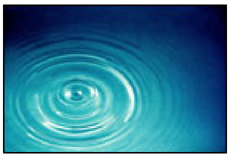
GreenFacts
Facts on Health and the Environment



Scientific Facts on

Water Resources

Source document:
UN-Water WWAP (2006)

Summary & Details:
GreenFacts

Level 2 - Details on Water Resources

This Digest is a faithful summary of the leading scientific consensus report produced in 2006 by the UN World Water Assessment Programme (UN-Water WWAP): *"The United Nations World Water Development Report"*

The full Digest is available at: https://www.greenfacts.org/en/water-resources/

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- Each question is answered in Level 1 with a short summary.
- These answers are developed in more detail in Level 2.
- Level 3 consists of the Source document, the internationally recognised scientific consensus report which is faithfully summarised in Level 2 and further in Level 1.

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1. Introduction: pressures on water resources

The past decade has witnessed a fundamental shift in public awareness of and concern about the threats to water resources and surrounding ecosystems. But when it comes to policy, little has changed. Most decisions about the management of water resources remain the product of economic criteria and politically charged reasoning – regardless of whether they concern a town, a region, a country or even several countries. Despite repeated calls from world experts, we are a long way from an approach to the management of water resources that reflects scientific understanding and use of best available practice. Meanwhile, the pressure on our water resources is mounting.

The factors affecting water resources include the following:

- population growth, particularly in water-short regions,
- movement of large numbers of people from the countryside to towns and cities,
- demands for greater food security and higher living standards,
- increased competition between different uses of water resources, and
- pollution from factories, cities, and farmlands.

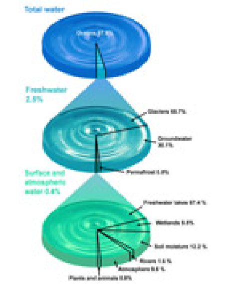
Climate change and natural variability in the distribution and occurrence of water further complicate the sustainable development of our water resources.

Still, some progress is being made. At the national and regional levels, officials are evaluating how much water of what quality is available, and coordinating efforts to manage its use. Increasingly these activities are being carried out by new organizations working across borders to address water resources shared by more than one country. For example, communities in flood-prone areas stand to benefit from recent international initiatives that take a joint approach to flood control.

2. Where and in what forms is water available on Earth?

The world's water exists naturally in different forms and locations: in the air, on the surface, below the ground and in the oceans.

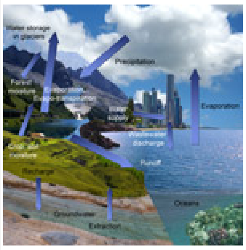
Just 2.5% of the Earth's water is freshwater, and most is frozen in glaciers and ice sheets. About 96% of all liquid freshwater can be found underground. The remaining small fraction is on the surface or in the air.



Global distribution of the world's water
[see Annex 2, p. 14]

Knowing how water cycles through the environment can help in determining how much water is available in different parts of the world. The Earth's water cycle is the global mechanism by which water moves from the air to the Earth (precipitation) and eventually back to the atmosphere (evaporation).

The principal natural components of this cycle are precipitation, infiltration into the soil, runoff on the surface, groundwater discharge to surface waters and the oceans, and evapotranspiration from water bodies, the soil, and plants.



Schematic of the hydrologic cycle components in present-day setting
[see Annex 3, p. 15]

"Blue water"— the water in rivers, lakes, and aquifers— can be distinguished from "green water" — which feeds plants and crops, and which is subsequently released into the air. This distinction may help managers focus on those areas which green water feeds and passes through, such as farms, forests, and wetlands.

2.1 How does water move from the atmosphere to the ground and back?

2.1.1 About 10% of the Earth's freshwater that is neither frozen nor underground is found in the atmosphere. Precipitation, in the form of rain or snow, for instance, is an important form of available freshwater. About 40% of precipitation has previously evaporated from the oceans; the rest from land. The amount of precipitation varies greatly around the world, from less than 100 mm a year in desert climates to over 3 400 mm a year in tropical settings.

In temperate climates, about a third of precipitation returns to the atmosphere through evaporation, a third filters into the ground and replenishes groundwater and the remainder flows into water bodies. The drier the climate, the higher the proportion of precipitation that returns to the atmosphere and the lower the proportion that replenishes groundwater (see table 4.1).

Table 4.1 Precipitation distribution into surface water and groundwater components
[see Annex 4, p. 16]

2.1.2 A large part of the freshwater that returns to the atmosphere passes through soil and plants. Reliable figures are available only for some regions. Soil moisture is important for plant growth. Finding out how much moisture soil contains is important for such activities as farming and "river-flow forecasting", and for understanding climate and natural and water systems. Satellite data are increasingly complementing measurements of soil moisture taken on the ground to provide a broader and more up-to-date picture to decision-makers.

