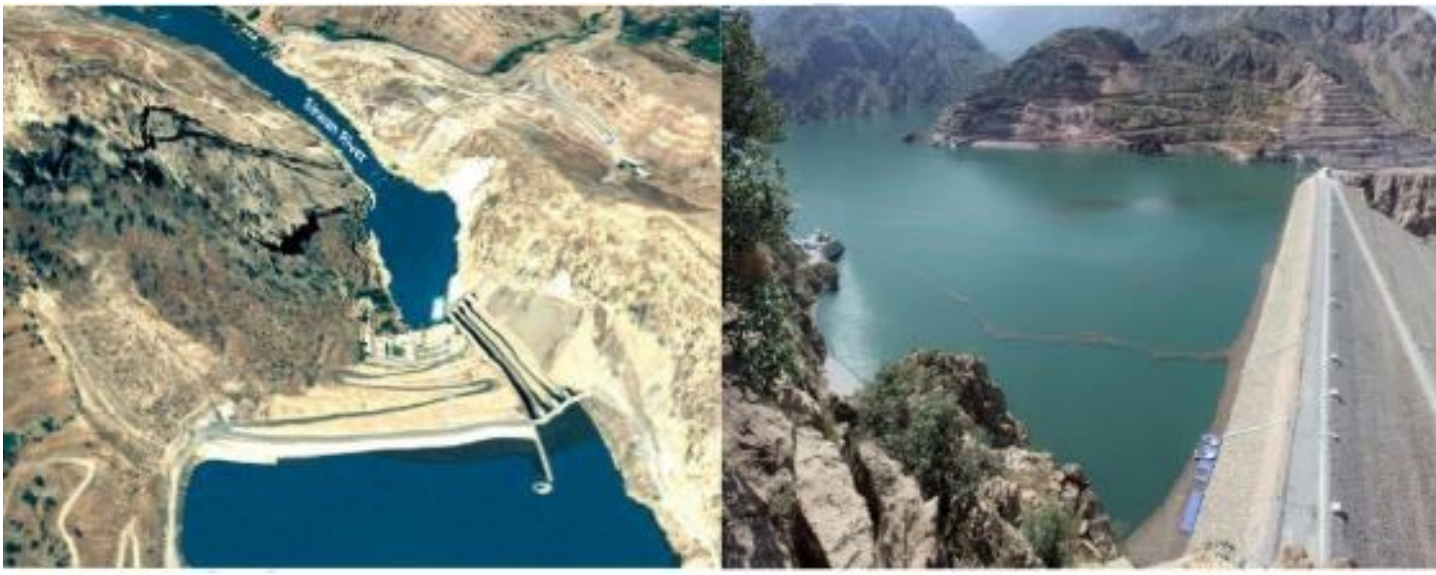
Map 1-35. Qanats of Bm (Ghāsem Ābād & Akbar Ābād) Core Zone

XX. Upstream Dams

Major dam projects on the Tigris and Euphrates rivers, particularly in Turkey, have significantly reduced downstream water flow to Iraq and Syria. This has caused further desertification, wetland loss, and the expansion of dust sources.

Upstream dams, both within Iran and in neighbouring countries, have significantly contributed to Iran's severe water crisis by disrupting river flow and damaging ecosystems. These projects have intensified water shortages, particularly in drier regions, leading to social, economic, and environmental problems.

Upstream dams within Iran



Reduced river flow and dried wetlands: Dams built in recent decades, including those on the Karun and Karkheh rivers, have drastically reduced downstream flow, contributing to the drying of major wetlands, such as the Hoor Al-Azim wetland.

Salinisation of soil and water: The Gotvand Dam, built on a saline plateau on the Karun River, is considered an engineering failure. Its reservoir has released salt, severely increasing the river's salinity. This has damaged local agricultural lands and killed vast numbers of palm trees in the Ahvaz region.

Increased dust storms: The drying of wetlands and riverbeds leaves behind barren land. Loose soil and salt from these areas are then picked up by the wind, causing increased sand and dust storms that degrade air quality and threaten human health.

Depletion of groundwater: Damming has decreased the natural recharge of groundwater. In response to surface water shortages, Iran has over-extracted groundwater, causing a severe decline in aquifer levels and resulting in land subsidence.

Inefficient resource management: Rather than solving the water crisis, large-scale damming has enabled the expansion of water-intensive agriculture in arid regions, further straining the country's water resources.

Upstream dams in neighbouring countries

Transboundary river disputes: Iran is an outflow country for several rivers whose headwaters are in neighbouring countries, including Turkey and Afghanistan. Dam projects in these countries have caused transboundary water disputes and reduced water flow into Iran.

Diminished water from Afghanistan: Dams built on the Helmand River in Afghanistan, such as the Kamal Khan Dam, have reduced flow into Iran's Sistan-Baluchestan province, severely impacting the local water supply and livelihoods. Similar damming on the Harirud River has also diminished water levels in the Doosti reservoir, which Iran shares with Afghanistan and Turkmenistan.

Reduced river flow from Turkey: Turkey's extensive dam projects on the Tigris and Euphrates rivers, part of the Southeastern Anatolia Project (GAP), have dramatically cut the flow of water to downstream countries, including Iraq and Iran. This has worsened water scarcity in Iran and sparked diplomatic tensions.

Economic and social consequences

Agricultural decline: Water scarcity has hindered crop production and destroyed farmland through salinisation, endangering rural livelihoods.

Forced migration: With few options for employment in rural areas facing severe water shortages, many people have been forced to migrate to urban centres, increasing pressure on water and other resources in cities.

Hydro-political instability: Water shortages have triggered public outrage and protests across Iran, which have sometimes turned violent. They have also fuelled broader resentments and challenges to government legitimacy.

XXI. Regional Deserts

Other major external sources include the Syrian Desert, the Arabian Peninsula (including the Rub' al Khali desert in Saudi Arabia), and the Karakum Desert in Turkmenistan. The Shamal winds, a powerful northwesterly wind system, carry dust from these deserts across the Persian Gulf and into Iran.

Transboundary dust sources

Mesopotamian Plains (Iraq and Syria): This region is one of the most important sources of dust affecting western and central Iran. Factors contributing to this include decades of drought, drying of wetlands like Hour al-Azim, and military conflicts.

Arabian Deserts (Saudi Arabia, Kuwait, Oman): Dust from deserts across the Arabian Peninsula, including the Rub' al Khali, is frequently carried across the Persian Gulf and into southwestern Iran.

Karakum Desert (Turkmenistan): This desert, located north of Iran, is responsible for dust events in Iran's northeastern regions.

Herat Province (Afghanistan): Located to the east of Iran, the deserts and dry lakebeds in this area contribute to dust storms affecting the Sistan and Khorasan provinces.

Internal factors

Dust storms also originate from sources within Iran, intensified by climate change and poor domestic water management practices.

Dasht-e Kavir and Dasht-e Lut: The dry, sandy surfaces of these major Iranian deserts, combined with strong winds and minimal vegetation, serve as prominent internal dust sources.

Two large deserts, the Dasht-e Kavir and the Dasht-e Lut, dominate Iran's central and southeastern plateau regions. The mountainous terrain surrounding the plateau contributes to a hyper-arid climate, with extreme temperature variations and little rainfall.

Dasht-e Lut (Lut Desert)

Located in southeastern Iran, the Lut Desert is a UNESCO World Heritage Site known as one of the hottest and driest places on Earth.

Geological formations: This area is famous for its massive wind-sculpted sand ridges, or yardangs (known as kaluts), that can be seen from space. The desert also features some of the world's tallest sand dunes, reaching up to 475 meters high.

