FRESHWATER BIODIVERSITY

DIVE INTO THE LIFE FOUND IN FRESHWATER ECOSYSTEMS!

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Freshwater includes rivers, lakes and wetlands and are habitats which are rich in biodiversity. Such systems provide us with many services such as our drinking water, food (such as fish), a means of transport as well as recreational opportunities. Unfortunately freshwater systems are some of the most endangered habitats in the world and have alarming rates of species extinction.

LAKE CHAD BASIN, AFRICA.

WHAT ARE FRESHWATER ECOSYSTEMS?

Simply put, "fresh" water is water without salt, which distinguishes these environments from marine, or saltwater, ecosystems. There are many kinds of freshwater ecosystems, such as:

RIVERS: in which the water flows, usually towards the sea.

LAKES: larger areas of standing water (shallow or deep).

WETLANDS: areas of land covered either permanently or temporarily with water, usually shallow, covered by plants (including trees) which grow out of the water or mixed with areas of open water. Examples of wetlands include swamps, marshes, bogs, peatlands, estuaries, mangroves and rice paddies.

Freshwater ecosystems are part of the landscape and interact with land. For example, rainwater falling on land flows into streams and rivers, and fills up lakes and wetlands, carrying with it nutrients and plant material (such as seeds and leaves).

But freshwater ecosystems also supply water to land environments – for example, they provide water to recharge water stored below ground (groundwater), which supports plants living on land (such as forests). These movements of water are part of the "water cycle" (see box: "The Water Cycle"), which connects land, "groundwater", freshwater and coastal areas.

SHOTOVER RIVER CANYONS IN QUEENSTOWN, NEW ZEALAND.

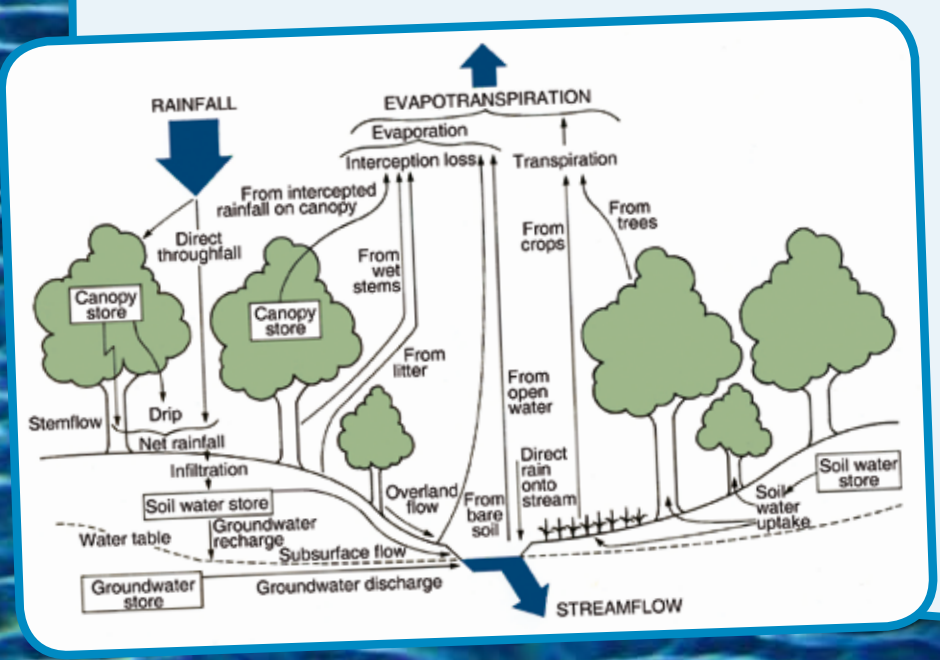
LAKE IN CHILE.

MANGROVES IN THE GALAPAGOS ISLANDS.