2.2 How much freshwater is found at the Earth's surface?

2.2.1 About three-quarters of the world's freshwater is frozen in **ice sheets and glaciers**. Most remains inaccessible, located in the Arctic, Antarctica or Greenland. Land-based glaciers and permanent snow and ice, however, supply water in many countries, releasing water in amounts that vary seasonally and over longer time periods. Because of climate change, glaciers are now being more closely monitored.

2.2.2 **Surface waters**, including lakes, ponds, reservoirs, rivers, streams and wetlands hold only a small volume of the Earth's total fresh water (0.3%). Still they represent about 80% of the renewable surface water and groundwater that is available in a given year. These water bodies perform many functions in the environment, and provide people with the prime source of drinking water, energy and recreation, as well as a means of irrigation and transport.

Lakes and other reservoirs counteract fluctuations in river flow from one season to the next because they store large amounts of water. Lakes contain by far the largest amount of fresh surface water. But the hydrology of only about 60% of the largest lakes has been studied in detail, leaving much to be learned.

2.2.3 River basins are a useful "natural unit" for the management of water resources, though they often extend across national borders. International river basins have drainage areas covering about 45% of the Earth's land surface (excluding the polar regions). Some of the largest basins are the Amazon, which carries 15% of all water returning to the oceans, and the Congo-Zaire Basin, which carries one-third of all river water in Africa.

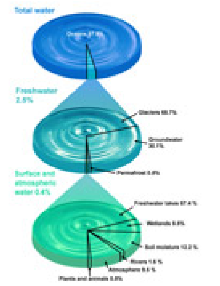
River flows can vary greatly from one season to the next and from one climatic region to another. In tropical regions, large flows are witnessed year round, whereas in drylands, rivers are often ephemeral and only flow periodically after a storm. Drylands make up about 40% of the world’s land area and have only 2% of all water runoff.

Past data records for river flow and water levels help to predict yearly or seasonal variations, though it is difficult to make accurate longer-term forecasts. Some records in industrialised countries go back up 150 to 200 years. By contrast, many developing countries started keeping records only recently and data quality is often poor.

2.2.4 **Wetlands**, including swamps, bogs, marshes, and lagoons, cover 6% of the world’s land surface and play a critical role in the conservation of water resources. Many wetlands were destroyed or converted to other uses during the last century. Those that remain can play an important role in supporting ecosystems, preventing floods, and increasing river flows.

2.3 How much freshwater can be found underground?

Ninety-six percent of liquid fresh water can be found underground. Groundwater feeds springs and streams, supports wetlands, helps keep land surfaces stable, and is a critical water resource.



Global distribution of the world’s water
[see Annex 2, p. 14]

About 60% of the water that is taken from the ground is used for farming in arid and semi-arid climates, and between 25% and 40% of the world’s drinking water comes from underground. Hundreds of cities around the world, including half of the very largest, make significant use of groundwater. This water can be especially useful during shortages of surface water.

Groundwater aquifers vary in terms of how much water they hold, their depth, and how quickly they replenish themselves. The variations also depend on specific geological features.

Much of the water underground is replenished either very slowly or not at all, and is thus termed “non-renewable”. The largest aquifers of non-renewable water are found in North Africa, the Middle East, Australia, and Siberia. There is some debate about how and when to use this water. Many aquifers that contain non-renewable groundwater resources are shared by more than one country and need to be managed in common for the benefit of all administrative entities concerned.

If the infiltration of precipitation recharges the aquifer, the groundwater is considered “renewable” and can be used for irrigation, domestic and other purposes. While most renewable groundwater is of a high quality and does not require treatment, it should be analysed before it is used to avoid possible health impacts. However, few countries measure the quality of underground water or the rate at which it is being withdrawn. Monitoring is being improved in Europe and India, but remains minimal in many developing countries, and is deteriorating in many industrialised ones. This makes it hard to manage underground water resources sustainably.

3. How much freshwater is available in different countries?

The Food and Agricultural Organization (FAO) of the United Nations has developed and maintains a widely used database on water known as AQUASTAT. Based on the figures it contains, the FAO has compiled an index of how much water is, in theory available and, more particularly, for each person, on average, in each country. This index takes into account runoff and groundwater replenished by precipitation, water that flows into and out of a country, and water shared with other countries.

The average amount of water available per person varies from less than 50 m^3 per year in parts of the Middle East to over 100 000 m^3 per year in humid and sparsely populated areas.

Though the database has become a common reference tool, it has some limitations. Estimates indicate only the theoretical maximum amount available for a country and may overestimate the amount actually available. For instance, about a quarter of the runoff in the world each year (which would figure as such in the FAO's index) is actually floodwater, which is unusable. Another drawback is that the index gives annual and country-wide, but not seasonal or local figures, which are both important. It gives information by country, but not by climatic region within countries. It does not give figures for "green water", which sustains natural systems and supports farming, or for water from other sources such as non-renewable water from underground; nor does it take full account of how much water actually leaves a country. Finally, the index does not distinguish between different socio-economic groups in terms of who has access to water, even though differential access is common (e.g., slum dwellers have inadequate access to clean water).