Location: The Lut Desert spans parts of Kerman, Sistan and Baluchestan, and South Khorasan provinces.

•

Dasht-e Kavir (Great Salt Desert)

Situated in the middle of the Iranian Plateau, the Dasht-e Kavir is Iran's largest desert, consisting of salt marshes (kavirs), sand, and gravel.

Salt flats: This desert's most significant feature is the vast Kavir Buzurg (Great Kavir), a massive salt marsh that is a remnant of an ancient lakebed.

Salt domes: Unique salt domes have formed over centuries as buried salt deposits pushed up through layers of mud and rock.

Location: The Dasht-e Kavir stretches across several provinces, including Khorasan, Semnan, Tehran, Isfahan, and Yazd. A portion of it is also protected within Kavir National Park.

Other notable desert areas

In addition to the two major deserts, Iran has several smaller, noteworthy desert regions that offer unique landscapes and attractions:

Rig-e Jenn: A remote and mysterious dune desert within the Dasht-e Kavir, known for its treacherous quicksands.

Rig-e Jenn is inherently an arid and harsh environment, characterised by a lack of stable water sources and vegetation, which makes it particularly vulnerable to climate change and water scarcity

Varzaneh Desert: Famous for its pristine, white sand dunes and its proximity to a salt lake and wetland.

Drought conditions Varzaneh Desert

Multiple decades of severe drought in the Varzaneh Desert region of Iran are caused by a combination of climate change, long-term government mismanagement of water resources, and overexploitation of water by agriculture and industry. These factors have depleted the Zayandeh Rud river, which historically supplied the Varzaneh area and its Gavkhouni wetland.

Natural factors

Climate variability and change: Iran is experiencing higher temperatures and lower precipitation, which intensifies water scarcity throughout the country. For the past three years, the country has experienced severe drought. Projections indicate that the country could see average temperatures increase by 2.6 °C and precipitation decrease by 35% in the coming decades.

Dryness of the Gavkhouni wetland: The desiccation of the Gavkhouni wetland, once a key environmental feature of the region, has contributed to higher local temperatures in the Varzaneh area. This increases the rate of evaporation and worsens the drought.

Human factors

Mismanagement of water resources: The Iranian government has long mismanaged water resources through inefficient policies and projects. Inconsistent water distribution has exacerbated the issue, with decision-making processes lacking transparency and farmer participation.

Upstream water diversions: Water from the Zayandeh Rud river, the region's main source, has been redirected through tunnels to other cities and provinces for decades. This has drastically reduced the amount of water flowing downstream to Varzaneh.

Unsustainable water use: A large portion of Iran's water resources—more than 90%—is consumed by agriculture, much of it through wasteful irrigation methods. Industry, including water-intensive steel plants, also diverts significant amounts of water for its own use.

Overexploitation of groundwater: Widespread, unregulated drilling of deep wells has caused a severe drop in the water table across central Iran. This overuse has led to land subsidence, soil salinisation, and further groundwater depletion.

Population growth: Rapid population growth and migration to urban areas like Isfahan have increased demand for water for drinking, agriculture, and industrial purposes, straining limited resources.

Maranjab Desert: Features high sand dunes, a historical caravanserai, and a nearby salt lake. It is located near the city of Kashan.

Drought conditions Maranjab Desert

The drought conditions in Iran's Maranjab Desert are caused by a combination of climate change and severe water mismanagement, including over-extraction of groundwater, construction of dams, and inefficient water use in agriculture. The region is also negatively impacted by excessive tourism, which destroys local plant life.

Climate change

Intensified heat: Climate change has led to higher temperatures and increased evaporation rates across Iran. This phenomenon, known as "desert warming amplification," is exacerbated in arid regions like the Maranjab Desert, causing soil to dry out faster.

Reduced precipitation: Decades of declining rainfall across Iran have intensified drought conditions. Studies show that climate change has made severe dry periods more likely in the region.

Water mismanagement

Over-extraction of groundwater: Decades of excessive groundwater extraction, largely driven by population growth and agricultural demands, have caused a drastic drop in the water table. Aquifer levels are falling by up to 50 cm annually in central Iran, leading to land subsidence and increased water salinity.

Dam construction: The construction of dams and inter-basin water transfers, often based on flawed planning, has diverted water away from natural ecosystems. This has contributed to the drying of lakes and rivers in the region.

Inefficient agriculture: The agricultural sector accounts for most of Iran's water consumption. Inefficient irrigation and the cultivation of water-intensive crops, like sugarcane in arid areas, have strained water resources even further.

Other factors

Excessive tourism: Increasing recreational activities, particularly unregulated off-road vehicles, damage the desert's fragile ecosystem. This disrupts native flora and fauna by destroying vegetation that is crucial for soil stabilisation.

Unsustainable land use: The conversion of natural rangelands to farmland and urban areas, along with overgrazing, has accelerated soil degradation and desertification

Mesr Desert: A picturesque desert with rolling sand dunes located in Isfahan province, known for its traditional village and starry night skies.

Drought conditions Mesr Desert

The primary causes of drought conditions in Mesr Desert and throughout central Iran are a combination of climate change and decades of poor water resource management. The mismanagement of water has been a critical factor, creating a "water bankruptcy" situation where water demand significantly outstrips the natural supply.

