22 MAY 2013
INTERNATIONAL DAY
FOR BIOLOGICAL DIVERSITY
WATER & BIODIVERSITY

NATURAL SOLUTIONS FOR WATER SECURITY

UNEP

Convention on
Biological Diversity

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FOR FURTHER INFORMATION, PLEASE CONTACT:

Secretariat of the Convention on Biological Diversity
World Trade Centre
413 St. Jacques Street, Suite 800
Montreal, Quebec, Canada H2Y 1N9

Phone: 1 (514) 288 2220
Fax: 1 (514) 288 6588
E-mail: secretariat@cbd.int
Website: www.cbd.int

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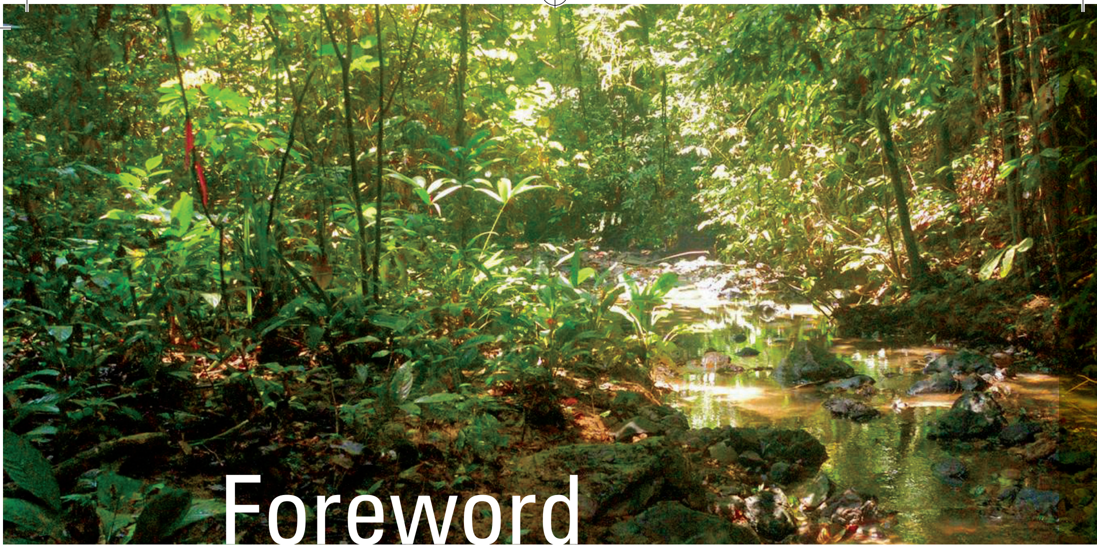
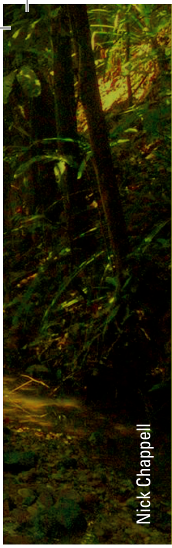


Foreword

The International Day for Biological Diversity, celebrated every year on 22 May, is a special occasion to reflect on the role of biodiversity for our lives. In 2013 the theme for the day is Water and Biodiversity in recognition of the United Nations designation of 2013 as the International Year of Water Cooperation.

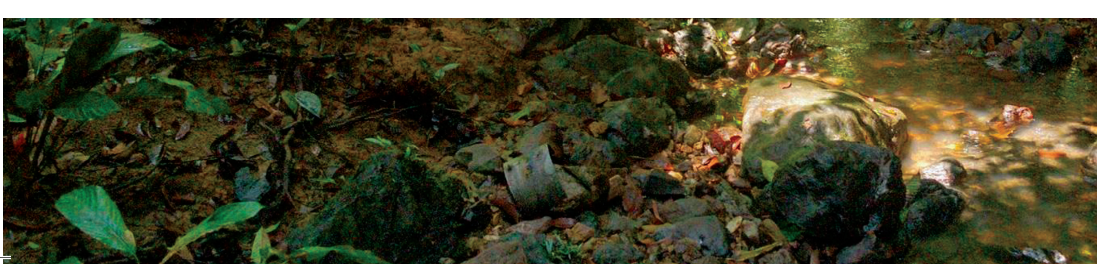
Although seemingly abundant, only a miniscule amount of the total water on our planet (0.03%) is available as liquid freshwater at or near the land surface; the remainder is saltwater in the oceans or freshwater locked away in the ice caps or deep groundwater. This water supports all terrestrial and freshwater biodiversity, underpins most aspects of human welfare and is essential for sustainable development. Water is recyclable but not replaceable. We have options to produce energy and food, but not water. Water is essential for basic human needs, food security and most economic activities. The "nexus" between water, food and energy is one of the most fundamental relationships - and increasing challenges - for society. Water is, therefore, our most precious natural resource and it is important to be aware that Biodiversity and particularly wetland ecosystems are increasingly understood to be at the core of this nexus.



We live in an increasingly water-insecure world where demands often outstrip supply and water quality often fails to meet minimum requirements. Under current trends, future demands on water to feed growing human populations, increasing consumption of water for intensive production of goods and to support growing economies will not be met. Widespread droughts and floods already reflect the starkest of realities. Water increasingly limits farmers' livelihoods and food security. Women and young girls in many countries continue to carry the full burden of water inequality. For too many, water is literally a matter of life or death. Climate change exerts its impacts on people and ecosystems largely through water and therefore increases the already significant risks. Few countries are immune. Although developing countries face the severest challenges, water is becoming increasingly insecure in rich nations too. For these reasons water is already very high on the public, political and economic agendas.

Against this background of pressing and immediate problems, biodiversity and the ecosystem services it supports can help us achieve sustainable water security. Water is an ecosystem service. Ecosystems, especially forests and wetlands, play a central role in the water cycle and influence the local, regional and global availability and quality of water. This means that ecosystem management has a central role to play in managing water. Forests can help regulate soil erosion and protect water supplies. Wetlands are natural infrastructures that can be used to store water, clean water, allocate water to a wide range of user groups, from the mountain to the sea and reduce flood risks. Soil biodiversity is critical for maintaining water availability for plants, as well as supporting nutrient availability, and together these attributes not only underpin food security but also reduce agricultural impacts on water. Using ecosystems to manage water has been rapidly advancing in recent years as we search for more cost-effective and sustainable solutions. There are significant opportunities to further upscale the approach.