Recently, a more accurate picture has been produced of how many people, and where, are living in areas suffering severe water shortages. The higher level of detail allows us to see differences within a country, and suggests that about three times more people than was previously thought are living in areas with severe water shortages.

4. How can human actions seriously affect water resources?

Our water resources face a host of serious threats, all of which are caused primarily by human activity. They include sedimentation, pollution, climate change, deforestation, landscape changes, and urban growth.

One of the most serious threats to water resources is the degradation of ecosystems, which often takes place through changes to landscapes such as the clearance of forests, the conversion of natural landscapes to farmland, the growth of cities, the building of roads, and surface mining. Each type of change to a landscape will have its own specific impact, usually directly on natural ecosystems and directly or indirectly on water resources.

Although it is difficult to integrate the intricacies of ecosystems into traditional assessment and management processes a holistic ecosystem approach to water management is strongly recommended.

4.1 How are aquatic ecosystems threatened by sediment in water?

Sediments can occur in water bodies naturally, but they are also produced in large amounts as a result of land-use change and agriculture.

Activities such as farming, clearing forests, building roads, and mining can put too much soil and particulate matter in rivers. This sediment can harm plants and animals by carrying toxic chemicals into the water, smothering fish eggs and small organisms used by fish as food, raising water temperature, and reducing the amount of sunlight penetrating the water.

Sediment can also reduce the capacity of reservoirs and make it difficult for ships to navigate in waterways. It can also damage equipment used in water supply installations and hydroelectric plants, thus increasing their maintenance costs.

Table 4.4 Principal sources and impacts of sedimentation [see Annex 5, p. 17]

Sedimentation should be factored into strategies to protect water resources

4.2 How can different kinds of pollution affect water resources?

Wastes that people dispose of can pollute the air, the land, and water resources. They affect the quality of rainwater and of water resources both above and below ground, and damage natural systems.

The causes of freshwater pollution are varied and include industrial wastes, sewage, runoff from farmland, cities, and factory effluents, and the build-up of sediment.

Emissions from factories and vehicles are released into the air. They can travel long distances before falling to the ground, for instance in the form of acid rain. The emissions create acidic conditions that damage ecosystems, including forests and lakes. The pollution that passes directly into water from factories and cities can be reduced through treatment at source before it is discharged. It is harder to reduce the varied forms of pollution that are carried indirectly, by runoff, from a number of widely spread non-point sources, into freshwater and the sea.

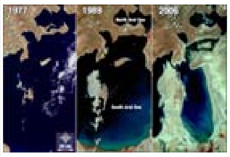
Only a small percentage of chemicals are regulated, and concern is growing about contamination by unregulated chemicals. A variety of pharmaceutical products, such as painkillers and antibiotics, are having an impact on water resources above and below ground. Conventional water treatment does not work for many of them.

In general, it takes much longer to clean up polluted water bodies than for pollution to occur in the first place, and there is thus a need to focus on protecting water resources. In many cases, clean-up takes more than 10 years. Although underground water is less easily polluted than water above ground, cleaning it once it is polluted takes longer and is more difficult and expensive. Ways are being found to assess where and how underground water is most vulnerable to pollution. The findings are important in cases where aquifers supply drinking water, and where natural ecosystems depend on them.

Sewage and runoff from farms, farmlands and gardens can contain nutrients, such as nitrogen and phosphorus, that cause excessive aquatic plant growth, and this in turn has a range of damaging ecological effects.

Complicating the problem of water pollution is the overall lack of adequate information about the quality of water around the world. Many countries do not collect enough data, and most of them are not prepared to sharing it. But this is changing because of growing awareness of the need for such information, and due to the availability of an international database, GEMSTAT, that went online in March 2005.

4.3 What are the consequences of excessive water withdrawal?



Aral Sea evolution between 1977 and 2006 [see Annex 1, p. 13]
Source & ©: NASA/GSFC

Around the world certain lakes, rivers and inland seas are in the process of drying up because too much water is being drawn from them or from their tributaries. Groundwater, too, is used faster than it is replenished, as is clear from a growing number of reports documenting sharp drops in aquifer levels. In many cases, drought periods have compounded this well-documented trend.

The Niger, the Nile, the Ganges, the Tigris, the Euphrates, the Yangtze, the Colorado, and the Rio Grande are just some of the major rivers suffering substantial reductions in flow. Numerous lakes and inlands seas are shrinking dramatically in many geographic regions. The Aral Sea and Lake Chad have decreased dramatically in size over the last few decades.

These problems persist though their causes have been evident for quite some time. Foremost are the very inefficient ways in which water is supplied to farms and cities, deforestation, and the failure to properly manage and control the withdrawal of water, and to think of more economic ways to use water.

Not enough consideration has been given to minimizing use and conserving water resources. Instead the supply has been further strained by the construction of new reservoirs and inappropriate diversions. While some towns and cities are taking action, only broad-based and fundamental change in national and regional practices can reverse the impact.