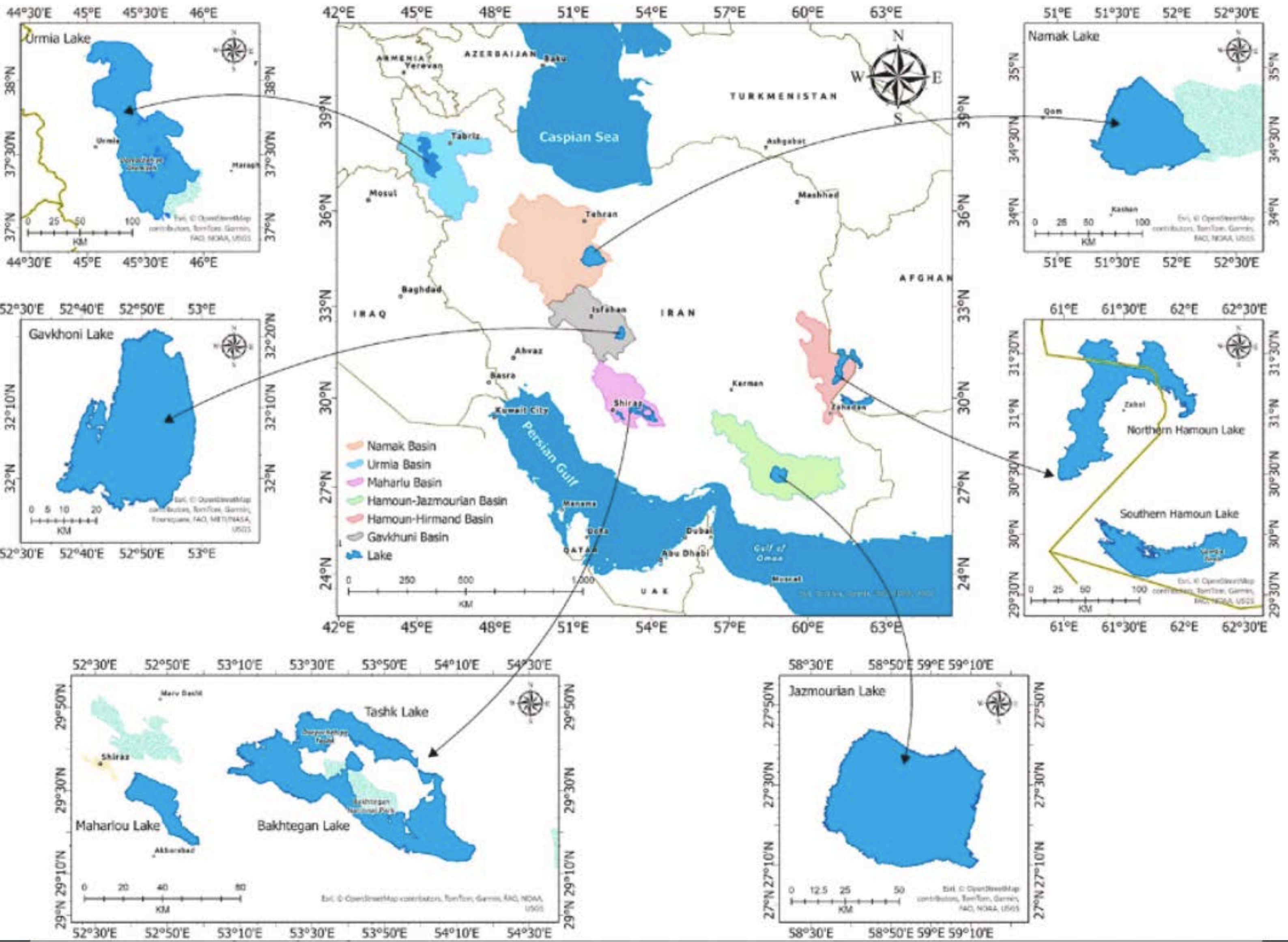
Climate change

Intensified heat: Climate change has caused a substantial increase in temperatures in Iran. This heightened heat has significantly worsened droughts, primarily by increasing evaporation from soil, plants, and surface water bodies.

Reduced precipitation: Iran has experienced a long-term trend of decreasing rainfall over the past several decades, especially in central and eastern regions where precipitation levels are already low. This has led to dry rivers and vanishing lakes.

More frequent extreme events: Climate change has made droughts of this intensity much more frequent. A recent study found that while climate change may not have been the direct cause of low rainfall, it has made intense droughts in Iran significantly more likely.

XXII. Desiccated lakes and wetlands



Shrinking water bodies within Iran's borders are significant dust hotspots. A number of major lakes and wetlands in Iran have become desiccated, turning into salt flats and dust sources. The primary causes are a combination of prolonged drought exacerbated by climate change and unsustainable human activities like excessive dam construction and agricultural water consumption.

Desiccated lakes and wetlands in Iran

Lake Urmia: Once the largest salt lake in the Middle East, it has shrunk by over 90% due to upstream dams and intensive water use for agriculture. The remaining dry lakebed is now a major source of salt storms that affect the health of millions and damage farmland.

Hamoun Wetlands: Situated on the border with Afghanistan, these wetlands are now largely dry due to drought and diversion of the Hirmand River, which was their primary water source. This has triggered massive dust storms.

Gavkhouni Wetland: This international wetland is located at the terminus of the Zayandeh-Rud River in Isfahan province. It has been desiccated due to upstream damming and water diversion for agricultural, industrial, and urban use.

Bakhtegan Lake: As one of Iran's largest wetlands, this lake in Fars province has experienced significant drying due to drought and dam construction on its feeding rivers. It is listed on the Montreux Record of threatened wetlands.

Maharloo Lake: This lake in Fars province has experienced declining water levels and shrinking, resulting in a higher concentration of salt.

Jazmourian Wetland: In southeastern Iran, this wetland has suffered significant desiccation due to drought and upstream development.

Shadegan Wetland: A Ramsar-listed wetland in Khuzestan province, it is drying due to dam construction, wastewater discharge, and oil extraction activities.

Salehiyeh Wetland: Located south of Tehran, this wetland has largely dried up and become a major source of dust storms affecting the densely populated areas of Karaj and Tehran.

Anzali Wetland: On the Caspian Sea coast, this wetland is shrinking due to climate change, decreased river inflow, increased sediment loads, and water mismanagement.

Consequences of desiccation

Salt and dust storms: The exposed, dry lakebeds release large amounts of salt and dust into the air, which can cause respiratory illnesses, damage crops, and render agricultural land unusable.

Damage to agriculture: The loss of water sources and salt intrusion has severely harmed agricultural productivity, impacting local economies and food security.

Forced migration: Environmental and economic crises have led to large-scale migration from affected rural areas to urban centres, increasing social and political instability.

Ecological disruption: Drying wetlands have destroyed habitats for wildlife, leading to a significant decline in migratory bird populations.

Land subsidence: The excessive pumping of groundwater has caused the ground to sink rapidly, threatening vital infrastructure in cities like Isfahan

Hamoun Lakes: Water diversion and extreme drought have caused these wetlands, located on the border with Afghanistan, to shrink over the last 30 years. Strong seasonal winds, known as the "120-day winds," pick up dust from the dry lakebeds and deposit it in Iran's Sistan region.

The primary causes of drought conditions affecting the Hamoun Lakes are reduced water flow from the Helmand River due to damming and water diversion in Afghanistan, combined with the effects of climate change that lead to prolonged periods of low rainfall. The Hamoun wetlands straddle the border of Iran and Afghanistan in the Sistan Basin.

Reduced water flow

The Hamoun Lakes are seasonal wetlands fed primarily by the Helmand River, which originates in the Hindu Kush mountains of Afghanistan.

Upstream dams: Numerous dams built in Afghanistan on the Helmand River, including the Kajaki and Kamal Khan dams, have significantly reduced the amount of water flowing downstream into the Hamoun Lakes.

Water diversion: Water from these dams is used for agricultural irrigation within Afghanistan, further limiting the supply that reaches Iran. Water disputes over the river have been ongoing for decades.

Changes in river patterns: The management of the Helmand has changed the river's morphological and discharge patterns, with studies showing a significant reduction in the river's width.

Climate change and drought

Prolonged, severe droughts have been a recurring issue in the region, intensified by a warming climate and reduced rainfall.

Decreased precipitation: Climate change has resulted in lower-than-average annual rainfall in the Hirmand watershed, decreasing the natural water supply to the lakes.

High evaporation rates: The region's hot, arid climate means that water evaporates quickly. With less incoming river water to replenish the lakes, the effects of low rainfall are worsened.

Natural variability: Hamoun Lakes are naturally seasonal and have experienced dry periods throughout history. However, anthropogenic (human-induced) stresses have compounded these natural climate impacts, causing more severe and longer-lasting desiccation.

Consequences of the drought

The near-complete drying of the Hamoun Lakes has led to severe environmental and social consequences.

Dust storms: The exposure of the dry lakebeds leaves fine sand and silt vulnerable to high seasonal winds, resulting in increased frequency and intensity of dust storms.

Economic collapse: The local economy, which historically relied on fishing, reed harvesting, and agriculture, has collapsed. The resulting loss of livelihood has forced many residents to migrate.

Environmental damage: The habitat for fish, migratory birds, and other wildlife has been largely destroyed, resulting in a collapse of biodiversity.

Lake Urmia: This saltwater lake in northwestern Iran has seen a marked decline in water levels due to a combination of climate change and excessive water withdrawal, creating a large, dusty lakebed.

A combination of anthropogenic and climatic factors has caused the drought conditions at Lake Urmia in Iran. While prolonged droughts and climate change, which have reduced precipitation and increased temperatures, have contributed to the decline, mismanagement of water resources is considered the primary cause.