Governments have realized this and are acting. The tenth meeting of the Conference of the Parties to the Convention on Biological Diversity, in Nagoya, Japan in 2010, recognized the important links between water, biodiversity and sustainable development. Water was incorporated into the Strategic Plan for Biodiversity 2011-2020 and the Aichi Biodiversity Targets adopted at the same meeting. The eleventh meeting of the Conference of



the Parties, in Hyderabad, India, 2012, further recognized the importance of the water cycle, and the influence of climate change upon it, to most areas of work of the Convention and to achieving most of the Aichi Biodiversity Targets. They also recognized the role of the water cycle, as a cross-cutting theme, when implementing the Strategic Plan for Biodiversity 2011-2020. A call was also made for a cooperatiåve partnership to promote awareness of, and capacity building for, ecosystem based solutions for water resources management as a means to enhance the implementation of the Strategic Plan for Biodiversity 2011-2020 by the broadest range of stakeholders, as a contribution to sustainable development and to the United Nations

International Year of Water Cooperation (2013). The meeting also recognized the importance of ecosystem restoration and called for significantly enhanced efforts towards this. Restoring water-related services is one of the most obvious and attractive social and economic benefits of ecosystem restoration and therefore also a major source of financing.

This year also marks an acceleration of discussions around the progress achieved towards the Millennium Development Goals and the discussion on a post-2015 sustainable development agenda. Numerous forums and consultations are already noting the high profile water should have in these discussions and their outcome. Focus is rightly on the water-related future we want which, one way or another, centres on achieving universal water security. But outcomes need to be accompanied by ways and means to achieve them. This booklet explains why biodiversity is central to achieving the vision of a water secure world.

The central message throughout this booklet is that biodiversity is here to help – as a sustainable solution. Through this approach we can truly demonstrate the concrete links between biodiversity conservation and sustainable development. We are able to talk in tangible and immediately relevant terms – indeed about life and death itself. What subject could be more compelling? Through this booklet and messaging we, as “biodiversity practitioners”, are offering a partnership to collectively achieve a more water secure world. We encourage you to spread this message and help us move towards the full cooperation among all that will be required to overcome the significant but not un-surmountable challenges ahead.

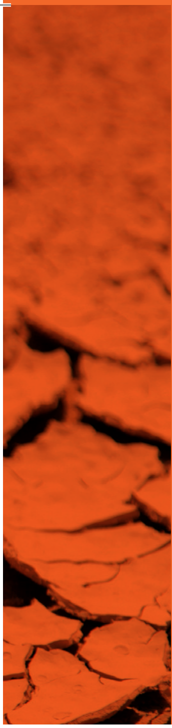
Braulio Ferreira de Souza Dias
Executive Secretary, Convention on Biological Diversity

Anada Tiega
Secretary General, Ramsar Convention on Wetlands

Summary

This years’ theme for the International Day for Biological Diversity, “Water and Biodiversity”, was chosen to coincide with the United Nations designation of 2013 as the International Year of Water Cooperation. Sustainable water management requires cooperation among a wide range of stakeholders, if not all.

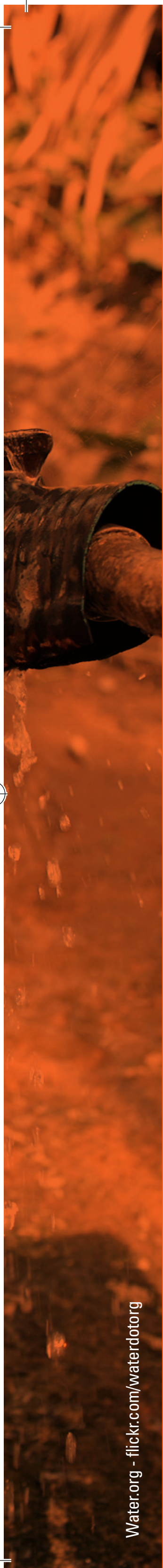
Water is our most precious natural resource and central to sustainable development. Of all of the world’s water, only 0.03% is available as liquid freshwater at or near the land surface. This water supports all terrestrial and freshwater biodiversity, underpins most aspects of human welfare and is essential for sustainable development. Water is a renewable but a finite resource. It can be recycled but not replaced. Water security is very high on the government, public and business agenda. In a 2012 survey by the World Economic Forum, water supply crises were listed as the second ranked global risk after major systemic financial failure, and ahead of food shortage crises, chronic fiscal imbalances and extreme volatility in energy and agricultural prices.



We live in a world suffering from rapidly increasing water insecurity. Currently 884 million people (12.5% of the global population) are living without safe drinking water and 2.5 billion people (40%) do not have adequate sanitation. By 2025, 1.8 billion people will be living in countries or regions with absolute water scarcity, and two-thirds of the world population could be under water stress conditions. The water extremes of drought and flood are ever increasing problems. Worldwide, more than 7,000 major disasters have been recorded since 1970, causing at least US $2 trillion in damage and killing at least 2.5 million people. Water-related hazards account for 90% of all natural hazards, and their frequency and intensity are generally rising. Some 373 natural disasters killed more than 296,800 people in 2010 alone, affected nearly 208 million others and cost nearly US $110 billion.

Set against this background managing the impact of water on biodiversity will be an increasingly difficult challenge. Faced with such pressing demands on water, the stark realities of achieving access to and supply of water as a human right, and the importance of water to economic growth, many might place a low value on biodiversity in trade-offs in water allocation and management decisions. But water is an ecosystem service. Biodiversity is critical to the maintenance of both the quality and quantity of water supplies and plays a vital but often under-acknowledged role in the water cycle. This changes the water-biodiversity paradigm by requiring us to look at how biodiversity influences water. The equation becomes less about trade-offs and more about converging interests between biodiversity and water. We shift from potential conflict to partnerships and cooperation.

Javier Carcamo - flickr.com/javic



Water moves around the planet in the water cycle, which is influenced heavily by ecosystems and the life associated with them. Forests, grasslands, soils, wetlands all influence water. Vegetated land cover regulates water movement across land and water infiltration into soils. Biodiversity supports water and nutrient cycling in soils and therefore plants, including all food crops. Together these processes control land erosion and regulate water quality. Plant transpiration, in turn, is a major contributor to local and regional humidity and rainfall. Wetlands in particular have particularly visible hydrological functions such as the ability to store water and hence some can assist in helping us regulate floods. These functions of ecosystems operate at local, regional and global scales and offer us opportunities to consider them as "natural water infrastructure" to be used in ways to achieve the same objectives as hard engineered infrastructure such as dams, pipelines, water treatment plants, irrigation systems, drainage networks and flood management embankments. In most cases natural and hard-physical infrastructure would work in parallel with the benefits of each approach delivering optimal benefits overall in a mutually reinforcing way.

There is now a very substantial evidence base that natural infrastructure solutions work and in most cases offer cost-effective and sustainable solutions. Examples include: using forests to protect water supplies; wetlands or forest serving as buffer strips to recycle pollutants and hence improve water quality; rehabilitating soil biodiversity and functions to deliver improved water availability to crops and hence improve food security, whilst simultaneously reducing water use and off-farm impacts; replacing, or reducing running costs of, water treatment facilities by rehabilitating landscapes; reducing flood, drought and erosion risks by restoring natural water storage in catchments, in particular using wetlands but also through restoring land cover and soil health; protecting coastal communities from storms through strengthening coastal ecosystems as buffers; and addressing desertification through restoring land cover and soils to keep water where it is needed (in the ground). There are substantial opportunities for natural infrastructure solutions for water and climate management for sustainable cities. Natural infrastructure solutions are already widespread and incorporated into many modern water management strategies. But there is substantial opportunity to mainstream and upscale the approach. Natural infrastructure can play a vital role in increasing resilience to disasters, and its degradation is often a primary cause of disasters in the first place.