The threat to groundwater is not as obvious as that to lakes and rivers. There is less visual evidence and the effects of withdrawing too much groundwater take longer to recognise. In the last half-century, pumping from aquifers increased globally. But often the benefits—bigger harvests for example—were short-lived, ultimately resulting in lower water tables, drilling of deeper wells, and, sometimes, even the depletion of the groundwater source.

Cases from all climatic regions illustrate that excessive use of groundwater is relatively common practice. The consequences can be seen in reduced spring yields, diminished river flow, poorer water quality, damage to natural habitats such as wetlands, and the gradual sinking of land, known as subsidence.

4.4 How is climate change affecting water resources?

Exactly how global warming is affecting water resources is not altogether clear. New research suggests that climate change is increasing existing stress, for example by reducing runoff in areas already suffering from water shortages. Scientists agree that extreme weather events stemming from global warming, such as storms and floods, are likely to be more frequent in the future. However, based on current knowledge, scientists can only make general predictions about the impact of climate change on water resources. More information is needed, for instance, about impacts on water resources in specific regions and under different policy scenarios.

One type of water resource that has been clearly affected by climate change is glaciers. Scientists have long observed that land and mountain glaciers are shrinking, and this trend has accelerated considerably in recent years. For example, it has been predicted that most glaciers in Tibet could melt by 2100. And while it was initially thought that the water released could benefit China's arid north and west, it now appears that the additional runoff evaporates long before it reaches drought-stricken farmers downstream.

5. How can the growing demand for water be met?

The response to the growing demand for water has focused on compensating for natural variability and improving the quality and quantity available.

In dry regions, new ways to meet demand—such as desalination, re-use, replenishment of underground water, and transfer between river basins – are complementing conservation methods that have been in use for a long time.

In regions where water is more abundant it was often assumed that shortages could be overcome and that pollution or damage to ecosystems could be undone. It was not generally expected that human activities would deplete water resources and endanger ecosystems as much as they have. Consequently, some of the same practices used in dry regions are now being adopted in those with sufficient water.

Awareness of the relationship between water resources and ecosystem health has increased recently, and there has been a growing focus on how the condition in a river, wetland or coastal zone supports economic development and poverty alleviation.

5.1 Intercepting, diverting, storing and transferring water

5.1.1 People have been collecting **rainwater** for thousands of years – for example in Palestine, Greece, Rome, and South Asia. In India, rainwater has recently been used to replenish underground water. This technique is inexpensive and can be implemented locally. Larger projects have also been carried out to increase infiltration into the ground in areas where deforestation has reduced the availability of water.

5.1.2 **Diverting surface water** into basins and pits to increase infiltration into the ground can reduce evaporation, help replenish groundwater aquifers, and improve the quality of water. This practice is used in the Middle East and the Mediterranean. Runoff is collected and diverted in a variety of ways. Some methods reduce the need to treat the water.

For example, in Binh Thuan province in Viet Nam, a large area of tropical forest was cleared to make room for rice fields. This led to desertification and severe water shortages in periods of low rainfall. To remedy the situation, rainfall is being diverted into aquifers during the rainy season for use during the dry season. The quality of underground water has improved, and it can be used for a variety of purposes, including farming.

A number of associations are working with UNESCO and international donors to support these techniques by conducting research, building local capacity, and running pilot projects in Australia, China, Europe, Kenya, Mexico, Oman, South Asia, Southern Africa, and the United States.

5.1.3 **Dams and reservoirs** provide hydropower, supply water during shortages, enable fishing and the irrigation of farmland, and protect people from both floods and droughts.

However, they have also had a significant negative impact, including on the water cycle, and have brought about social and environmental consequences. In response to media attention and protests, fewer large dams are being built for the moment and alternatives are being considered. Some dams have been decommissioned, or modified to allow releases of water. Keeping a balance between the water that enters a reservoir and the water that is released yields significant benefits.

5.1.4 The long-standing practice of **interbasin transfer** of water from one aquifer or river basin to another can help alleviate water shortages caused by agriculture and other human activities. In India, a long-distance link is being proposed between rivers to counteract droughts and floods. There are major interbasin links existing in China, and more are under consideration or being planned for instance between the basins of the Yangtze and Yellow River. Though such schemes may be technically feasible, their impact on people and the environment must be considered before they are implemented.

5.2 Water re-use

The re-use of wastewater, made possible by technological advances in the last century, is now widespread. Once it has been extensively treated to remove biodegradable material, nutrients, and pathogens, it could be drunk, or used in a number of other ways. Non-potable quality water can be used directly for irrigation, as a coolant in industry and to maintain river flows. Cities around the world where freshwater supplies are limited, such as San Diego in the United States, are developing programmes to re-use water and to replenish aquifers with treated wastewater. Use of these techniques is expected to increase. The most viable programmes use reclaimed waste water instead of drinking water for agricultural, industrial, and other uses.

Countries in both water-short and more temperate but high-population regions are expected to increase their use of reclaimed water in the coming years. Reclaimed water is expected to account for 25% of Israel's water supply in the next few years. Jordan will have to increase its use of reclaimed water fourfold to meet demand; Egypt, tenfold. Most Middle Eastern countries are expected to re-use more than half their wastewater.