Human-induced causes

Expansion of agriculture: In the Lake Urmia basin, agricultural activities have significantly expanded over the past four decades, leading to greater water consumption. Farmers in the region often cultivate high-water-demand crops, and inefficient irrigation methods, like flood irrigation, further intensify the water demands. This has put immense pressure on local water resources, with agriculture accounting for more than 90% of the basin's water use.

Excessive water withdrawal: To support the expanding agricultural sector, a massive number of deep wells—many of them illegal—were established to withdraw groundwater. This over-extraction of both surface and groundwater has led to a major decline in the aquifers that feed the lake.

Dam construction: The construction of numerous dams on the rivers that flow into Lake Urmia has severely reduced the lake's water supply. A 2021 study found that human water management activities, including dam construction, caused 86% of the lake's water depletion between 1995 and 2010.

Causeways: The construction of a causeway and bridge across the lake in the early 2000s divided it into northern and southern basins. The structure restricted water circulation and contributed to the increased salinity and desiccation, with the southern basin turning into a salt flat years before the northern section.

Climatic factors

Decreased precipitation: While human factors play the dominant role, studies show that reduced rainfall, along with higher temperatures, has contributed to the problem. Droughts in the region have become longer and more severe, particularly since the 1990s.

Increased temperatures: The region has experienced a gradual but significant increase in average annual temperature. Higher temperatures lead to increased evaporation and potential evapotranspiration, which decreases the total water available in the basin.

Consequences

As the lake dries, it leaves behind a massive salt flat that can lead to wind-blown salt storms, which damage agriculture, contaminate water supplies, and pose health risks to the local population.

XXIII. Technological Solutions of the Ionospheric Climate Modification Technology (ICM) for the Islamic Republic of Iran:

Technological solutions of the Ionospheric Climate Modification (ICM) program presents the opportunity for seasonal regulation of atmospheric processes on the territory of the Islamic Republic of Iran by transferring wetted air masses from over-wetted water areas of the Indian and Pacific oceans to arid areas and to ensure permanent and long-term presence of additional moisture in arid regions and maintain the achieved steady state of weather on a specified territory.

Integrated technological solutions of the Climate Modification program for managed weather change will increase precipitation, regulate groundwater levels, eliminate the causes of dust storms, and also levelling of seasonal temperature contrasts to a comfortable level in the defined area of the Islamic Republic of Iran.

- The results of the application of the proposed Weather Management program will be visible within 2-3 months.

- **Integrated use of technology for Weather Management program for a period of 2-3 years will substantially resolve the Islamic Republic of Iran's needs of water resources**.

- A stable change of weather conditions in the defined areas (territory) of the Islamic Republic of Iran will occur within 5-7 years.

- Within 5-7 years the Islamic Republic of Iran's water security will be completely ensured.

The proposed Integrated Plan for Weather Management developed in accordance with the mechanism "UN - Water Resources" and take into account a national program to optimise water and energy consumption and other projects to improve water supply in the Islamic Republic of Iran.

The Weather Management program takes into account the critical water situation in the Islamic Republic of Iran and determines the key role of Iran in addressing the problems of water scarcity and ensuring water security of countries located within the Persian Gulf.

The Weather Management program for the Islamic Republic of Iran takes into account significant efforts of Iran to protect the environment.

XXIV. SUPPLIES OF WATER RESOURCES OF ATMOSPHERIC ORIGIN

Supplies of water resources of atmospheric origin and ensuring water security of the Islamic Republic of Iran with use Technological Solutions for Weather Management, namely:

A. Regulation of the Amount of Rainfall in a Given Area of the Islamic Republic of Iran

- Raising the level of rainfall approximately 50% in the arid season in the defined area of the Islamic Republic of Iran ;
- Ensuring the required amount of precipitation in a given area within an agreed time frame;
- Increasing the average levels of precipitation in the defined area the Islamic Republic of Iran;
- Filling of reservoirs with fresh water and Regulation of the water levels in reservoirs;

Problematics:

Iran's water resources are unevenly distributed, with more abundant surface water in the mountainous north and west, while the vast central and eastern regions of the country are primarily arid basins reliant on groundwater. These differences are due to the country's diverse geography and climate.

Iran is divided into six main water basins, each with distinct features.

1. Caspian Sea Basin

Location: Northern Iran, along the Caspian Sea coast.

Key features: This region has a relatively mild and humid climate with the highest annual precipitation in the country, up to 1,280 mm.

Water resources:

Rivers: Several rivers, including the Sefidrud, Haraz, and Tonekabon rivers, flow from the Alborz Mountains into the Caspian Sea.

Groundwater: Extensive aquifers are recharged by high rainfall and mountain snowmelt.

2. Persian Gulf and Oman Sea Basin

Location: The western and southern parts of the country.

Key features: Drains the western Zagros Mountains and features a warmer, more arid climate toward the south.

Water resources:

Rivers: Major rivers include the Karun, Iran's only navigable river, and the Karkheh, which flow into the Persian Gulf.

Tigris–Euphrates System: The basin is part of the larger Tigris-Euphrates river system.

Surface Water Reliance: Historically, this area relied on surface water, though it has seen significant reductions in recent decades.

3. Lake Urmia Basin

Location: Northwestern Iran.

Key features: The basin's main feature is Lake Urmia, once one of the largest saltwater lakes in the world.

Water resources:

Rivers: Numerous smaller rivers and streams drain into the lake.

Water Scarcity: Decades of drought, intensive water extraction, and upstream dam construction have severely diminished the lake's surface area and a high brine content now limits most aquatic life.

4. Central Plateau Basin (Dasht-e Kavir)

Location: The central and largest part of Iran, encompassing vast desert areas like the Dasht-e Kavir.

Key features: An arid region with very low rainfall, mostly occurring between October and March.

Water resources:

Rivers: Most rivers are seasonal, flowing only in spring from mountain snowmelt and draining into salt lakes or kavirs (playas) that dry up in the summer.

Groundwater: The region heavily depends on groundwater, including traditional qanat systems, though aggressive over-extraction is causing a severe water table decline.

5. Eastern Boundary Basin (Hamun basin)

Location: Eastern Iran, bordering Afghanistan.

Key features: A very dry region with some shared water resources and challenges with neighbouring countries.

Water resources: Includes seasonal rivers and salt lakes connected to the Iran-Afghanistan border region.

6. Ghareghom Basin

Location: Northeastern Iran, bordering Turkmenistan.

Key features: A basin with seasonal variations in flow, which has been studied for its climate variability.

Water resources: Streams and rivers in this region are often seasonal.

Water distribution challenges and solutions

Iran's significant water scarcity is driven by a combination of high climate variability, unequal water distribution, rising demand from population growth, and poor water management practices.

Groundwater over-extraction: Many areas, particularly the Central Plateau, rely heavily on groundwater, leading to a severe drop in water table levels.

Interbasin transfers: To address the imbalance between water-rich and water-poor areas, Iran has undertaken large-scale water transfer projects, including from the Caspian Sea to the central regions.

Desalination projects: The government is investing in seawater desalination projects and pipelines to supply water to inland cities from the southern coasts.

Water management: The Iran Water Resources Management Company (IWRMC) is responsible for managing these resources and enforcing water distribution regulations.

Multiple central and eastern provinces in Iran experience some of the lowest water resources per capita due to a combination of arid climates, increased population, and environmental mismanagement. While Tehran is frequently cited due to its large population and severe water cuts, provinces like Sistan and Baluchestan, Razavi Khorasan, and Isfahan consistently face extremely high water stress.