Natural infrastructure solutions also deliver substantial co-benefits in addition to improved water outcomes. These include tourism, recreation and cultural benefits, improved resilience and biodiversity conservation. There is a rapidly expanding knowledge base demonstrating that biodiversity conservation and development objectives can be aligned through simple, practical and cost-effective approaches to achieving water security.

The impacts of climate change are mediated largely through water. Climate change affects the mean availability of water but in particular will worsen the extremes of drought and flood. Using the natural water infrastructure of ecosystems is therefore a primary response to adapt to climate change in order to protect both human society and biodiversity from increasing risks. Because the water and carbon cycles are inter-dependent, using natural infrastructure also forges strong links between climate change mitigation (carbon) and adaptation (water).

Investing in natural infrastructure does not necessarily require new financial resources. In fact, the approach can reduce investment costs. Considerable sums of money are already spent on capital and maintenance costs of water-related infrastructure and much more is required. Using natural water infrastructure is already a major source of "biodiversity financing" and certainly a key area with significant further potential. Even a small shift towards further integrating natural infrastructure solutions into ongoing investment strategies can mobilise substantial financial resources for sustainable economies, ecosystems and biodiversity.

The water-biodiversity interface is best seen not as one of conflict and trade-offs but one of cooperation for mutually supporting ends. The key message is that **biodiversity is a solution to help achieve water security**. The objectives of most of the multilateral environment agreements (and in particular the CBD, UNFCCC, UNCCD and the Ramsar Convention) reveal common ground centred on cooperation regarding harnessing the water related benefits of healthy ecosystems. The Strategic Plan for Biodiversity 2011-2020 has, at its heart, the sustainable management of water related ecosystem services as a contribution to sustainable development. This is also a central theme in the current discussions of the sustainable development agenda post-2015 and in particular regarding how environmental sustainability is not only an important goal in itself, but a means for achieving most other objectives which are underpinned by sustainable water security.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Introduction

IMPORTANCE OF WATER

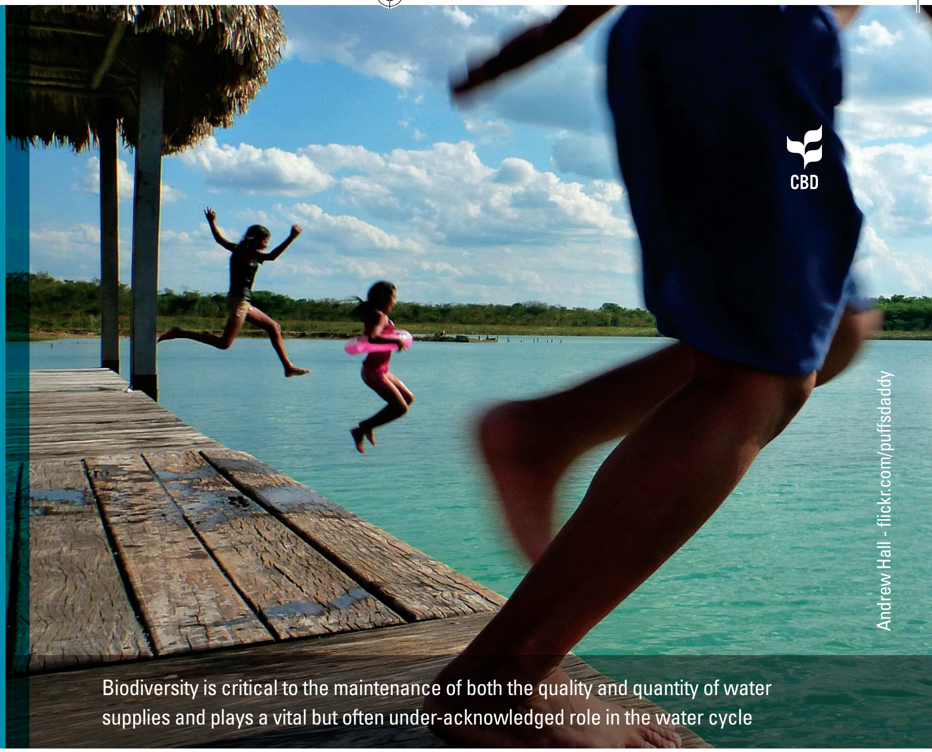
Water is the essence of life. Our search for extra-terrestrial life starts with the search for water. The Earth without water is a planet without life. With water covering approximately two-thirds of the planet and accounting for more than 65% of the human body, water is the essential ingredient in the complex chemistry that makes all life on Earth possible. The very vastness of water on the planet gives it an aura of illimitability.

But in the words of the Ancient Mariner, "Water, water everywhere, nor any drop to drink" reminds us that useful water, that in its freshwater form, is indeed extremely limited. Of all the world's water, less than 3% occurs as freshwater but most of this is locked in the ice-caps and glaciers or deep underground. Only 1% of this freshwater (0.03% of total water) is available as liquid water at the Earth surface.

Species that depend on freshwater include not only those living within it but all terrestrial species which require freshwater to survive. The richness of freshwater dependent species is in the region of 100 to 150 times higher than for marine species on a volume of water basis (and is 10,000 - 15,000 times higher if frozen water and groundwater volumes are discounted). This richness may be even greater considering that many coastal and brackish-water species depend on freshwater inputs.

Water is the critical natural resource which underpins all social and economic activity. Without water food production stops, cities cease to function, economic activity halts, green forests turn to desert. As demand rises and competition for this precious resource increases, all users across the planet can no longer guarantee uninterrupted access to water supplies and therefore the water dependent benefits such as agriculture, energy and health.

Water is required to support biodiversity. Without sufficient water, stresses on species increase driving global biodiversity losses. Released in 2005, the Millennium Ecosystem Assessment[1], an analysis of the state of the Earth's ecosystems produced by over 1000 of the world's leading scientists, concluded that under all potential future scenarios water withdrawals were considered to exert continuing impacts on freshwater ecosystems. This viewpoint is nothing new. A report produced by UK-based Non-Governmental Organisations in the mid-1990s urged the Government to take on board proposed actions necessary to enable the sustainable use of water resources across the country. The overriding tone of the report is captured in the following quote:

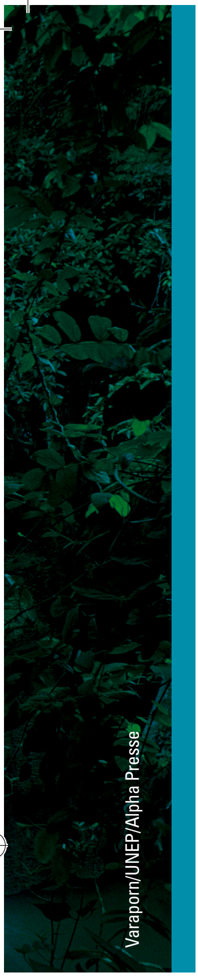


Biodiversity is critical to the maintenance of both the quality and quantity of water supplies and plays a vital but often under-acknowledged role in the water cycle

> "Clean fresh water is vital for life and many species are adapted to living in, on or beside water or watery habitats. Rivers and wetlands are a major part of the UK's biodiversity heritage. They are essential not just for wildlife, but for humans too. When the water is sucked out of these habitats through over-abstraction, whole river lengths disappear and wetlands slowly dry out. Both people and wildlife suffer."