THE **WATER CYCLE**

The water cycle is the continous movement of water around the planet. During this cycle water can be in various states: solid, liquid or gas. Water moves by processes of **evaporation** (water turning from a liquid to a gas), **transpiration** (the movement of water through vegetation and soil), condensation and precipitation. Water travels above and infiltrates below the ground and accumulates in rivers, lakes and oceans and evaporates or transpires into the atmosphere where it condenses to form clouds and then returns to the Earth's surface through precipitation (rain, snow, hail and sleet). The changes in the state of water during the cycle requires the exchange of heat, therefore cooling or heating the environment (for example, evaporation requires energy and therefore cools the environment). The water cycle also has the effect of purifying water courses, replenishing water supplies and moving nutrients and other elements to different parts of the world.

Biodiversity (i.e. trees and other plants) is a necessary part of the cycle. The soils in which they are rooted absorb water and store it safely, while their leaf canopies return water, in the form of vapour, to the atmosphere, where it becomes precipitation. Large-scale removal of vegetation can disturb the cycle, often resulting in changed rainfall patterns and soil erosion. Biodiversity, therefore, supports the availability of water for people and other living things to use.



Graphic source: L. S. Hamilton 2008. Forests and Water. FAO Forestry Paper 155, Rome: FAO, 3.

FRESHWATER LIFE

"Freshwater biodiversity", at the species level, includes life which is very obviously living in freshwater but also includes life which is adapted to live in or around freshwater habitats. Examples include:

- Fish
- Amphibians (e.g. frogs and salamanders)
- Wetland-dependent mammals (e.g. hippopotamuses (see box: "The Hippopotamus"), river dolphins (see box: "River Dolphins: Species in Danger"), porpoises, seals, otters, moose, beaver, manatees)
- Waterbirds (e.g. pelicans, flamingos, cranes, ducks, geese)
- Reptiles (e.g. crocodiles, turtles)
- Insects (e.g. dragonflies, mosquitoes)
- Aquatic plants and plants rooted in water but with stems and leaves that emerge from the water

There are also many plants which are adapted to life in or near freshwater habitats, other than those permanently living underwater. This includes peat, sedges (tall grass-like plants, including papyrus), mangroves and rice (see box: "Rice Paddies: Farmed Wetlands").

PELICANS AT THE LAKE NAKURU NATIONAL PARK IN KENYA.

THE **HIPPOPOTAMUS**

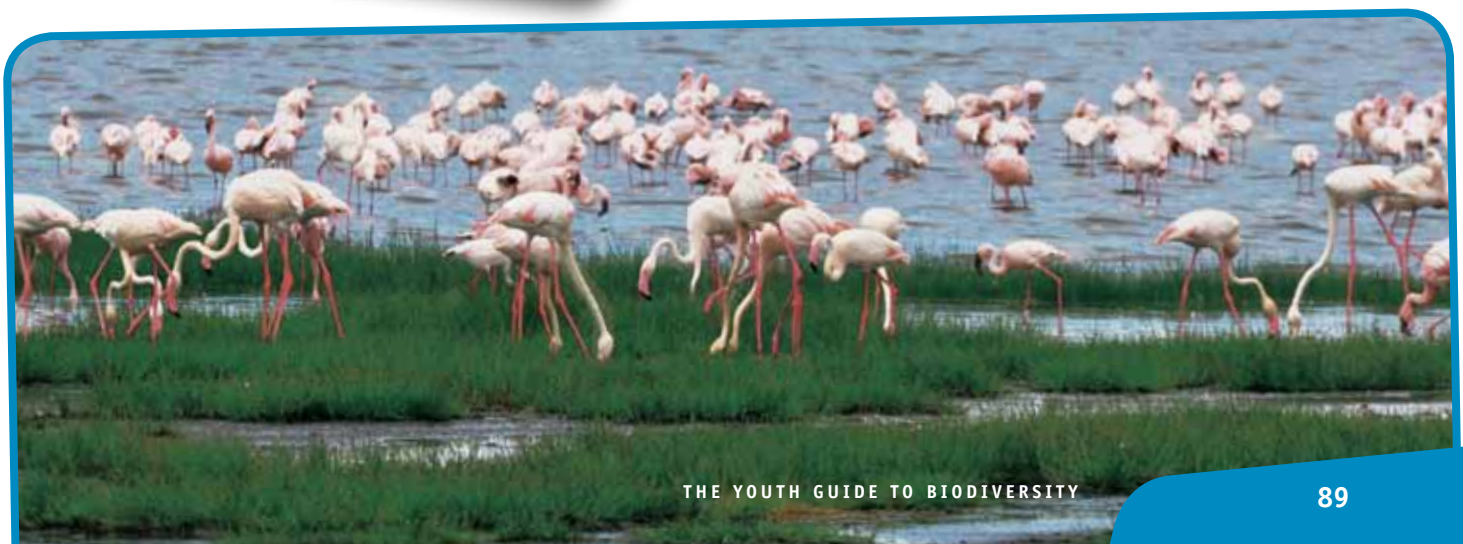
The hippopotamus is considered to be a freshwater mammal because, although it feeds on land, like a cow, it is adapted to life in water.