Provinces with critically low water resources

Sistan and Baluchestan: This province in southeastern Iran is historically dry and is one of the most vulnerable regions. In 2025, rainfall was reported to be 72% below the long-term average. The drying of wetlands has also led to severe dust storms that make living conditions even more difficult.

Razavi Khorasan: Located in the northeast, this province and its major city, Mashhad, are in a state of permanent drought emergency. Years of low rainfall and dwindling water reserves have pushed Mashhad to the brink of a water crisis, with officials warning that rationing is unavoidable.

Isfahan: This central province has faced severe water shortages after its main waterway, the Zayandeh Rud River, frequently dried up. The situation is driven by climate change, diversion of water to other provinces, and unsustainable water-intensive industries.
Tehran: Although not traditionally the driest province, Tehran faces critical water stress due to its enormous and growing population. The heavy demand puts immense pressure on local water resources, with warnings that the capital could face a complete depletion of its water supply.

The national context

The water scarcity in Iran is a national challenge driven by multiple factors, with the lowest resources per capita occurring in areas facing the worst combination of drought, high population density, and poor water management. An estimated 28 million Iranians live in regions with high to very high water stress.

Proposed Solution:

The uniqueness of the technology for weather management allows the delivery of Mega-litres (ML) of water over long distances and the precipitation of atmospheric origin in huge areas determined by the Government of the Islamic Republic of Iran, as a Client which allows solving problem of water security of the Islamic Republic of Iran, including the regions suffering from water scarcity.

Integrated technological solutions of the Ionospheric Climate Modification program allow for the provision of additional inflow of moisture into the arid regions of the country by the transfer of wetted masses of air, which will increase precipitation in arid areas at least 300 mm a year that will eliminate water scarcity for household and industrial needs of cities of the Islamic Republic of Iran.

Thus, integrated technological solutions of the Climate Modification Technology allow radically reduce costs for regulation of the amount of rainfall in the areas of the Islamic Republic of Iran suffering from water scarcity and also radically reduce costs for regulation of groundwater level.

Thus, the unique way of supplying large volumes of water of atmospheric origin has a colossal advantage over the conventional methods of supplying fresh water and has a positive impact on the agricultural sector, energy sector and the entire economy of the Islamic Republic of Iran.

B. Regulation of Groundwater Level

1. Rise of groundwater level;

2. Reduction of groundwater salinity;

3. Change the level of humidity of soil;

Problematics:

Many of the world's most important farming regions cannot rely on rain alone to to irrigate their crops, as such, they pump freshwater from underground aquifers that have slowly filled up over many thousands of years.

The underground aquifers take an excessively long time to recharge, the farmers are drawing water faster than natural replenishment, creating a further problem as the basins will eventually run dry.

Iran Aquifer Depletion

Iran's aquifers are being rapidly depleted due to decades of unsustainable groundwater extraction, primarily for agriculture. This widespread and excessive withdrawal is compounded by poor governance and climate variability, creating a severe water crisis that threatens the country's environmental, economic, and social stability.

Causes of aquifer depletion

Unsustainable agricultural water use: Agriculture accounts for approximately 92% of Iran's water consumption. The pursuit of food self-sufficiency led to a dramatic increase in groundwater extraction through the drilling of millions of wells, far exceeding the natural replenishment rate of aquifers.

Poor water management and governance: Decades of short-sighted policies have been described as "water bankruptcy," with ineffective regulations on water usage. This includes:

- **Uncontrolled drilling:** As of 2025, there are over one million extraction points, with a reported 500,000 illegal wells operating across the country.
- **Subsidised water and energy:** Inexpensive access to water and power encourages overuse, as consumption is not limited by cost.
- **Misguided infrastructure projects:** The construction of dams often prioritised political and economic gain over environmental impact, leading to the drying up of major rivers and wetlands.

Climate change and drought: As a predominantly arid country, Iran's water resources are highly sensitive to climate shifts. Decades of declining rainfall and rising temperatures have reduced natural aquifer recharge, intensifying the water crisis.

Effects of aquifer depletion

Land subsidence: The most visible consequence is the massive sinking of land, caused by the compaction of sediments as water is drained.

- Land subsidence affects 3.5% of Iran's territory, with rates among the highest in the world. Some regions, like the pistachio-producing Kerman province, are sinking at over 35 cm per year.

- This has resulted in irreversible damage, including vast cracks, earth fissures, and sinkholes.

Infrastructure damage: The sinking ground puts critical infrastructure at risk.

- Airports, roads, and railways across the country intersect with subsidence zones.
- In Tehran alone, subsidence threatens major infrastructure, including 14 metro stations and the Imam Khomeini International Airport.

Water and food security threats: Aquifer depletion is directly compromising Iran's access to fresh water and food.

- The cumulative depletion of groundwater is estimated to be 3.4 times the capacity of China's Three Gorges Dam.
- Salinisation of soil and remaining groundwater has risen sharply, jeopardising salt-intolerant crops and accelerating desertification.

Social and economic instability: As rural water sources disappear, displaced farmers and rural populations migrate to urban centres, intensifying competition for resources and increasing poverty.

Increased dust storms: The drying of wetlands and lakebeds, such as Lake Urmia, liberates contaminated salt and dust particles. Strong winds can carry this polluted dust, harming millions in nearby areas.

Status and outlook

Despite the alarm, effective solutions have yet to be implemented. Experts warn that unless there is a transformative shift away from resource-extractive development, the crisis will continue to worsen.

- Recent satellite data show that depletion and subsidence are not recovering, even during wetter years.
- While engineers attempt to implement small-scale artificial recharge projects, these measures are vastly outpaced by the rate of depletion.
- Studies project that over the next few decades, Iran's aquifer deficits could increase by 42% to 174%, depending on climate scenarios

Proposed Solution:

Integrated technological solutions of the ICM program allow for the restoration and maintenance of the required level of groundwater within the agricultural and industrial areas of the Islamic Republic of Iran by providing additional annual rainfall in the arid areas..

The uniqueness of the technology for weather management allows the delivery of Megalitres (ML) of water over long distances and the precipitation of atmospheric origin in large pre-determined areas by the Government of the Islamic Republic of Iran, as a client, which will ensure restoration to the required level of groundwater within the regions suffering from water scarcity.

The unique way of supplying an immense volume of water of atmospheric origin provides a major advantage over the conventional methods of supplying fresh water, for the restoration of the required level of groundwater, and will provide a positive impact on the agricultural sector, energy sector and the entire economy of the Islamic Republic of Iran.

Thus, innovative technology for weather-management effectively provides restoration the required of groundwater level and radically reduce costs for combating water scarcity and ensuring of national water security for the Islamic Republic of Iran.

C. Reduction of the Effect of Dust Storms Within the Islamic Republic of Iran

Neutralise Atmospheric Anomalies in Advance

1. Elimination of factors generating dust storms;

2. Elimination of factors of generating tsunami, cyclones, tornadoes and hurricanes in the water areas of the Indian and Pacific Oceans.

Elimination of Factors Generating Dust Storms

Problematics:

Dust storms in Iran are caused by a combination of regional environmental degradation, human activities, and climate change, with both internal and transboundary sources contributing to the problem. External sources, particularly from neighbouring Iraq and Syria, are estimated to be responsible for 60–80% of the dust affecting Iran.

Transboundary factors

Dust from outside Iran is largely generated in the deserts and dried marshlands of neighbouring countries to the west and northwest, carried by strong regional wind systems.