Biodiversity is critical to the maintenance of both the quality and quantity of water supplies and plays a vital but often under-acknowledged role in the water cycle.

The loss and degradation of biodiversity generates impacts on human well-being. The benefits people obtain from ecosystems, termed “ecosystem services” are eroded with progressive degradation and loss of biodiversity. Services such as the supply of freshwater and food, the reduction of risk from flooding and drought, the cycling of nutrients and the removal of contaminants from water, the moderation of the climatic extremes and the importance for cultural and recreational activities can all be compromised as biodiversity is lost. As vital services are eroded human well-being can be damaged, or else costs must be borne to replace or restore these lost services.

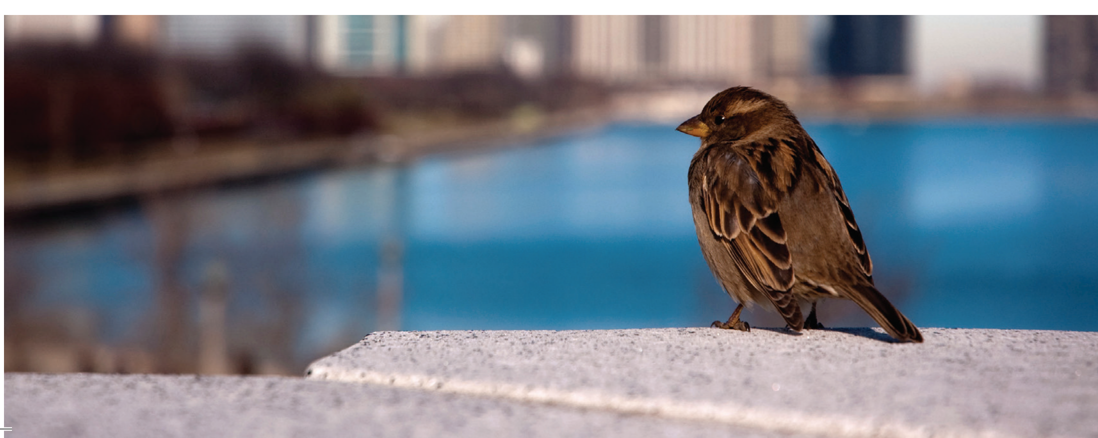


BIODIVERSITY FOR WATER – A NEW PARADIGM

The message is clear and unambiguous, both humans and biodiversity need water. Without appropriate stewardship and management, unsustainable use of water resources will continue to drive biodiversity loss and compromise human well-being. However, increasingly the relationship between biodiversity and water is being refocused. The world should no longer consider biodiversity as simply an end user of water. Without ecosystems, and the complex biological relationships and processes that they support, the quantity and quality of global water resources would be severely compromised. The current paradigm, in which water and biodiversity are managed separately, is obsolete. In paraphrasing a famous quotation by former US President John F. Kennedy this paradigm shift can be summarised as:

> "Ask not what water can do for biodiversity;
> ask what biodiversity can do for water."

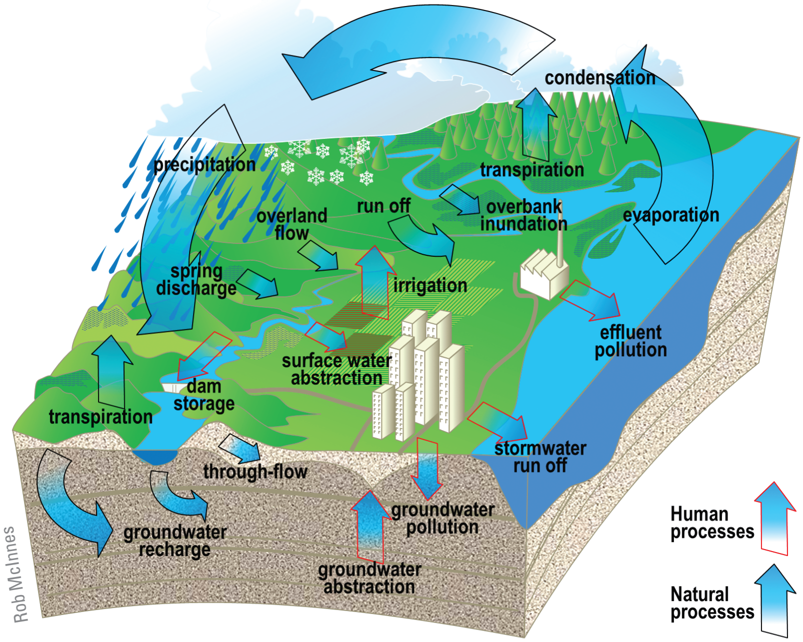
Well-functioning watersheds, including forests, grasslands and soils, and wetlands, including watercourses, lakes, swamps and floodplains, provide water storage, clean water, manage flood flows and provide society with a vast array of benefits. These are the "natural water infrastructure" upon which human well-being depends. Experience from around the world is showing that natural infrastructure provided by ecosystems can be conserved and restored to manage water for a variety of objectives including mitigating flooding and drought, reducing vulnerability to erosion and storm damage, providing sustainable clean supplies of water, supporting food production and regulating global and local climatic processes. Increasingly, hard hitting economic arguments are demonstrating that the protection, management and restoration of natural infrastructure are providing cost-effective and sustainable solutions to deal with uncertain future events. Essential to this is the relationship between water and biodiversity.



THE CONCEPT OF "NATURAL INFRASTRUCTURE"

The area of water policy remains dominated by interest and investment in hard (physical) infrastructure and planning and management is heavily biased towards engineering approaches. The more we refer to the ability of Earth's ecosystems to achieve water-related management objectives as natural infrastructure, the more readily they will be received as a possible alternative or complement to hard infrastructure. For example, wetlands, well vegetated catchments and soundly managed soils can all deliver similar water quality outcomes as artificial physical/chemical water treatment facilities and similar water storage outcomes (including flood and drought risk reduction) as dams, drainage, networks and impoundments.

The approach is founded on the fact that ecosystems are not just the victims of water use, but are also responsible for making water available in the first place. The considerable advantages of this include improved sustainability and often cost-effective solutions and in the delivery of co-benefits, in addition to sustaining water for direct human use: for example, the recreational and cultural benefits of an improved landscape, regulating and maintaining soil formation, soil transfer and the health of estuaries, and supporting fisheries.



