

University of Mila
Faculty of Natural and Life Sciences
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Course: Sustainable Management of Water Resources
Master 1: Ecosystem Protection

Learning objectives

- Distinguish the main categories of water resources and explain their place in the hydrological cycle.
- Define aquifers, groundwater recharge, watersheds, water scarcity, and water contamination.
- Describe the distribution and use of water resources in Algeria using the figures reported in the course materials.
- Explain the principal infrastructure used to mobilize conventional and non-conventional water resources.
- Identify major pressures on water quantity and quality and outline principles of sustainable management.

Course outline

1. Key concepts and the global distribution of water
2. Types of water resources
3. Groundwater: occurrence, contamination, and sustainable management
4. Water resources in Algeria: distribution and use
5. Water-resource mobilization infrastructure
6. Non-conventional resources
7. Threats and principles of sustainable management

Introduction

Water is an essential natural resource for life, human activities, and ecosystem functioning. However, its availability varies considerably across geographical regions and seasons. Population growth, climate change, pollution, and increasing

water demand are placing growing pressure on water resources worldwide. These resources include surface water, groundwater, and non-conventional sources, all of which are interconnected through the hydrological cycle. Understanding their distribution, characteristics, and uses is essential for ensuring sustainable management. Groundwater is particularly important in arid and semi-arid regions, where surface-water resources are often limited. In Algeria, water-resource management represents a major challenge because of irregular rainfall, uneven geographical distribution, and increasing demand. Dams, groundwater extraction, water-transfer systems, desalination, and wastewater reuse contribute to meeting national water needs. Nevertheless, protecting water quality and improving water-use efficiency remain essential priorities. This course examines the main types of water resources, their distribution and utilization, groundwater management, and the infrastructure used to mobilize conventional and non-conventional resources. It also addresses the major threats to water quantity and quality and introduces the principles of integrated and sustainable water-resource management.

1. Key concepts

1.1. Water source

A water source is a place where groundwater naturally emerges at the land surface. Discharge may occur directly through an opening or indirectly through fractures and permeable geological formations. Springs commonly form where

groundwater intersects the ground surface or where geological conditions force groundwater to emerge.

1.2. Environment

The environment comprises the physical, chemical, biological, climatic, geographical, and cultural conditions in which organisms and humans in particular live and develop. For water-resource management, it includes both natural systems and human activities that influence water quantity, quality, and availability.

1.3. Aquifer

An aquifer is a geological formation capable of storing and transmitting usable quantities of groundwater to wells, springs, or other discharge points. An aquifer is not necessarily an underground river or lake: water is generally held and transmitted through pores, fractures, or other connected openings in rock and sediment.

1.4. Drainage basin (watershed)

A drainage basin is the land area from which precipitation and surface runoff drain toward a common outlet, such as a river, lake, reservoir, or sea. Basin boundaries are defined by topographic divides. Water generally moves downslope from headwaters to the outlet, although groundwater flow may cross-topographic boundaries in some geological settings.

1.5. Water scarcity

Water scarcity occurs when the quantity and/or quality of available water is insufficient to meet demand. Scarcity may be physical (limited water availability), economic or infrastructural (water exists but cannot be accessed reliably), or quality-related (pollution makes water unsuitable for a given use).

2. Types of water resources

Category	Main forms	Key characteristics
Groundwater	Unconfined and confined aquifers; wells and springs	Stored below ground; replenishment depends on recharge, geology, and climate.
Surface water	Rivers, streams, lakes, reservoirs, and hill reservoirs	Directly influenced by rainfall, runoff, evaporation, and catchment activities.
Non-conventional resources	Desalinated seawater; treated wastewater reused for suitable purposes	Can supplement conventional supplies, but require energy, treatment, monitoring, and appropriate management.

These categories are connected through the hydrological cycle. Precipitation may infiltrate and recharge aquifers, run off into streams and reservoirs, or return to the atmosphere through evaporation and plant transpiration. Groundwater can sustain river flow during dry periods, while rivers and managed structures may contribute to aquifer recharge.