Drying of Mesopotamian marshes: Decades of conflict, drought, and water mismanagement in Iraq have led to the significant drying of wetlands like the Mesopotamian marshes, including the Hawr al-Azim and West Hammar Marshes on the Iran-Iraq border. These exposed lakebeds have become major dust sources.

The drying of the Mesopotamian marshes, primarily located in southern Iraq, is caused by deliberate drainage under Saddam Hussein's regime, dam construction in upstream countries, climate change, and mismanagement of water resources. This environmental disaster has caused desertification, forced migration, loss of biodiversity, and increased pollution.

Causes

Political draining by Saddam Hussein: In the 1990s, the Iraqi government systematically drained around 90% of the marshes to punish the Marsh Arabs (Ma'dan) who participated in the 1991 uprising. Major canals were built to divert the Tigris and Euphrates rivers, devastating the ecosystem.

Upstream damming: Turkey and Iran have constructed numerous dams on the Tigris and Euphrates rivers and their tributaries, drastically reducing the water flow into Iraq. The UN has reported that Turkey's dam networks have cut Iraq's water share by 60%.

Climate change: Iraq is identified by the UN as the fifth most vulnerable country to climate change. Record-low rainfall and soaring temperatures have caused severe droughts and accelerated evaporation, placing additional stress on the marshes.

Water mismanagement: Outdated irrigation systems and poor water management practices within Iraq contribute to the crisis. Reports indicate that politically influential individuals have illegally diverted water, further disadvantaging marsh communities.

Consequences

Desertification and soil salinity: The draining of the wetlands has led to desertification across thousands of square miles. Without a continuous flow of fresh water, salt has built up in the soil and water, making it unsuitable for agriculture and native species.

Forced migration and cultural loss: Tens of thousands of Marsh Arabs have been displaced from their ancestral homes, becoming internal or international refugees. With many abandoning their traditional way of life, a culture that existed for thousands of years is at risk of being lost forever.

Collapse of livelihoods: The crisis has decimated traditional marsh activities like water buffalo herding, fishing, and reed harvesting. Many herders have lost their livestock to disease and malnutrition, while fishermen report smaller catches of low-quality fish.

Ecosystem and biodiversity loss: The marshes, once a haven for diverse wildlife, have seen a massive decline in species. Bird populations have fallen significantly, with some endemic species possibly driven to extinction.

Increased dust storms: Dried-up lake beds and marsh areas have become sources of dust, contributing to more frequent and intense dust storms that harm air quality and public health in the region.

Restoration efforts and challenges

Partial restoration: After Saddam Hussein's fall in 2003, Marsh Arabs began to re-flood the areas by tearing down embankments. Initial UN and Iraqi government efforts successfully restored some areas, reaching 58–75% of their original size by 2008.

Ongoing threats: Despite restoration, the marshes remain vulnerable to drought and continued upstream damming. The long-term outlook is described as bleak without radical changes to water management and greater international cooperation.

Water management

Unsustainable water use: The Mesr Desert is located in Iran's Central Plateau, a naturally arid region. The pursuit of agricultural self-sufficiency has led to inefficient and water-intensive farming practices, which are unsustainable for the region's climate.

Depletion of groundwater: Increased demand from agriculture and a growing population has led to the excessive drilling of deep wells and over-extraction of groundwater. This has severely depleted aquifers, causing dropping water tables and significant land subsidence in many areas of Iran.

Over-reliance on dam construction: Decades of aggressive dam construction have disrupted natural water flow and have led to increased water loss through evaporation. While dams are used to regulate river flow, in Iran they have contributed to surface water shortages and the drying of wetlands downstream.

Uneven water distribution: Water from the few water-rich regions is often diverted to the central desert, creating tension and exacerbating water scarcity in both the source and destination regions.

Drought and desertification: Long-term drought and climate change are degrading soil and accelerating desertification across Iran's arid and semi-arid regions. The resulting lack of vegetation cover leaves the soil vulnerable to wind erosion.

Poor resource management: Inefficient land and water management practices, including the mismanagement of wetlands and rivers, have worsened desertification. Some wetlands have been drained for agriculture or oil extraction, transforming them into dust sources.

Proposed Solution:

The integrated technological solutions of the Climate Modification Technology provide an effective tool for combating the generation of dust storms within the Islamic Republic of Iran

Technological solutions of the Climate Modification program effectively combat the generation of dust storms, by ensuring the required level of fine precipitation (finely dispersed rains) within a defined period of time over desert areas where dust storms generate.

The unique technology for weather management would ensure the delivery of Mega-litres (ML) of water over long distances and the precipitation (finely dispersed rains) of atmospheric origin directly to areas of desert where dust storms are known to generate.

Thus, innovative technology for weather management allow to effectively provide elimination of the factors that generate dust storms at a radically reduced cost, one that is far less than the current annual estimated losses to Iran’s economy.

D. Combating Atmospheric Air Pollution

Integrated technological solutions of the Ionospheric Climate Modification Technology combat atmospheric air pollution by the change the strength and direction of prevailing winds

Problematics:

In Tehran, water crises are strongly linked to high Air Quality Index (AQI) readings, though not as the primary cause. While Tehran's location, traffic, and industry are the main drivers of pollution, water scarcity has significantly worsened the city's air quality through indirect effects, particularly by increasing dust storms.

The connection between water scarcity and air pollution is well-documented and has prompted severe warnings from experts.

How water scarcity impacts Tehran's air quality

Dust storms from dried wetlands: Decades of severe water mismanagement, including extensive dam construction and groundwater depletion, have dried up key wetlands and lakes in Iran, such as Lake Urmia and Hoor al-Azim. These dried-up lakebeds and wetlands turn into vast sources of sand and salt-laden dust that are carried by the wind and severely degrade the air quality in Tehran and other major cities.

Increased use of heavy fuel oil (mazut): Droughts reduce the output of hydroelectric power plants. To compensate, power plants and industrial facilities increase their use of heavy fuel oil, or mazut, which is a major source of air pollution. The burning of mazut has been directly linked to a significant number of annual deaths in Tehran due to air pollution.

Impact of migrating populations: Water shortages in rural areas cause people to migrate to cities like Tehran, placing a greater strain on urban infrastructure and increasing traffic congestion and pollution. This adds to Tehran's already severe and consistent pollution problem.

Recent AQI reports during water crises

September 2025: Tehran was reported among the world's most polluted cities, with dangerous levels of pollution recorded. These reports coincided with warnings about critically low dam water reserves—some as low as 12%—due to severe drought.

January 2025: A combination of mazut burning and the drying up of the Salehiyeh Wetland (which became a source of dust) contributed to alarming air pollution and health problems in Tehran.

May 2022: As severe water shortages plagued the country, the air quality index in Tehran reached "hazardous" levels.

Summer 2021: Large-scale protests occurred in provinces like Khuzestan over water shortages and the resulting harmful effects, including severe air pollution from dust storms.

Tehran's inherent air pollution issues

While the water crisis has exacerbated pollution, Tehran's geography and urban characteristics create a persistent pollution problem regardless:

Geographic location: The city is situated in a valley, with mountains trapping pollutants. During the colder seasons, temperature inversions worsen the issue by trapping cold, stagnant air and emissions.

Traffic and emissions: The city's immense traffic and reliance on fossil fuels are primary contributors to smog and poor air quality

Proposed Solution:

The technological solutions of the Climate Modification program effectively combats pollution of atmospheric air by transferring air masses over long distances.