THE NEVER ENDING WATER CYCLE

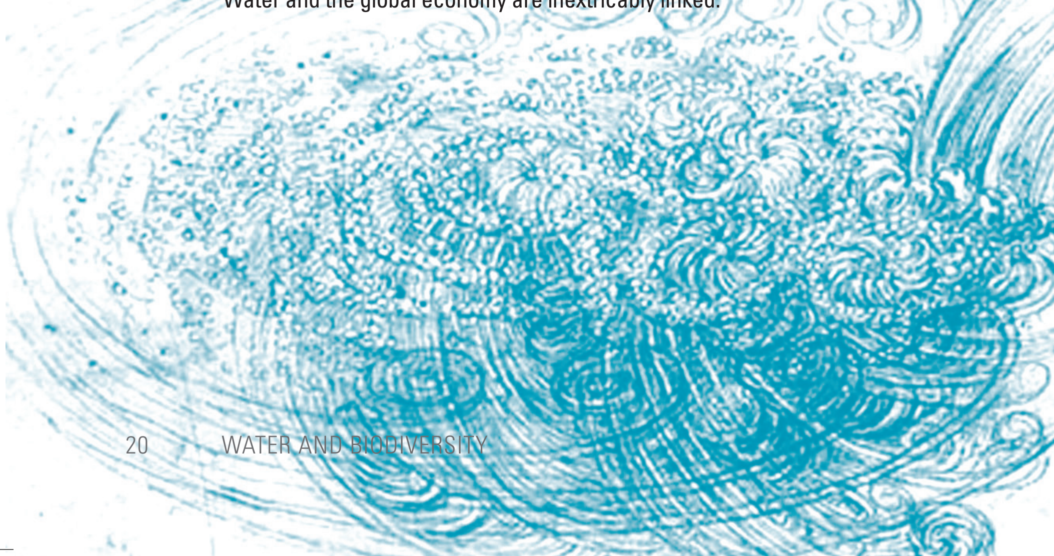
Water is constantly changing states from liquid to solid to gas and being recycled around the Earth. This hydrological, or water, cycle is driven by complex, interrelated dynamic natural processes. Driven by solar energy, and influenced by the Earth's tilt and rotation, vast amounts of water are continually lifted from the oceans into the atmosphere and transported over the land surface where they fall back to Earth as life-giving precipitation. On land, evaporation from the ground surfaces and, in particular, transpiration of plants contributes to local and regional precipitation. However, precipitation delivers freshwater to the planet's surface unevenly across both space and time. Increasingly the world is facing greater variability between arid and humid climates and rainfall patterns are becoming more dynamic and unpredictable from season to season and year to year. This is driven by both climate change and variability and changing land and water use patterns. As a result, the global distribution of freshwater resources is irregular and increasingly more difficult to predict.

> Water is our most valuable resource. It is finite and whilst it is recyclable it is not replaceable.

Humans are complicit in increasing the variability of the global circulation of moisture. Changes in atmospheric temperatures and the warming of the oceans are altering the subtleties of the global hydrological cycle. Deforestation is changing regional rainfall patterns. Whilst some countries have more water available than others as a result of global climactic processes, human activities are indirectly changing this pattern. However, this relatively simple perspective becomes increasingly complex when the water availability per person is considered. Such a consideration provides a more appropriate indication of the total water available for social or economic purposes and the direct impacts human society can have on water resources.

THE SOCIO-ECONOMIC CONTEXT

Water is our most valuable natural asset and it is central to sustainable development. Socio-economic demands on water resources are influenced by a range of local and global factors including population growth, economic development, dietary requirements, as well as physical interventions such as engineered infrastructure to protect settlements from flooding and physical infrastructure to transfer water from one watershed to another. All of these influences can introduce greater uncertainty regarding the use and availability of water resources in addition to the existing uncertainties relating to the Earth's climatic system and hydrological cycle. These uncertainties are ultimately manifest in socio-economic outcomes and decision-making. Water and the global economy are inextricably linked.



LEONARDO DA VINCI'S WATER CYCLE

The great artist/scientist Leonardo da Vinci (1452 - 1519) was the first to systematically and accurately describe and depict the water cycle including recognizing the role of biodiversity in it:

> *"The water which sees the air through broken veins of the high mountain summits is suddenly abandoned by the power which brought it there, and escaping from these forces resumes its natural course in liberty. Likewise the water that rises from the low roots of the vine to its lofty head falls through the cut branches upon the roots and mounts anew to the place whence it fell." "Water is the driver of nature. Water, which is the vital humour of the terrestrial machine, moves by its own natural heat."*

In *Leicester Codex* (probable dates 1506-1510), a collection of 18 double sheets of paper, Leonardo wrote thousands of lines of his observations on water and the science of hydraulics. He also recognized the role of water in erosion:

> *"[Water]... carries away or sets down, hollows out or builds up, tears or establishes, fills or empties, raises itself or burrows down, speeds or is still; is the cause at times of life or death, or increase or privation, nourishes at times and at others does the contrary; at times has a tang, at times is without savour, sometimes submerging the valleys with great floods. In time and with water, everything changes".*

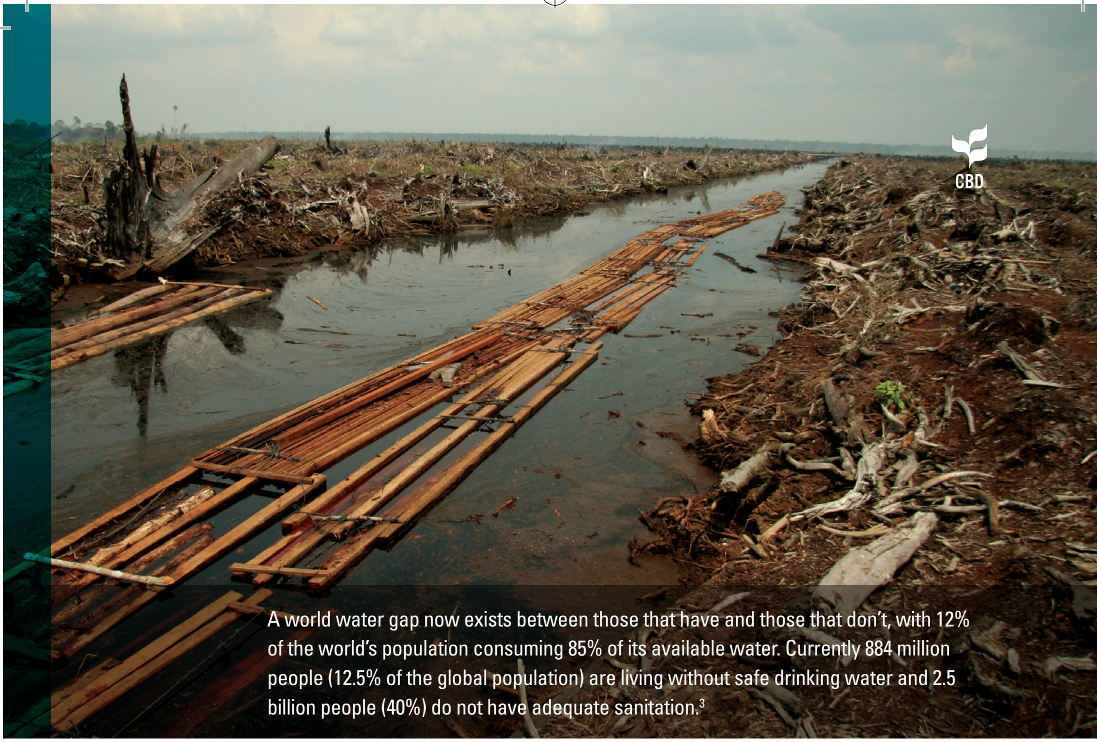
Leonardo also described water as *"the vehicle of nature"* ("vetturale di natura"), believing water to be to the world what blood is to our bodies.