Australia, Belgium, China, Germany, Japan, and the United Kingdom are also expected to increase their use of reclaimed water, as this practice becomes an integral part of the management of water resources.

5.3 Desalination

Desalination involves reducing its mineral content by taking salt out of seawater and brackish water and producing water of freshwater quality. It is used mainly by cities and industry, primarily in the Middle East (50%), but also in North America (16%), Europe (13%), and Asia (11%). The high costs of desalination, principally arising from the energy used, have dropped significantly in recent years due to technological advances.

That energy is produced primarily with fossil fuels, which pollute the air, and each method of disposing of the by-products of desalination—for example in the ocean or in deep wells—has an impact on the environment. It has been suggested that the various means of disposal be assessed according to a single set of criteria, so that the impact of each desalination plant can be consistently evaluated.

It is expected that desalinated water will be put to new and innovative uses, particularly to support a variety of economic activities in coastal areas.

6. How could water resources be developed sustainably?

6.1 What are the obstacles to sustainable water management?

A number of factors present difficulties for the sustainable development of water resources, including climate change and the natural variability of the resource, as well as pressures caused by human activities.

These factors, combined, increase competition for water and lead to gross inefficiencies in how water is supplied. The fundamental problem, however, is that the long-term vision required for sustainable practices to take hold is relegated due to economic short-term gains and political considerations. Managers should ideally consider best current practices and the latest techniques in drawing up their water plans.

Scientists must persuade policy-makers of the relevance of their recommendations so that they can be implemented. Most up-to-date solutions will be required to meet the challenges of managing water resources sustainably. Increased funding for the collection of information will also be required.

There is often limited understanding of processes and interactions among the various elements of the water cycle, such as rain, snow, soil moisture, evapotranspiration, and meltwater from glaciers. This makes it difficult to develop comprehensive strategies to protect water resources. More comprehensive assessments methods are needed.

It is relatively easy, based on long-term measurements taken in many places, to predict, and find solutions for annual and seasonal differences in water flow. However, it is much more difficult to predict long-term variations over several decades. Underground water could be used during long dry spells, while surplus runoff could replenish aquifers.

However, solid information on underground water is lacking in many developing countries—especially in Asia and Africa, where monitoring programmes have been cut drastically.

Most developing countries also lack adequate monitoring of water quality, and this poses considerable public health challenges. Information on the consumption, pollution, and withdrawal of water globally is still fragmentary.

The poor quality of water and the inadequacy of supplies can have a negative impact on economic development, public health, and living conditions.

Changes to the landscape such as the growth of cities, the removal of wetlands, deforestation, construction of roads, and surface mining disrupt environmental water flows, cause ecosystem changes, and complicate water planning. They also make it more difficult to understand what local and regional impacts climate change will have on water resources—already a major challenge, given the scarcity of information.

We have a good understanding of the effects of pollution and of drawing too much water from aquifers and from rivers, lakes, and inland seas. Fighting these effects will require substantially increased funding in most developing countries.

Practices that are more sustainable are now being included in new water programmes, and these give reason for hope.

6.2 How could water be used more efficiently and sustainably?

More attention should be paid to making better use of existing natural resources, controlling demand and reducing losses, and achieving greater efficiencies in water management.

New approaches, such as desalination and the replenishment of aquifers complement standard techniques such as storing runoff. In some very dry countries, water is drawn from the ground without being replenished.

Most water companies focus on developing infrastructure rather than on managing demand. A shift towards reducing demand will require changes in patterns of behaviour by individuals and organizations, as well as political commitment to enforce rational water management.

Countries have responded to the present situation with new laws, new techniques, and local knowledge. Regular assessments of basins and aquifers will bring economic, social, and environmental benefits.

Climate change is expected to bring more erratic weather, with greater variations in the level of rainfall, which may reduce harvests and create widespread water shortages. In order to prevent or reduce damaging consequences, we need a comprehensive approach that takes into account all aspects of the water cycle.

The most recent, integrated approaches to the management of water resources consider the relations between the water cycle and ecosystems. Such approaches need complete information and should also include in their scope social, economic, and environmental considerations.

Conservation programmes that try to reduce the demand for water differ from the standard method, under which all water is regarded as available, and promote awareness, as well as efficiency and fairness in the use of water. Conservation programmes have not been readily implemented, even though they can bring economic benefits for water supply and treatment plants, and for sewage disposal systems. They also help sustain ecosystems and reduce freshwater pollution.

Programmes that focus on managing demand emphasise steps to encourage lower consumer use and fewer leaks in water distribution networks. Such leaks can lead to the loss of from 40% to 70% of the water within the supply system.

Levels of consumer use could fall by as much as 40% once conservation measures are introduced in households. These figures suggest that, if conservation programmes were carried out more widely, some large-scale investments in plants and equipment might not be necessary.

In recent years, water resources have been looked at from the standpoint of potential use, with an eye on social equity and the health of ecosystems, among other things. These analyses require a reliable generation of water data from many monitoring stations around the world. However, investment in such stations has fallen sharply since the mid-1980s, particularly in Africa and Eastern Europe.