3. Groundwater resources

3.1. Groundwater in the hydrological cycle

Groundwater is the portion of water stored beneath the Earth's surface in saturated geological formations. Recharge commonly occurs when precipitation or surface water infiltrates through soil and permeable geological layers. Groundwater discharges naturally to springs, rivers, wetlands, and coastal waters, or is abstracted through wells and boreholes.

3.2. Unconfined and confined aquifers

Feature	Unconfined aquifer	Confined aquifer
Upper boundary	Water table; no continuous confining layer above it	Bounded above by a low-permeability layer, at least over part of its extent
Recharge	Often receives direct recharge from infiltration at the surface	Recharge generally occurs where the aquifer outcrops or through leakage

Water pressure	Water level in a well corresponds approximately to the water table	Water rises in a well to the potentiometric level; it may rise above ground in artesian conditions
Vulnerability	Often more directly exposed to surface-derived contamination	May be better protected, but can still be contaminated through recharge areas, wells, or leakage

3.3. Groundwater contamination

Groundwater contamination occurs when physical, chemical, or biological agents enter an aquifer at levels that impair its intended uses or harm ecosystems and human health. Contaminants may persist because groundwater movement is often slow and natural attenuation can be limited.

3.4. Main anthropogenic sources

Pressure/source	Potential contaminants or effects	Management priorities
Urbanization	Untreated wastewater, pathogens, nutrients, oils, metals, chemicals, and leachate from waste	Wastewater collection and treatment; secure waste disposal; stormwater management; protection zones around wells
Industry	Solvents, oils, process chemicals, metals, and potentially hazardous wastes	Effluent treatment; containment; monitoring; safe storage and disposal
Mining	Acid mine drainage and mobilized metals; changes to groundwater flow	Mine-water management; prevention of acid drainage; long-term monitoring and remediation
Agriculture	Nitrate, pesticides, herbicides, veterinary pharmaceuticals, salts, and irrigation-related changes	Nutrient planning; careful pesticide use; efficient irrigation; soil and groundwater monitoring

3.5. Groundwater overexploitation

Overexploitation occurs when abstraction causes unacceptable long-term impacts. These may include declining groundwater levels, higher pumping costs, reduced spring discharge and river baseflow, wetland drying, land subsidence in susceptible settings, and saline intrusion in coastal aquifers. A simple long-term

sustainability principle is to avoid abstraction that persistently exceeds renewable recharge; however, sustainable yield must also account for ecological needs, water quality, and the location and timing of recharge and discharge.

3.6. Principles of sustainable groundwater management

- Monitor groundwater levels, abstraction volumes, recharge, and water quality.
- Control activities that may contaminate aquifers, particularly in recharge areas.
- Prevent excessive pumping and account for the water needs of rivers, springs, and wetlands.
- Assess environmental impacts before implementing major abstraction or recharge projects.
- Use artificial recharge only where hydrogeological conditions, source-water quality, and long-term monitoring make it appropriate.

4. Water resources in Algeria

Algeria covers approximately 2.4 million km². The course material emphasizes the strong north-south contrast: most renewable surface-water resources are concentrated in the north, while much of the south is arid or hyper-arid. The source slides report that around 90% of the national territory is desert, where precipitation is very low.

4.1. National resource estimates reported in the source

Resource category	Reported volume	Context / caution
Renewable surface water	12.5 billion m ³ /year	Reported for the northern Mediterranean-draining basins and associated planning assessments.
Renewable groundwater	2.5 billion m ³ /year	Source estimate for northern groundwater resources.
Saharan resources	5.5 billion m ³ /year	Reported as approximately 0.5 billion m ³ /year of surface flow and 5 billion m ³ /year of groundwater, described in the source as fossil groundwater.