For example, it has a flat head on which the eyes and nostrils protrude, enabling it to remain submerged, but still able to see and breathe; a cow could not do this.

A TREE GROWING IN THE MEKONG RIVER IN LAOS – NOTE HOW THE TREE ROOTS BUTTRESS THE TREE AGAINST THE RIVER FLOW (RIGHT TO LEFT IN THIS PHOTO), AN ADAPTATION TO LIFE IN RIVERS.

HIPPOS SWIM IN LAKE NAIVASHA, KENYA.

FLAMINGOS AT THE LAKE NAKURU NATIONAL PARK IN KENYA.



RIVER DOLPHINS: SPECIES IN DANGER

RIVER DOLPHIN.
© Dolf En Lianne

Although often regarded as marine (saltwater) species, some dolphins live exclusively in freshwater rivers and lakes; others have adapted to live in both marine and freshwater environments. River dolphins differ from oceanic dolphins in several ways, including having a much longer snout – up to 20 percent of their body length – and extremely poor eyesight. Most are comparable in size (about 2.5 m) to the more common and better-known bottlenose dolphin, a marine species seen in aquariums and featured in movies and on television.

There are six species of river dolphins:

- Ganges River dolphin (Bangladesh, India, Nepal, Pakistan) – the "Susu"
- Indus River dolphin (Pakistan)
- Amazon River dolphin (South America) – the "Boto"
- Yangtze River dolphin (China) – the "Baiji"
- Irrawaddy and Mekong River dolphin (salt- and freshwater – Myanmar, Laos and Cambodia)
- Tucuxi (salt- and freshwater – east coast of Central and South America).

CHINA'S BAIJI, OR YANGTZE RIVER DOLPHIN.
© Cathy McGee

The Yangtze River dolphin has been presumed extinct since 2006; the others (with the possible exception of the Amazon River dolphin and the Tucuxi, about which little data are available) are highly endangered. By comparison, the bottlenose dolphin is relatively abundant, and is not in danger of **extinction**.

The survival of river dolphins is threatened by **habitat loss** and degradation, as a result of dam construction and river diversion, which reduces water flow; **pollution** from industry and agriculture; overfishing; and accidental capture in fishing lines and nets (known as bycatch).

RICE PADDIES:
FARMED WETLANDS

Rice is a wetland-dependant (freshwater) plant and the staple food for over half the world's population. It provides about 20 percent of the total calorie supply in the world and is grown in at least 114 countries worldwide, particularly in Asia.

Rice paddies are naturally flooded or irrigated fields in which rice is grown. Rice grows with its roots submerged, but with its leaves and seeds (rice) above the water. Rice paddies usually dry out at harvest time, illustrating that these systems shift between aquatic and terrestrial (dry land) phases.

Rice is just one crop. But living in the water in the paddy fields are thousands of species of aquatic **organisms**. Rural populations benefit directly from some of this biodiversity by harvesting reptiles, amphibians, fish, crustaceans, insects and molluscs for household consumption. But other biodiversity associated with rice paddies supports the health and productivity of the rice itself through, for example, controlling rice-pests and helping to make nutrients available to the rice plants.