The technological solutions of the Climate Modification program change the strength and direction of prevailing winds, replacing polluted air masses with clean atmospheric air above the industrial cities within Iran or over a defined territory of the Islamic Republic of Iran

The integrated technological solutions of the Climate Modification program ensure the complete or partial purification of the atmosphere of large industrial cities of Iran, for example, the Tehran, namely:

- Washing out of solid and water-soluble contaminants from the atmosphere of Tehran with the assistance of precipitation in the form of fine dispersion rain.

- Changing the direction of the prevailing winds (Wind Rose), moving polluted air outside the city limits and forming horizontal air mass transfer "channels" for removal of contaminated air masses from the Tehran atmosphere.

- Formation of vertical convective flows and channels of air mass transfer for the influx of clean and cold air from the upper layers of the atmosphere, with follow removal of contaminated air masses from the surface layers beyond the "dead" zone to a height from 500 m. to 5000 m. and further removal of contaminated air masses by horizontal "channels" of air mass from the Iran atmosphere.

Thus, innovative technology for CGCT Weather Management program radically reduce the pollution of Riyadh atmosphere and other cities of the Islamic Republic of Iran from the "Hazardous" and "Unhealthy" levels to "Moderate" and "Good" levels and radically reduce costs for combating atmospheric air pollution.

E. Regulation of Seasonal Temperature Contrasts

1. Changing maximum and average temperature in a given territory;

2. Change the temperature of the environment (up to 5-10 Celsius degrees);

3. Levelling seasonal and territorial weather and temperature contrasts to a comfortable level;

4. Change the level of humidity of air;

Problematics:

Iran has immense seasonal temperature contrasts due to its diverse geography of mountains, deserts, and coastal areas. The country's four main climate zones can result in temperature differences of more than 50°C (90°F) between the coldest winters in the northwest and the hottest summers in the desert.

Northern coastal and mountainous regions

Caspian Coast

Summer: Hot and humid, with average July temperatures around 26°C (79°F), and highs that can reach 38°C (100°F). Humidity from the sea makes the heat feel more oppressive than the dry heat inland. This area is a popular domestic summer escape from the heat of the central plateau.

Winter: Mild and wet, with subzero temperatures being uncommon. Rainfall occurs year-round but is heaviest from late summer to mid-winter.

Northwest Mountains (Alborz and Zagros)

Summer: Mild to warm, with cooler temperatures at higher elevations. Summers are typically dry.

Winter: Severely cold, with heavy snowfall and sub-freezing temperatures. In cities like Tabriz, temperatures regularly drop well below freezing. The high altitudes allow for skiing and other winter sports.

Central and eastern plateau

Central Deserts (Dasht-e Kavir and Lut Desert)

Summer: Scorchingly hot and arid. Temperatures can exceed 50°C (122°F) during the day, with the Lut Desert having recorded some of the highest ground temperatures on Earth.

Winter: Cold and dry, especially at night when temperatures can drop below freezing. There is very little precipitation throughout the year.

Central Cities (e.g., Tehran, Yazd, Isfahan)

Summer: Hot, with dry air and high temperatures. In Tehran, July daytime temperatures average 35°C (95°F). In Yazd, temperatures can reach 39°C (102°F).

Winter: Cold and wet. Temperatures are lower than in the desert but higher than in the mountains. In Tehran, January temperatures can drop to 5°C (41°F) during the day and well below freezing at night, with occasional snow.

Southern coastal regions

Persian Gulf and Gulf of Oman

Summer: Extremely hot and humid, with average temperatures in July around 35°C (95°F). The combination of high temperatures and high humidity creates a very oppressive and uncomfortable climate, with a risk of heat exhaustion.

Winter: Very mild and pleasant. Average winter temperatures are much warmer than in the rest of the country, making it a popular winter travel destination.

Summary of seasonal differences

Region	Summer (Jun–Aug)	Winter (Dec–Feb)
Caspian Coast	Hot and humid; average 26°C (79°F), up to 38°C (100°F).	Mild and wet; subzero temperatures are rare.
Northwest Mountains	Mild to warm and dry.	Severely cold with heavy snow; temperatures well below freezing.
Central Deserts	Extremely hot and arid; day temps over 50°C (122°F).	Cold and dry, with freezing nighttime temperatures.
Central Plateau Cities	Hot and dry; Tehran average 35°C (95°F).	Cold and wet; occasional snow; Tehran average 5°C (41°F).
Southern Coasts	Extremely hot and humid; average 35°C (95°F).	Mild and pleasant; popular for winter travel.

Proposed Solution:

The integrated technological solutions of the Ionospheric Climate Modification program allow reduction of the maximum and average summer air temperatures, by creating conditions for controlled quasi-convection influx of cold air masses from the upper layers of the troposphere into the heated surface layer of the atmosphere and mixing them, which results in a steady decrease of the maximum and average temperature by 8-10 degrees as well as increases the humidity of surface air.

The integrated technological solutions of the Ionospheric Climate Modification program provide formation of managed vertical convective flows and channels of air mass transfer for the influx of clean and cold air from the upper layers of the atmosphere, with follow removal of heated air masses from the surface layers beyond the "hot" zone to a height from 500 m. to 5000 m. and further removal of hot air masses by horizontal "channels" of air mass from the atmosphere of big cities within the Kingdom of Saudi Arabia.

The regulation of seasonal temperature contrasts will ensure a year-round beach season in the tourist areas of Iran, leading to further development of tourism sector as well as having a positive impact on the entire agricultural sector of the country that will significantly improve the efficiency of the entire economy of the Islamic Republic of Iran.

The complex technological solutions of the Climate Modification program allow radically reduce costs for combating with the consequences of weather contrasts and temperature anomalies.

XXV. COMPARISON OF WEATHER MITIGATION SERVICES TECHNOLOGIES:

Compare our ICM technology and other rain generating techniques, such as cloud seeding, currently available.

WATER RESOURCES OF ATMOSPHERIC ORIGIN (IONOSPHERIC TECHNOLOGIES)

There are some technologies that are able to generate rainfall from dense clouds, but there are **no other technologies** like ICM that is able to move heavy rain bearing clouds from one place to another or from Oceans to any land area, even over distances in excess of thousands of kilometres, or change the direction and speed of winds, quench hurricanes, change their direction and weaken them, and increasing or decreasing the monthly and yearly temperature.

CLOUD SEEDING (CHEMICAL TECHNOLOGIES)

The technology of cloud seeding is a technology for increasing the amount of precipitation (rain, snow, hail, and fog) that falls from clouds by means of dispersing into the air chemicals that include the silver iodide, potassium iodide, and dry ice (solid carbon dioxide, and also could use Liquid propane, which expands into a gas and can produce ice crystals at higher temperatures than silver iodide. Also Sodium, which is becoming more popular.

Cloud seeding chemicals may be dispersed by aircraft or by dispersion devices located on the ground (generators or canisters fired from anti-aircraft guns or rockets). For release by aircraft, silver iodide flares are ignited and dispersed as an aircraft flies through the inflow of a cloud. When released by devices on the ground, the fine particles are carried downwind and upward by air currents after release.

XXVI. Summary of Previous ICM Projects Within The Islamic Republic of Iran

Project "Kerman" - Iran 2007

On the 31st May 2007 CGCT began a two month demonstration of the Climate Modification Program over a 100 square kilometre pre-determined area within the Hamun-e Jaz Murian region of Iran - coordinates 31.4360° N, 49.0413° E.

Th designated area was situated in the western part of a valley between the Makran and Kuh Rud mountain ranges, and bordered by the Kuh Rud foothills to the West, a dry lake to the East, and the newly constructed road to Iranshahr to the North.

The nearest meteorological station, that had archive data available that included the pre-determined project area, was Kahnuj, that is located approximately 660km to the South East of Hamun-e Jaz Murian.