On most continents, the assessment of water resources is becoming less centralised and more focused on river basins. This approach will always have to face issues of competition and sovereignty, but the joint collection of information on water resources in basins shared by more than one country will benefit all sides, in terms of economic development, people's livelihoods and the health of ecosystems.

7. Conclusions on water resources

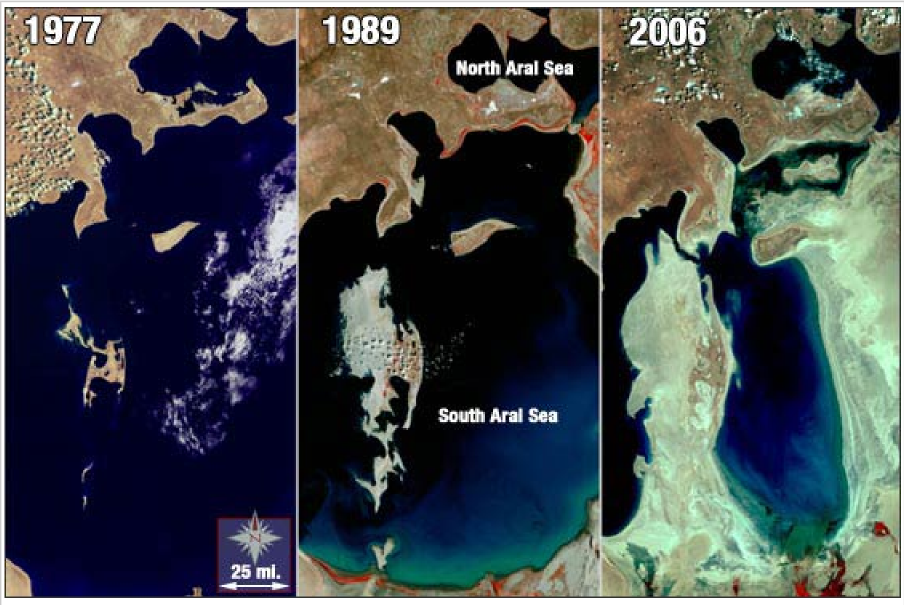
A number of key messages emerge from the foregoing discussion of water resources. Demand for these limited resources continues to increase as populations grow and move. Sound management depends on reliable information about the quantity and quality of water available and how this availability varies in time and from place to place. It is important to enhance the understanding of all elements of the water cycle and how human activities affect it, so that water resources can be protected and developed sustainably.

- Climate change greatly affects weather, precipitation, and the entire water cycle, including water resources both above and below ground.
- The growing problem of surface water availability and the increasing levels of water pollution and water diversions threaten to hamper or even disrupt social and economic development in many areas, as well as the health of ecosystems.
- Groundwater resources can help meet demand, but too much of it is being withdrawn and some of it is being polluted. It is important to better control the use of underground water that will not be replenished.
- Longstanding practices, such as collecting rainwater, are being refined and supplemented by newer techniques such as artificial recharge, desalination and re-use. More support is needed, not only for innovative technical solutions to improve supplies, but also for the management of demand and the promotion of efficiency in water use.
- Growing changes in the availability of water resources will require political support for the collection of information on water resources. That information will allow policy-makers to make better decisions about the management and use of water.