These wetlands also support the conservation of internationally important populations of resident and migratory waterbirds.

TERRACED RICE PADDIES NEAR A RED ZAO VILLAGE OUTSIDE OF SAPA, LAO CAI PROVINCE, NORTHERN VIETNAM.

THE IMPORTANCE OF FRESHWATER BIODIVERSITY

ORANGUTANS LIVE IN PEAT SWAMP FORESTS AND ARE THREATENED AS A RESULT OF HABITAT LOSS. THEY ARE **endemic** TO THE INDONESIAN ISLANDS OF BORNEO AND SUMATRA AND ARE FOUND NOWHERE ELSE IN THE WORLD (EXCEPT IN CAPTIVITY). THIS BORNEAN ORANGUTAN HELPS TO SPREAD TREE SEEDS, INCLUDING SOME SPECIES THAT CAN ONLY GERMINATE WHEN THEY HAVE PASSED THROUGH THE ORANGUTAN'S GUT!

Freshwater biodiversity provides a variety of benefits (ecosystem services) to people, including:

Food: in developing countries, inland fisheries can provide the primary source of animal protein for many rural communities (see box: "Aquaculture"). Aquaculture, the farming of fish and other aquatic animals (e.g. shrimp), can also provide food and income for many people, as can wetland agriculture, such as rice farming.

Fibre: throughout human history, many wetland plants have been a source of fibre for making such items as baskets, roofs, paper and rope. Papyrus, for example, was used for making paper as early as 4000 BC (think of the ancient Egyptian scrolls).

Recreational and cultural benefits: many rivers, lakes and wetlands are highly valued for recreational and cultural benefits, some of which have high economic value (such as tourism). In developed countries, sport fishing is also an important recreational activity and a significant source of income for many communities. Recreational fishers have been a major driving force in cleaning up freshwater environments to restore recreational benefits.

AQUACULTURE

Aquaculture is the farming of fish and other aquatic animals and plants (e.g. shrimp, frogs, mussels, oysters and seaweed). Freshwater aquaculture can be very beneficial and provide food and income for many people, particularly in rural communities in developing countries.

Aquaculture originated as freshwater carp farming in Asia and is now widespread. Asia still leads the way in this industry, accounting for 92 percent of global production (70 percent in China, 22 percent in the rest of the region).

Worldwide, about half of production is in fresh or **brackish water** (a mix of fresh and salt water), and the other half in marine environments. Most aquaculture production in freshwater is fish. The main freshwater species cultured include carp, tilapia, pacu, catfish and trout.

Production from freshwater fish species tends to be more sustainable than from marine species because most of it is based on vegetarian rather than carnivorous species. For example, it can take two kilograms of fish to produce one kilogram of salmon (a carnivorous fish), which doesn't sound like a good deal. Better to eat lower down the food chain!

Aquaculture can cause water **pollution** (from chemical use and waste products) and introduce **invasive alien species** (species that have spread outside of their natural habitat and threaten biodiversity in the new area). Efforts must be made to address these impacts, particularly as aquaculture develops, expands and intensifies.

A FISH FARM NEAR NEW DELHI, INDIA.
© FAO

Carbon storage: climate change is largely due to the release of carbon dioxide and other greenhouse gases into the atmosphere. Wetlands, particularly peatlands, are "carbon sinks": they remove and store significant quantities of carbon from the atmosphere. Peatlands alone store more than twice as much carbon as all the world's forests. Destruction of these wetlands results in the release of carbon into the atmosphere, increasing the intensity of global climate change. Human exploitation has destroyed 25 percent of the peatlands on Earth.

Water purification and filtration: plants, animals and bacteria in forests, soils and wetlands also filter and purify water. Wetland plants accumulate excess nutrients (such as phosphorus and nitrogen) and toxic substances (such as heavy metals) in their tissues, removing them from the surrounding water and preventing them from reaching drinking water. They can be thought of as "nature's kidneys" (see box: "Biodiversity = Clean Water = Human Health").