The World Economic Forum Survey of Global Risks (2012) ranked water supply crises as the second highest in terms of impact, after major systemic financial failure, and ahead of the other top five ranked risks - food shortage crises, chronic fiscal imbalances and extreme volatility in energy and agricultural prices. Water supply crises rank in the top five in terms of likelihood along with severe income disparity, fiscal imbalances, green-house gas emissions and cyber attacks.*

Set against these uncertainties is the daily requirement for every human on the planet to have access to 20-50 litres of clean water, free from harmful chemical and microbial contaminants, for drinking, cooking and hygiene purposes. However, in the 50 years from 1950 to 2000, human population growth has reduced the amount of available freshwater per person by 60%. Sustainable water management is a key global concern and a matter of life and death for a huge number of humans.

How much water do we eat, wear and write on? In addition to individual needs, such as water for drinking, cooking and washing, human society uses vast water resources in its production systems. Food, paper, cotton clothes, even the motor car all require water for their production. Agriculture alone accounts for 65-70% of global water use and is often a relatively low-value, low efficiency and highly subsidised user. In some regions, irrigated agriculture accounts for 70-90% of water withdrawals[3]. Meat production can use nearly ten times more water than cereal production.

* *http://www3.weforum.org/docs/WEF_GlobalRisks_Report_2012.pdf*



A world water gap now exists between those that have and those that don't, with 12% of the world's population consuming 85% of its available water. Currently 884 million people (12.5% of the global population) are living without safe drinking water and 2.5 billion people (40%) do not have adequate sanitation.[3]

EXAMPLES OF WATER REQUIREMENTS [3]

3 litres of water to make 1 litre of bottled water
2-13 litres for an A4 sheet of paper
140 litres to make one cup of coffee
170 litres for a pint of beer
800-4,000 litres for a kilo of wheat
1,000-4,000 litres per litre of biofuel
2,393 litres for a burger
2,000-8,700 litres for a kilo of cotton
2,000-16,000 litres for a kilo of beef
9,982 litres for a pair of jeans

Adam Valvasori - flickr.com/mrfink

To deliver successful water management it is important to understand both direct and indirect water use from the perspectives of both consumers and producers of goods and products. Understanding the 'water footprint' of an individual, community or business, or the total volume of freshwater that is used to produce the goods and services consumed by these individuals, communities or industries, is essential element of sustainable water management.

Increasingly, the water footprints of human activities are becoming unsustainable. Water usage has been growing at more than twice the rate of population increase in the last century, and, although there is no global water scarcity as such, an increasing number of regions are chronically short of water. The situation will be exacerbated as rapidly growing urban areas place heavy pressure on neighbouring water resources and associated environments.

How do we ensure access to precious water resources for a growing population whilst ensuring the future protection of the very ecosystems upon which we depend? This is where recognition of the fundamental ecological functions of ecosystems as regulators of water regimes comes into its own. Ecosystems are the Earth's natural infrastructure which regulates the supply of freshwater. The continued loss and degradation of a variety of ecosystems directly compromises the water cycle and challenges human well-being.

SCA Svenska Cellulosa Aktiebolaget - flickr.com/hygienematters

By 2025, 1.8 billion people will be living in countries or regions with absolute water scarcity, and two-thirds of the world population could be under water stress conditions[3].

THE THEME FOR THE 2013 INTERNATIONAL DAY FOR BIOLOGICAL DIVERSITY

The theme **WATER AND BIODIVERSITY** was chosen to coincide with the United Nations designation of 2013 as the International Year of Water Cooperation. Water and Biodiversity is the theme for the International Day for Biological Diversity (IDB) in 2013. Designation of IDB 2013 on the theme of water provides Parties to the Convention on the Biological Diversity (CBD) and the public at large the opportunity to raise awareness about this vital issue, and to increase positive action.

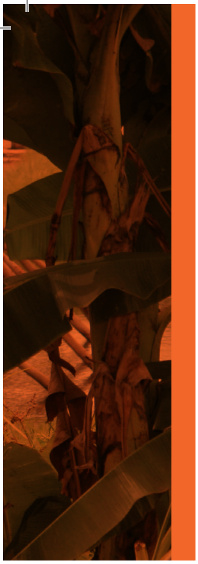
In view of the importance of water to sustainable development, and pressing problems with water availability and quality, the emphasis of this booklet is on how biodiversity provides us with solutions to meet water-related challenges.

Water and Ecosystems

BACKGROUND

Water and ecosystems are fundamentally linked through processes, structure and function. Human society is responsible for the management of these ecosystems and, *de facto*, the management of water. Ecosystems should not be viewed as consumers of water, but rather they are essential elements of natural infrastructure within water management.

Biodiversity, in terms of richness and diversity of species, is highly variable across different ecosystems. However all ecosystems, from near pristine forests or peatland systems to highly modified and managed agricultural or urban systems, play an essential role in influencing and maintaining the hydrological cycle. Impacts upon these systems invariably generate commensurate impacts on the water cycle.



The specific influence of ecosystems on water availability and quality at any location is subject to three major variables:

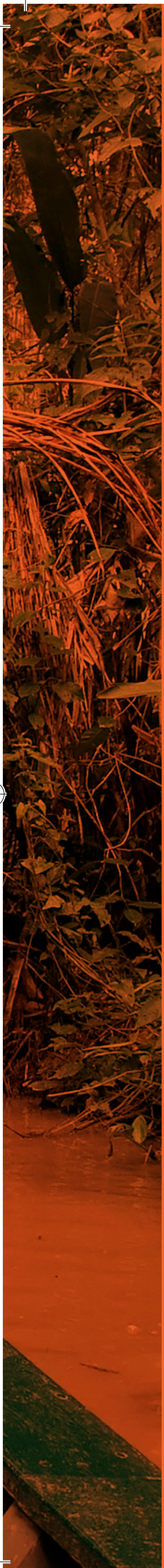
1. Physical features and the underlying geology, in particular the slope and elevation of the land, the presence of physical infrastructure such as roads or dams, and geo-physical structure of the soils;
2. Geographic location, such as latitude and the relative location in relation to coastlines; and
3. Ecological factors, in particular the nature of land cover, wetlands and soil biodiversity and their relative condition.