Annex

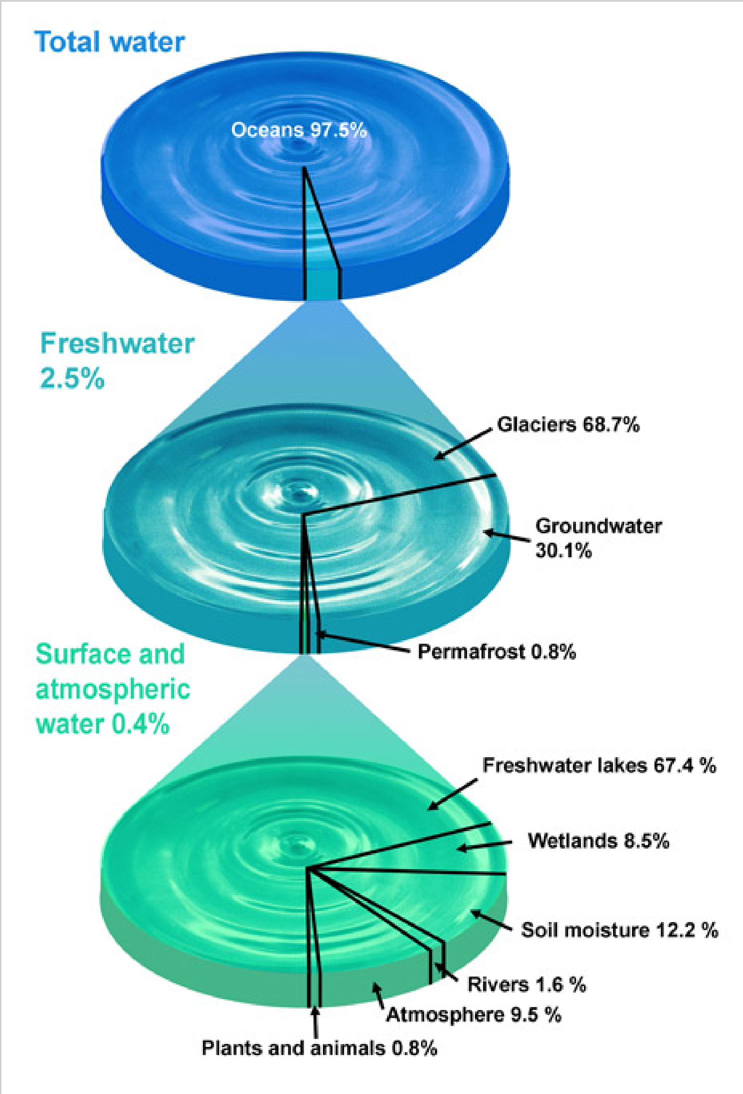
Annex 1:
Aral Sea

Over the last decades, diversion of rivers for irrigation has reduced its size by 60% and its volume by 80% , deeply affecting the local fishing industry and the livelihood of the population.



Source: © NASA/GSFC

Annex 2:
Figure 4.1: Global distribution of the world's water

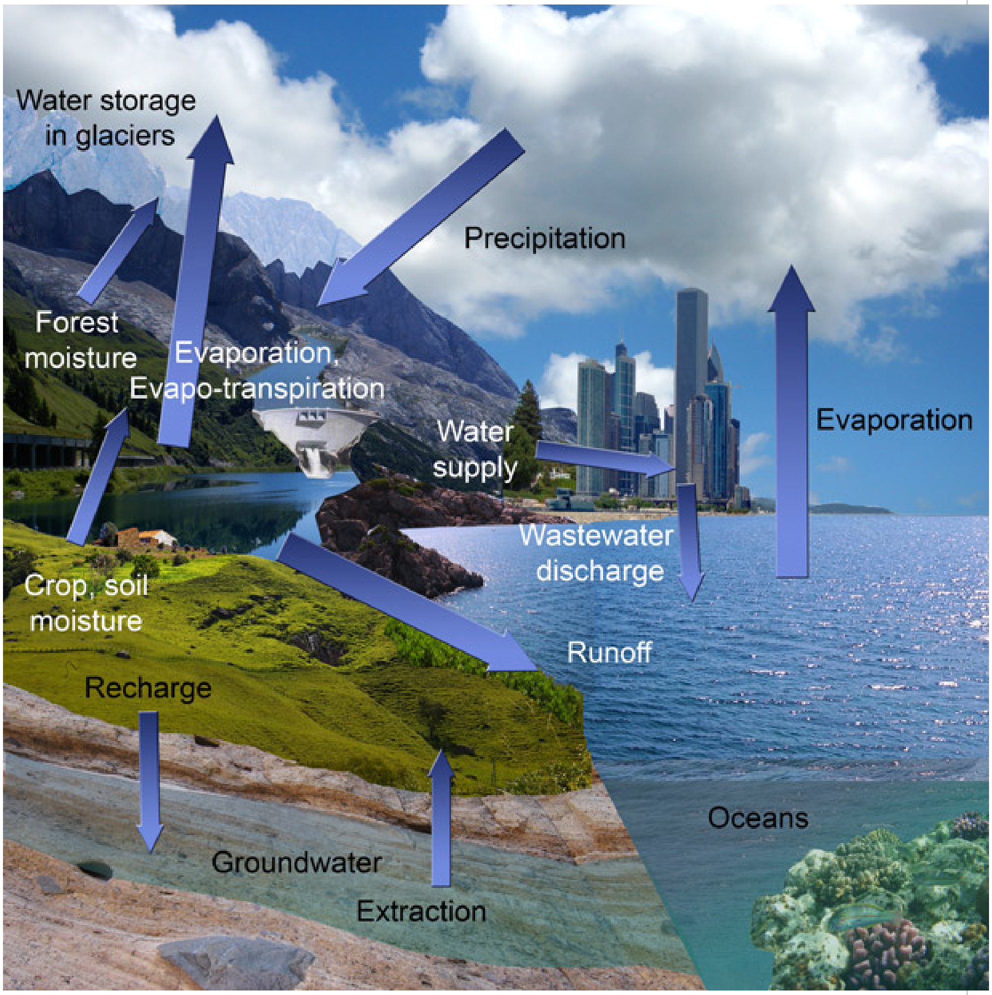


Data from Shiklomanov and Rodda, 2003. Freshwater has a global volume of 35.2 million cubic kilometres (km^3).