5. Water use and withdrawals in Algeria

5.1. Reported withdrawals by source

Source	Reported abstraction (hm ³ /year)
Surface water from dams	700
Surface water from rivers and hill reservoirs	100–150
Northern groundwater	1,600
Southern groundwater	1,700
Total reported	4,100-4,150

The source estimates total annual withdrawals at approximately 4.1-4.15 billion m³. These are figures reported by the teaching material for an unspecified recent period; the reference year should be supplied before they are presented as current data.

5.2. Agricultural water use

The course material reports 454,000 ha of irrigated land, distributed as follows:

Irrigation category / location	Area (ha)	Share (%)
Large schemes supplied by dams	38,000	8.4
Irrigation in ten southern wilayas	142,000	31.3
Small and medium irrigation in the north	274,000	60.3
Total	454,000	100.0

The source distinguishes three irrigation systems:

System	Description in the source
Large-scale irrigation	Large, formally organized irrigation schemes supplied mainly by major storage dams.
Medium-scale irrigation	Collective irrigation areas, including areas downstream of hill reservoirs, or groups of private farmers.
Small-scale irrigation	Individual irrigation using wells and pumping from wadis.

A separate source figure gives the following distribution: large-scale irrigation 19.2%, medium-scale irrigation 29.5%, and small-scale irrigation 51.3%. The original figure's labels and category mapping should be checked against the graphic before publication.

5.3. Domestic water use

The source material states that the share of drinking-water supply rose from 16% of total water consumption in 1975 to 40% at the time of the source. It reports average daily consumption of approximately 175 litres per person and compares this with a 250 L/person/day benchmark. It also estimates domestic water supplied at about 2 billion m³, with 60% originating from dams and 40% from groundwater.

The source further reports current drinking-water demand of 2,400 hm³/year and a projection of approximately 3,200 hm³/year by 2030 if demand-management practices remain unchanged. These figures require dates and confirmation from the relevant national planning source.

5.4. Industrial water use

The source gives an estimate of 125,000 m³/year for industrial water needs in 2009, with hydrocarbons accounting for nearly 45% and iron and steel for 18% of industrial consumption. It projects industrial demand of around 200,000 m³/year by 2030. The units and magnitudes should be verified: as written, these values may be inconsistent with the scale of national industrial water use.

6. Infrastructure for mobilizing water resources

6.1. Dams and reservoirs

Dams store surface water, regulate seasonal flows, and support drinking-water supply, irrigation, industry, and—in suitable systems—hydropower. Their performance depends on inflows, storage capacity, sedimentation, evaporation, operating rules, and environmental-flow requirements.

The source reports 44 dams in 1999, 68 in 2010, and 84 in a later period, with storage capacity increasing from 3.3 to 7 and then 9 billion m³. It also cites a target of 139 dams and at least 12 billion m³ of capacity by 2030. Another supplied document gives different counts (75 in 2015, 78 at the time of writing, and a projection of 124 by 2030). These series are inconsistent and likely refer to different dates, definitions, or planning documents; they must be reconciled before use.

Year / period shown in source	Dam count or target	Capacity reported
1999	44	3.3 billion m ³
2010	68	7 billion m ³
2014–2016 / later source period	84	9 billion m ³
2030 target in one source	139	At least 12 billion m ³
Alternative historical series in second source	75 in 2015; 78 later	5 billion m ³ regulated volume reported for 2015

6.2. Hill reservoirs

The source states that a programme implemented during the 1980s produced 960 hill reservoirs with a combined storage capacity of 118 hm³. It reports that around 400 were damaged by floods and sedimentation or had fallen out of use. Elsewhere, it refers to more than 500 operational hill reservoirs with about 80 million m³ of storage and irrigation of roughly 20,000 ha. These figures describe different source periods and should be dated explicitly.

6.3. Inter-basin and inter-dam transfers

Interconnections can transfer water between reservoirs or regions, improve the flexibility of supply, help regulate storage, and reduce avoidable spillage during high-flow periods. Their planning should account for energy requirements, ecological effects, water quality, and the needs of donor and receiving basins.