These variables will work in consort to influence a range of water pathways and will vary from ecosystem to ecosystem and across global climatic zones. Understanding the role of biodiversity in regulating the movement of water through a variety of pathways is critical. Numerous hydrological pathways exists including the direct evaporation of water from wet tree canopies, the transpiration of water from physical plant structures, the infiltration of water into the soil, and the control of water flowing over the ground surface.

FORESTS AND WOODLANDS[4]

Forest and woodland areas with more than 10% tree cover currently extend over 4 billion hectares or 31% of the land area of the globe. Some 30% of the world's forests are considered to be production forests where commercial forestry operations predominate. Within some tropical regions, notably Asia, tree planting is offsetting the rate of forest loss. Within this region, newly forested areas now exceeded 120 million hectares. Despite considerable reforestation and afforestation efforts they cannot compensate for the net loss of 7-11 million km^2 of closed forests recorded over the last 300 years; this includes 2.4 million km^2 and 3.1 million km^2 lost from North America and Europe, respectively. All these changes contribute directly to alterations in the hydrological cycle through changing evapo-transpiration and infiltration of water into, and retention by, soils.

The diversity and structure of forests influence the hydrology: plantations, for example, have different hydrologic profiles to natural forest, whilst undisturbed natural systems function differently to disturbed systems. Forests deliver a range of watershed or water-related ecosystem services, such as delivering better quality water within rivers providing resources for abstraction of clean water.



The Mount Makiling Forest Reserve, approximately 100km south of Manila in the Philippines is a 4,244 ha area of forest administered and managed by the University of the Philippines, Los Baños. It is an important resource due to its biological, recreational, geothermal, educational and scientific values. It is also a major source of employment and economic benefit to the surrounding communities. More than 50% of the Reserve is forested and the ecosystem maintains water supplies to five water districts and several water cooperatives that provide water for domestic, institutional and commercial uses.[5]

There is a growing evidence base of the importance of forests in delivering a range of water-related ecosystem services beyond water supply. The role in forests in reducing erosion from slopes, excluding pollutant inputs to watercourses and the downslope utilisation of leached nutrients all result in natural forests playing a critical role in enhancing river water quality and reducing disaster risks associated with excessive erosion.

A survey in North America indicated that for every 10% increase in forest cover in a water supply catchment (up to about 60% forest cover) water treatment cost decreased by approximately 20%. Crucial within this analysis was the reduction in costs attributed to both security of supply and the exclusion of pollutants from water extracted for human consumption[6].

Of similar importance when considering forests and their role in the water cycle are the co-benefits that come from new schemes to promote forests in order to retain carbon within the landscape. For instance, the United Nations initiative aimed at 'Reducing Emissions from Deforestation and Forest Degradation' (REDD+) seeks not to just enhance the carbon storage within ecosystems as a contribution to influencing global carbon budgets, but also to deliver a range of co-benefits through water-related ecosystem services.

WETLANDS[4]

Wetlands occupy the transitional zones between permanently wet and generally drier areas; they share characteristics of both environments yet cannot be classified unambiguously as either fully aquatic or terrestrial. Similarly, they can be forested or non-forested and encompass a range of different habitat types. Hydrology is probably the single most important determinant for the establishment and maintenance of specific types of wetlands. When hydrological conditions in wetlands change the biota may respond with large changes in species richness and ecosystem productivity. Crucially, the presence of water at or near the ground surface creates the soil, its micro-organisms and the plant and animal communities, such that the wetlands function in a different way from either aquatic or dry habitats. This unique biodiversity drives the delivery of multiple benefits enjoyed by human society.

Wetlands are intrinsically linked with water and are significant in altering the water cycle. For example, the water storage functions of some wetlands can be determined primarily by local topography, but plants in the catchment influence water supply to them, and plants in wetlands can influence water flowing through and from them. Wetlands can be significant in altering the hydrological cycle, influencing evaporation, river flows, groundwater and lake levels, so although they cover only 6% of the land surface they have a disproportionate influence on much of the world.

A key issue with wetlands is that not all wetlands behave the same and therefore different wetlands provide different ecosystem services. There is compelling evidence from around the world that wetlands on floodplains both reduce flood peaks and delay the flood arrival time downstream. Modelling of the River Cherwell in the UK demonstrated that removal of man-made embankments, which had separated the river from its floodplain, would result in a reduction in downstream flood magnitude of 132% due to storage of water on the floodplain and slowing of water speed by increased friction generated by the wetland vegetation. There is now considerable interest in the role of wetlands as natural infrastructure in the management of flooding and the improvement of resilience to risk in the face of changing global meteorological conditions.

Rob Gipman - flickr.com/gipukan

The role of the Lower Shire wetlands in Malawi and Mozambique and the Barotse floodplain in Zambia in reducing flood risk and the resultant damage to roads and houses, the relocation of people and loss of farmland has been estimated at around US $2 million per annum.

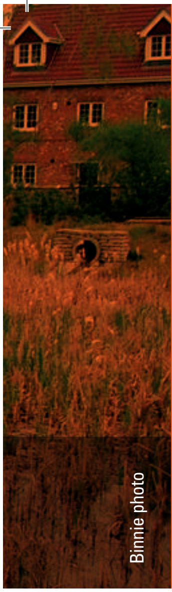
Wetlands often owe their presence in the landscape to underlying impermeable soils, which prevent the vertical movement of water. However, other wetlands play a crucial role in recharging groundwater supplies and maintaining regional aquifers. During high flows and inundation of the floodplains, the Senegal River and the Hadejia-Nguru wetlands in Africa water infiltrates downwards from the wetland surface to recharge the underlying aquifer ensuring security of water supply throughout the year. However, changes to the catchment hydrology, for instance through over-abstraction, can have alter these vital functions and compromise the ability of a wetland to deliver vital ecosystem services.

A wetland created at Glaslough in County Monaghan, Ireland, is sustainably removing pollutants from waste water providing approximately three times the treatment capacity at half the price of traditional electro-mechanical infrastructure, whilst also delivering a range of co-benefits such as carbon sequestration, recreation and biodiversity enhancement.

The importance of wetland biodiversity in the water cycle does not simply extend to physical hydrological issues. Certain wetlands, due to their unique assemblage of plants and animals, can remove a variety of pollutants and contaminants, including nutrients, heavy metals and pathogens, in a sustainable and cost-effective manner. Furthermore, due to the predominance of waterlogged conditions, wetland soils represent a huge carbon store. For instance, semi-natural and undamaged peatlands can accumulate carbon at a rate of 30-70 tonnes of carbon per km^2 per year and it has been estimated that peat soils contain a third of the world's total soil carbon.