Flood regulation: many wetlands provide a natural flood barrier. Peatlands, wet grasslands and floodplains at the source of streams and rivers act like sponges, absorbing excess rainwater runoff and spring snowmelt, releasing it slowly into rivers and allowing it to be absorbed more slowly into the soil, preventing sudden, damaging floods downstream. Coastal freshwater-dependent wetlands, such as mangroves, saltmarshes, tidal flats, deltas and estuaries, can limit the damaging effects of storm surges and tidal waves by acting as physical barriers that reduce the water's height and speed. As global climate change raises sea levels and increases extreme weather in many parts of the world, the need for these services has never been greater.

SITTING ON A ROOF, RESIDENTS IN NEW ORLEANS WAIT TO BE RESCUED AFTER HURRICANE KATRINA.

BIODIVERSITY = CLEAN WATER = HUMAN HEALTH

All life depends on water. Human beings need two to three litres of clean drinking water a day. Without food we can survive weeks. But without water, we can die of dehydration in as little as two days. More than one billion people in the world lack access to safe drinking water, and some two million people die each year of diarrhoea caused by unclean water, 70 percent of these are children.

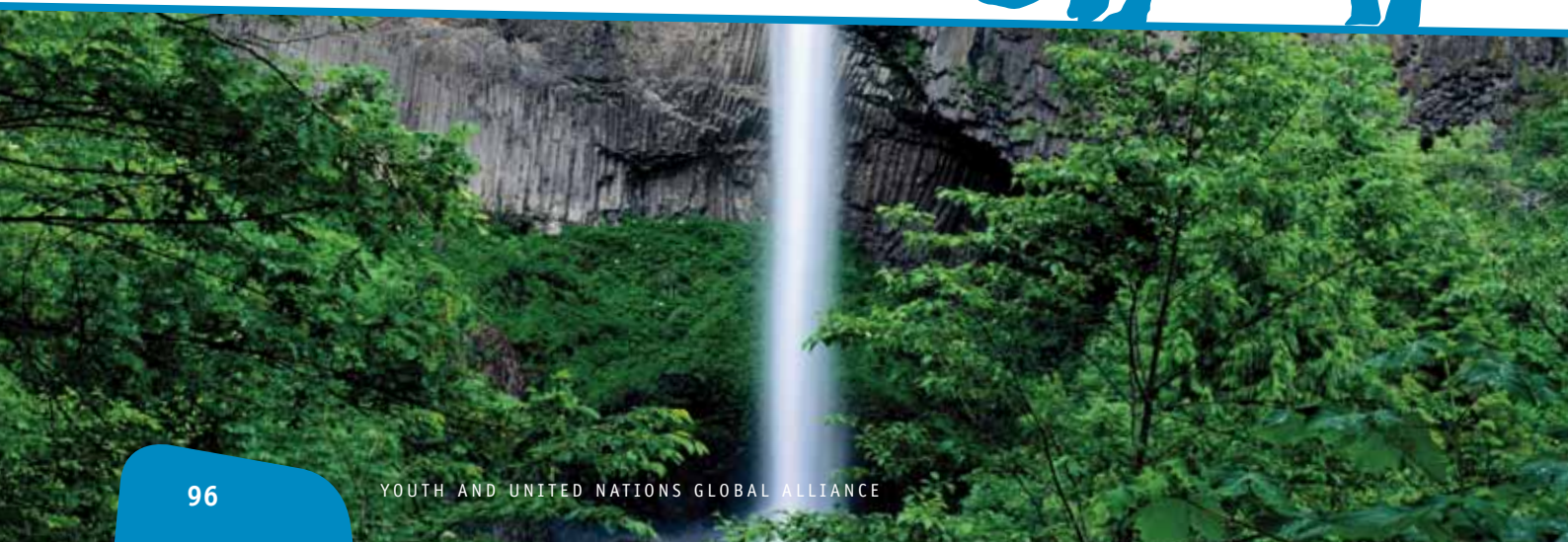
Healthy ecosystems contribute to providing clean water supplies. Many cities, for example, obtain their water supply from **protected areas** outside the cities.