6.4. Floodwater capture

Floodwater-capture structures aim to retain part of episodic runoff that would otherwise leave the basin rapidly. Their effectiveness depends on catchment conditions, sediment loads, flood risks, and the safe design and maintenance of the structures.

6.5. Boreholes and wells

Boreholes and wells provide access to groundwater for domestic, agricultural, and industrial use. Abstraction should be licensed and metered where feasible, and supported by monitoring of groundwater levels, salinity, and other quality indicators. The source contains several differing inventories of boreholes and wells; these should not be combined without checking their dates and definitions.

6.6. Artificial groundwater recharge

Artificial recharge directs suitable surplus water into an aquifer through infiltration basins, spreading areas, or engineered wells. It can help store water and support groundwater levels, but requires suitable geology, adequate pretreatment, protection against clogging, and monitoring to avoid contaminating the aquifer.

7. Non-conventional water resources

7.1. Treated wastewater reuse

Treated wastewater can supplement conventional supplies for applications such as industrial processes, irrigation of suitable crops, landscape irrigation, and—in carefully assessed cases—environmental or aquifer-recharge purposes. Reuse must follow treatment standards appropriate to the intended use, with controls for pathogens, salinity, nutrients, trace chemicals, and worker and public exposure.

7.2. Seawater desalination

Desalination converts seawater into freshwater and can strengthen supplies for coastal cities. It may also allow a larger share of dam water to be allocated to other

uses, including irrigation. Desalination planning must consider energy consumption, costs, intake impacts, brine disposal, and the reliability of distribution networks.

The source documents report 13 desalination units with a combined capacity of “2.260 million cubic metres” in 2010, and 43 stations by 2019; another section reports 11 large operational plants in 2018 with a total capacity of 1.82 million m³/day (about 665 million m³/year). The first figure is ambiguous as written and should be checked against the original source; the figures are historical, not a statement of current capacity.

8. Main threats to water resources in Algeria

Threat	Potential consequences	Management response
Population growth and rising demand	Higher withdrawals and competition among domestic, agricultural, and industrial users	Demand management, leakage reduction, water-saving technologies, and allocation planning
Drought and rainfall variability	Reduced runoff, lower reservoir inflows, and less reliable recharge	Drought planning, diversified supplies, storage operation, and monitoring
Groundwater over-abstraction	Declining water tables, reduced baseflow, higher pumping costs, and possible salinization	Abstraction controls, metering, monitoring, and protection of recharge areas
Water pollution	Loss of suitability for drinking, irrigation, industry, and ecosystems	Wastewater treatment, pollution prevention, enforcement, and catchment-scale monitoring
Evaporation and reservoir sedimentation	Reduced effective storage and greater losses, especially in hot and dry conditions	Reservoir operation, catchment management, sediment control, and

		appropriate infrastructure maintenance
Climate change	Potential shifts in precipitation, runoff, drought frequency, and ecosystem water needs	Climate-risk assessment, adaptive planning, and resilient infrastructure

9. Integrated and sustainable water-resource management

Sustainable water management requires coordinated decisions across surface water, groundwater, water quality, land use, ecosystems, and human demand. A basin-scale approach is particularly important because upstream activities can affect downstream water availability and quality.

- Manage surface water and groundwater as connected components of one hydrological system.
- Use reliable, regularly updated monitoring data and clearly state the year, spatial coverage, and definition behind every statistic.
- Prioritize demand management, repair of distribution losses, and efficient irrigation alongside new infrastructure.
- Protect aquifer recharge areas, river corridors, wetlands, and reservoir catchments.
- Apply pollution prevention and wastewater treatment before contaminants reach water bodies.
- Evaluate the full environmental and economic costs of dams, transfers, desalination, and reuse projects.
- Include drought preparedness, climate variability, and ecological water requirements in allocation plans.