The Khanuj station's data showed an average monthly precipitation level in June as just 0.7 mm and 2.9 mm in July for the preceding five years.

The Mohammad Abad Koteki Weather station, which is situated close to the centre of the demonstration area (longitude of 58-36E, latitude of 27-49N) reported that on the 24th July 2007 the level of precipitation in the pre-determined area was 23 mm.

There was a further 13 mm precipitation on the 26th July 2007 - a total precipitation of 36 mm was achieved within the pre-determined area within sixty days.

An additional result of the operation included a change of the weather conditions over the region.

The precipitation in Iranshahr during the month of June was increased 64%, based on the average annual precipitation rate and the precipitation level in July was in excess of thirty times the previous five year average.

Similar weather anomalies were registered throughout the entire region. These anomalies were caused by moisture alone, as ICM had discharged the bulk of water transferred from the Pacific Ocean into the Arabian Sea, which is illustrated by data from the Goddard Space Centre, that demonstrates the weekly precipitations accumulated over the period 21st - 27th June 2007.

The demonstration caused a dramatic change of the weather patterns, including anomalous tropical cyclone 03B**, that appeared during the moisture transfer process.

The tropical cyclone 03B was the main source of precipitation and energy to enable the transfer of the precipitation to the pre-determined region of the demonstration.

The tropical cyclone 03B was directed over the Hindustan peninsula to the Arabian Sea to ensure minimal loss of humidity and energy.

It should be noted that the main precipitation occurred on the south coast of Iran and in mountainous regions, which hindered higher levels of precipitation reaching the pre-determined Hamun-e Jaz Murian Valley.

** NASA Earth Observatory: https://earthobservatory.nasa.gov/images/18567/tropical-cyclone-03b

Project Kerman data and climatic imagery on file at head office and available

Project “Urmia" - Iran 2010

The aim of project Urmia was to raise precipitation levels above the seasonal norm by 30 - 40 mm during a month long trial. Project Urmia was a massive success, generating more than 60 mm of rainfall.

This was achieved via the active transfer of moisture, by forming of the localised stationary "mini-cyclone" to provide transfer of moisture from the Caspian and Black Sea region as well as the North Caucasus.

Precipitation for 30 days within the epicentre of the project target area from 30th May 2010 to 29th June 2010 was more than 100 mm and over the same period, in excess of 150 mm of rain fell within bordering regions in Iran.

Notably Khuzestan Province, which was the epicentre of the first precipitation and Tehran, the epicentre of the second precipitation experienced in excess 250% increase in precipitation, in comparison to the historic climatic norm.

An additional result of project Urmia was that significant levels of precipitation fell over 85% of Iran during the “dry season”.

Project Urmia data and climatic imagery on file at head office and available

Project "Khuzestan" - Iran 2011

The Scientific and Industrial Department of the Embassy of the Islamic Republic of Iran organised talks with regard to Practical Application of Technology driven climate change, in order to address environmental and economic problems within the Islamic Republic of Iran.

Iranian Representatives Present:

Mehrab Rouhbakhsh, Attach. of Science and Industry

Mehdi Ghalenovi, Director of Industrial Technologies Department, Centre for Innovation andTechnology Cooperation (CITC) (Iran)

Mr Hodemi, deputy governor of Khuzestan province (Khūzestān Province)

Abbas. Holacoei, Ahwaz Urban Railway Organisation Managing Director

Dr. Amir Mahmoodzadeh, Sharhes Sazan Managing Director

The Deputy Governor of Khuzestan province, Mr. Hodemi acted as the representative of the Client at the talks that took place in December 2010.

The client expressed a desire to achieve full climate conversion in the region via technology controlled climate change.

Project requirements:

1. increase rainfall in the province of Khuzestan (Khūzestān Province) with the aim to eliminate the effects of drought, recharge of water in natural water bodies and reservoirs as well as raise the level of groundwater;

2. decrease in the number and intensity of dust storms.

Khūzestān Province Coordinates: 31.4360° N, 49.0413° E

It should be noted: Due to the client's failure to provide confirmation of the required payment guarantees, it was decided that the project would continue, albeit as a short term demonstration of the localisation and intensity of changes in climatic parameters in the region, rather than the full climate change parameters as agreed.

Results

The demonstration region was the province of Khuzestan.

The month long demonstration took place from the 10th January 2011through to the 9th February 2011, during the demonstration period the precipitation level over the entire region was between 50 to 200 mm of rainfall, which equates to approximately 250% above the seasonal norm for this region in addition, zonal anomaly ranged from 60 to 150 mm of precipitation equating to an annual rate of 280 mm rainfall.

The majority of the precipitation was localised in the Khuzestan province but also included bordering provinces, including ones close to the UAE

Anomalies also provided precipitation (10-30 mm) over large parts of desert in Iraq and Saudi Arabia that were prone to dust storms. This also provided a convenient and favourable climatic conditions in the Persian Gulf countries, especially in coastal areas.

Rainfall on 9th February 2011 in the extended area ranged from 20 to 60 mm and excess rainfall over the 30 days in the period in the central zone was more than 150 mm (approx 300% over seasonal norm)

Project Khuzestan data and climatic imagery on file at head office and available

Cyclone Transfer - UAE 2019

Cyclone transfer provides capture and accumulation (concentration) of water vapour for subsequent transfer to a target area or region.

Control and formation of Cyclone transfer via ICM technologies generates high levels of energy within the activation zone - in this particular case; North-West part of Indian Ocean and Arabian Sea - forcing wind correction over the target area or region, as well as adjacent territories.

Maintenance of the process is realised by external high-energy pumping up of zones of activation, by interception and capturing of high speed wind flows on adjacent territories and creation of conditions for formation of self-supporting process within the framework of managing algorithms and programs.

The main purpose of creation of the Anomaly “Cyclone transfer” – is a demonstration of immensity (scale) of areas of impact and energy of involved processes and programs of managing of climate processes.

The additional purpose of creation of Anomaly “Cyclone transfer” – is the creation of an effective tool for managing correction of climate in the region.

The secondary purpose of creation of Anomaly “Cyclone transfer” – is adjustment of the technology for external high-energy pumping up of the zones of activation and creation of energy, temperature and wind anomalies, activation of cyclones, managing of trajectories and power of cyclones, retention of cyclones in the activation zones for a time comparable to the "life" of the cyclone.

Results

Formation of Anomaly “Cyclone transfer” began in the framework of program of trajectory management of cyclone VAYU** and was used for formation of a channel for transfer of precipitation deep into Arabian Peninsula and to the UAE territory (Abu-Dhabi emirate)

** Nasa Earth Observatory: https://www.earthobservatory.nasa.gov/images/145175/cyclone-vayu-approaches-western-coast-of-india

Cyclone Transfer data and climatic imagery on file at head office and available

XXVII. Payment Model - Climate CRON

Minimum area coverage for provision of water resources via Ionospheric Climate Modification program is 100,000 square kilometres and up to 3 million square kilometres.

ICM is also able to manage weather processes within commercial projects (minimum of 2,000 square kilometres)

The cost per square kilometre is 1 x Climate CRON (current price $US 55,000) - Minimum order for ICM program 100,000

Payment for the Ionospheric Climate Modification Technology is via CRON, specifically the Climate CRON

Climate CRON is a payment instrument for the governments of countries in order to carry out import-export transactions, as well as projects related to the climate and water security of the participating countries of the project.

For further Climate CRON information please go to https://climatecron.com

To order Climate CRON please go to https://climatecron.com/order

Presentation prepared for

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