WATER SAMPLES FROM INDIA'S MUSI RIVER TAKEN AT INTERVALS UP TO 40 KM DOWNSTREAM OF HYDERABAD. ON THE LEFT, CLOSE TO THE CITY, WATER IS HIGHLY POLLUTED FROM UNTREATED WASTES. WATER QUALITY IMPROVES DOWNSTREAM AS THE ECOSYSTEM BREAKS DOWN THIS WASTE.

THREATS TO FRESHWATER BIODIVERSITY

Biodiversity is being lost more rapidly in freshwater ecosystems than in any other ecosystem type.

- Some 20 percent of freshwater fish species are considered extinct or threatened, a far greater percentage than for marine fishes.
- 44 percent of the 1 200 waterbird populations with known trends are in decline (compared to 27.5 percent of seabirds being threatened).
- 42 percent of amphibian species populations are declining.
- Among groups of animals that live in many different areas, those species living in association with freshwater tend to show the greatest level of threat (including, for example, butterflies, mammals and reptiles).
- On average, over half of the natural wetland area has probably been lost in most developed countries. In Canada, for example, more than 80 percent of the wetlands near major urban centres have been converted for agricultural use or urban expansion; in many others, the loss is higher than 90 percent (e.g. New Zealand).



This loss of biodiversity is because of the human demands placed on freshwater and wetland habitats due to such factors as:

- **Conversion of habitat**, through the draining of wetlands for agriculture, urban development or damming of rivers.
- **Overuse** of water for irrigation, industrial and household use, interfering with water availability; (agricultural production alone accounts for over 70 percent of water extracted from rivers – the biggest use of water worldwide).
- **Pollution** of water through excess nutrients (phosphorus and nitrogen) and other pollutants such as pesticides and industrial and urban chemicals (see box: "Aren't Nutrients Good For You?").
- **Introduction of alien species**, causing local extinction of native freshwater species.

These threats are rapidly increasing as human populations grow and demands on water escalate.

Climate change is also becoming an important threat to wetlands and their biodiversity. Its main impacts will be on fresh water: melting glaciers and ice-caps (which are fresh water) causing rising sea levels, and changes in rainfall (less of it in some areas, leading to drought, more of it in others, leading to excessive flooding). One projection indicates that water availability will decrease in about a third of the world's rivers. Almost half the world's population will be living in areas of high water stress by 2030.

AREN'T NUTRIENTS **GOOD FOR YOU?**

What's wrong with nutrients? Aren't they good for you? All living things need nutrients, such as nitrogen and phosphorus, to grow and survive. That's why these nutrients are the main ingredients in agricultural fertilisers (helping crops to grow). Excess nutrients are also contained in sewage from both households and farms (excreted from all living things).

The problem arises when nutrients are dumped untreated or washed into waterways in excessive quantities: this leads to the excess growth of certain plants (algae), which consume the oxygen in the water as they grow and decay. This process, known as "**eutrophication**", makes the water unliveable for fish, and the algal blooms make the waterways unpleasant for recreational use; in some cases algal blooms even become poisonous.

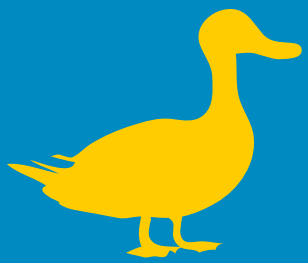
WHAT CAN BE DONE?

A number of organisations and international agreements aim to protect freshwater biodiversity, including:

- The Convention on Biological Diversity: this Convention has a programme of work specifically dedicated to protecting inland waters biodiversity.
- The Ramsar Convention on Wetlands: is an intergovernmental treaty that guides national action and international cooperation for the conservation and sustainable use of wetlands and their resources; almost 1 900 "Wetlands of International Importance" have been designated under the treaty.
- Wetlands International: a global organisation that works to sustain and restore wetlands and their resources for people and biodiversity.
- The International Union for Conservation of Nature (IUCN), The Nature Conservancy (TNC), The World Wide Fund for Nature/World Wildlife Fund (WWF) and Conservation International (CI) all have freshwater programmes. There are many other non-governmental organisations (NGOs) addressing freshwater issues at regional, national and local levels.