Source: UNESCO The United Nations World Water Development Report 2 [see http://www.unesco.org/water/wwap/wwdr2/pdf/wwdr2_ch_4.pdf]
Section 2: Changing Natural Systems,
Chapter 4, Part 1. Global Hydrology and Water Resources, p.121

Annex 3:

Figure 4.2: Schematic of the hydrologic cycle components in present-day setting



Source: UNESCO The United Nations World Water Development Report 2 [see http://www.unesco.org/water/wwap/wwdr2/pdf/wwdr2_ch_4.pdf]
Section 2: Changing Natural Systems,
Chapter 4, Part 1. Global Hydrology and Water Resources, p.122

Annex 4:

Table 4.1: Precipitation distribution into surface water and groundwater components (by climate region)

	Temperate climate		Semi-arid climate		Arid climate	
	%	mm	%	mm	%	mm
Total precipitation	100	500–1,500	100	200–500	100	0–200
Evaporation /Evapotranspiration	~ 33	160–500	~ 50	100–250	~ 70	0–140
Groundwater recharge	~ 33	160–500	~ 20	40–100	~ 1	0–2
Surface runoff	~ 33	160–500	~ 30	60–150	~ 29	0–60
Source: Hydrogeology Center, University Neuchâtel, 2003.						

Source: UNESCO The United Nations World Water Development Report 2 [see http://www.unesco.org/water/wwap/wwdr2/pdf/wwdr2_ch_4.pdf]
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Annex 5:

Table 4.4: Major principal sources and impacts of sedimentation

Pertinence	Sector	Action or mechanism	Impacts
SOURCES			
Agriculture areas, downstream catchments	Agriculture	• poor farming with excessive soil loss	• increase soil erosion • add toxic chemicals to the environment • sediment and pollutants are added to streams • irrigation systems maintenance cost increased
Forest and development access areas, downstream catchments	Forestry, Road Building, Construction, Mining	• extensive tree cutting • lack of terrain reforestation • lack of runoff control in steep terrain	• increase natural water runoff • accelerated soil erosion creating more sediment
MAJOR IMPACTS			
Major rivers and navigable waterways	Navigation	• deposition in rivers or lakes • dredging (streams, reservoirs, lakes or harbors)	• decreases water depth making navigation difficult or impossible. • releases toxic chemicals into the aquatic or land environment.
Aquatic ecosystems	Fisheries / Aquatic habitat	• decreased light penetration • higher suspended solids concentrations • absorbed solar energy increases water temperature • carrying toxic agricultural and industrial compounds • settling and settled sediment	• affects fish feeding and schooling practices; can reduce fish survival • irritate gills of fish, can cause death, destroy protective mucous covering n fish eyes and scales • dislodge plants, invertebrates, and insects in stream beds affecting fish food sources resulting in smaller and fewer fish, increased infection and disease susceptibility • stress to some fish species • release to habitat causes fish abnormalities or death • buries and suffocates eggs • reduces reproduction
Source: Adapted from Environment Canada (2005a), www.atl.ec.gc.ca/udo/mem.html			
Note: Water transforms landscapes and moves large amounts of soil and fine-grained materials in the form of sediment. Sediment is: 1) eroded from the landscape, 2) transported by river systems and eventually 3) deposited in a riverbed, wetland, lake, reservoir or the ocean. Particles or fragments are eroded naturally by water, wind, glaciers, or plant and animal activities with geological (natural) erosion taking place slowly over centuries or millennia. Human activity may accelerate the erosion. Material dislodged is transported when exposed to fluvial erosion in streams and rivers. Deposition occurs as on flood plains, bars and islands in channels and deltas while considerable amounts end up in lakes, reservoirs and deep river beds.			

Pertinence	Sector	Action or mechanism	Impacts
Lakes, rivers, reservoirs as water supplies	Water supply	• increased pump/turbine wear • reduced water supply usability for certain purposes • additional treatment for usability required	• affects water delivery, increases maintenance costs • reduces water resource value and volume • increased costs
Hydroelectric facilities	Hydropower	• dams trap sediment carried downstream • increased pump/turbine wear	• diminished reservoir capacity • shortened power generation lifecycle • higher maintenance, capital costs.
All waterways and their ecosystems	Toxic chemicals	• become attached or adsorbed to sediment particles	• transported to and deposited in, other areas • later release into the environment.
Source: Adapted from Environment Canada (2005a), www.atl.ec.gc.ca/udo/mem.html			
Note: Water transforms landscapes and moves large amounts of soil and fine-grained materials in the form of sediment. Sediment is: 1) eroded from the landscape, 2) transported by river systems and eventually 3) deposited in a riverbed, wetland, lake, reservoir or the ocean. Particles or fragments are eroded naturally by water, wind, glaciers, or plant and animal activities with geological (natural) erosion taking place slowly over centuries or millennia. Human activity may accelerate the erosion. Material dislodged is transported when exposed to fluvial erosion in streams and rivers. Deposition occurs as on flood plains, bars and islands in channels and deltas while considerable amounts end up in lakes, reservoirs and deep river beds.			

Source: UNESCO The United Nations World Water Development Report 2 [see http://www.unesco.org/water/wwap/wwdr2/pdf/wwdr2_ch_4.pdf]
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