FIND OUT WHERE YOUR WATER COMES FROM...

The first step in protecting freshwater biodiversity is to become aware of where fresh water comes from and how much we depend on it: not just for what we drink, but for personal hygiene, growing our food, and producing energy and the goods we consume.



FIND OUT HOW MUCH WATER YOU DRINK. AND EAT. AND WEAR. AND DRIVE. AND...

Globally, people use an average of 633 cubic metres per year.

Water footprints however vary greatly from one part of the world to another; for example, the average person consumes 173 cubic metres per year in sub-Saharan Africa, 581 cubic metres in Europe, and 1 663 cubic metres in North America.

Of the water consumed, only about 0.75 to 1.5 cubic metres per year, much less than one percent, is actually used for drinking. We consume much more in other ways, particularly by eating it.

Here are some water requirements to produce typical products:

Hamburger: 2 400 litres
Glass of milk: 200 litres
Cup of coffee: 140 litres
Cup of tea: 35 litres
Glass of apple juice: 190 litres
Cotton T-shirt: 4 100 litres
Pair of leather shoes: 8 000 litres
Tonne of steel: 230 000 litres

Meat production in particular, especially beef, consumes a great deal of water. The average volume of water (worldwide) required to produce one tonne of beef is 15 497 cubic metres; compare this to a tonne of chicken (3 918) or a tonne of soybeans or barley (1 789 and 1 388, respectively).

A sustainable diet, anyone?

CLEAN HOME, CLEAN EARTH...

Another way to reduce your impact on waterways is to reduce or eliminate your use of chemicals. Many laundry detergents today are phosphate-free, but this is not the case for most dishwasher detergents. What about the other cleaning, personal hygiene and gardening products you use? Are they really necessary? Find out what they contain and how you can replace them: for instance, there are plenty of biodegradable alternatives for many of the products we typically use. Most garden chemicals can be avoided by changing the plants grown, gardening practices and accepting a more natural landscape (which can also look nicer).

LOOK UPSTREAM, DOWNSTREAM AND BENEATH YOUR FEET...

Want to get more involved? Look "upstream" – and see how sustaining the water catchment can improve water security. Look "downstream" – and see how you can reduce your impact. And don't forget to look beneath your feet – promote the conservation of groundwater by avoiding polluting or overusing it and maintaining the nature above ground that helps to replenish it.

Join a group – or start one – and help clean up rivers and lakes, including the banks and wetlands. Support wetland protection and restoration. Promote approaches to water supply and management that use the abilities of ecosystems to supply clean water more securely and for reducing flood risk.

THE GOOD NEWS...

The loss of freshwater biodiversity and degradation of ecosystems are not necessarily irreversible. For example, many countries, in both rich and poor regions, are starting to take steps to restore wetlands that were drained in the relatively recent past. This is being done because the benefits of restoring the services provided by these wetlands can outweigh the costs of not having those services (e.g. poor water quality and increased flood risk). The process begins with public recognition of the values of these ecosystems to people and the economic benefits of managing them more wisely.

LEARN MORE

- Conservation International (CI): www.conservation.org
- Hamilton 2008. Forests and Water. FAO Forestry Paper 155, Rome: FAO, 3.
- The International Union for Conservation of Nature (IUCN): www.iucn.org
- The Nature Conservancy (TNC): www.nature.org
- Peatlands: www.wetlands.org/Whatwedo/PeatlandsandCO2emissions/tabid/837/Default.aspx
- The Ramsar Convention on Wetlands: www.ramsar.org
- Water Footprints: www.waterfootprint.org/Reports/Report16Vol1.pdf earthtrends.wri.org/pdf_library/data_tables/wat2_2005.pdf
- Wetlands International: www.wetlands.org
- The World Wildlife Fund / The World Wide Fund for Nature (WWF): www.wwf.org