MIGRATORY WATER-BIRDS: AN EXAMPLE OF SYNERGY BETWEEN BIODIVERSITY CONSERVATION AND HUMAN NEEDS FOR WATER.

When natural water infrastructure is conserved, or improved, multiple co-benefits can be achieved. For example, the major hydrological functions of the *Dashanbao Wetland* in China include flood control and water recharge to supply ground water to downstream and hillside spring vents, as well as being a peat moor with substantial carbon storage benefits. It is also a National



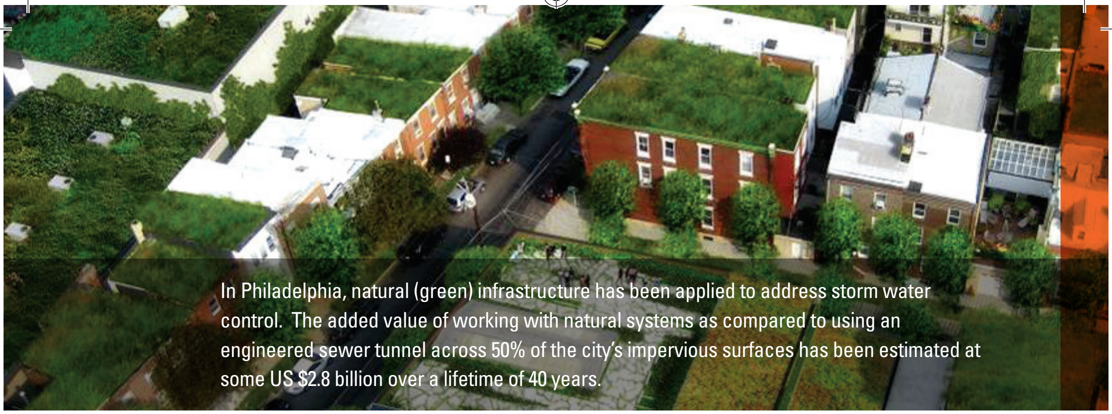
Nature Reserve, and Ramsar Site, supporting the highest concentration, representing 1/5 of the world population, of Black-necked Crane *(Grus nigricollis)*, a globally vulnerable species, and is important for other migratory water birds (http://www.ramsar.org/cda/en/ramsar-documents-list-anno-china/main/ramsar/1-31-218%5E16477_4000_0__). The wetland is one of many regional network sites which support these, and other, important waterbird migratory pathways.

The Convention on the Conservation of Migratory Species of Wild Animals (also known as CMS or Bonn Convention) aims to conserve terrestrial, aquatic and avian migratory species throughout their range (www.cms.int).

MOUNTAINS [4]

Virtually all the world's major river systems originate in mountain systems. Within the mountain context natural infrastructure is exceptionally rich in terms of biodiversity. Covering the nearly 40 million km^2, or about 27% of the Earth's land surface, mountains systems also range from the tropical, such as parts of the Andes, and subtropical to temperate climates, such as the Himalayas, to the polar extremes of Antarctic mountain ranges. Throughout the world, mountains provide a vast array of ecosystem services that impact the water cycle including modulating and maintaining climate, provisioning of water, flood control, soil and groundwater, and erosion prevention.

Due to the isolated nature and high variability at small scale, mountain biodiversity is highly endemic and vulnerable to climatic and environmental changes from which they typically only slowly recover, if at all. Mountain biodiversity, coupled with the great topographical and climatic variability which can be present over short distances, drive a range of hydrological processes the benefits of which have and can be experienced at considerable distance from source. Mountain ecosystems can contribute over 60% of the mean annual river discharge in some watersheds. Snow and glacier melts in the Hindu Kush Himalayan region comprises up to 50% of the annual flow



In Philadelphia, natural (green) infrastructure has been applied to address storm water control. The added value of working with natural systems as compared to using an engineered sewer tunnel across 50% of the city's impervious surfaces has been estimated at some US $2.8 billion over a lifetime of 40 years.

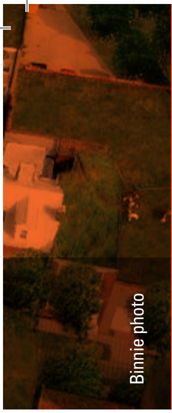
in the greater Indus River Basin. Even in developed regions in Europe, the mean annual contribution to river discharge from the Alps has been estimated at greater than 50% for a river such as the Po in northern Italy. In some arid areas, mountains are estimated to supply as much as 95% of the total annual river discharge.

> In the Austrian Alps it has been estimated that runoff generated during extreme rainfall events may be up to 80% lower in mountain forests than for areas which have been deforested and converted to pasture.

Runoff generation from mountain areas will vary by vegetation type. The clearance and removal of forest systems in mountains generally increase runoff and sediment yields. This subsequently increases rates of erosion and reduces resilience to disasters downstream. Therefore understanding the role of biodiversity in moderating the hydrological cycle is crucial in the mountain environment and beyond.

URBAN ECOSYSTEMS [4]

Urban areas are a human construct and as such human society has the power to influence their developmental trajectories and their relationship with both biodiversity and water. This has been the case for millennia. The first urban revolution occurred thousands of years ago giving rise to the great river civilisations of the Tigris-Euphrates, the Nile, the Indus-Ganges and the Yellow River. The development and prosperity of these early urban centres depended on the careful management of the relationship between biodiversity and water. There is increasing evidence that the collapse of many of these civilisations, and particularly the agricultural systems upon which they depended, was initiated by hydrological changes driven by both global climactic processes and the mismanagement of land.


Binnie photo

To date, the urban population is growing at an unprecedented rate setting the social, political, cultural and environmental trends of the world. As recently as the 1950s only three out of 10 people resided in urban areas. However in the late 2000s the majority of the human population resided in cities. By 2050 the number of urban inhabitants is expected to exceed six billion.

> It has been estimated that to support every new urban resident requires the conversion of 500m^2 of non-urban land.

However, despite rapid expansion, cities can be a driving force for the good of human society. They can act as hubs of national productivity and consumption generating wealth and opportunity. Compact, well-planned cities can generate resource efficiencies, reducing both energy consumption and carbon emissions. Increasingly, the appropriate planning and management of cities and their built infrastructure is seeking synergies with natural infrastructure to improve water efficiencies and to manage urban water issues. The combination of buildings alongside green and blue infrastructure creates local scale climatic regimes that can modify significantly the fluxes of heat and moisture and alter atmospheric processes. For instance, vegetated areas, such as urban parks and woodlands, as well as providing direct shading, under the right conditions can reduce air temperatures by 2-8°C in comparison to surrounding areas through heat exchanges associated with evapotranspiration. This can not only generate direct human health benefits, but can also contribute to lower energy and carbon costs through a reduction in the need to use traditional electro-mechanical air conditioning.

Urban water supply and sewage waste water systems are often a complex of interconnecting subsystems. Water is often piped to cities from distant watersheds, bore holes bring groundwater into the network, water supply and distribution pipes often leak, stormwater is discharged via soakaways and infiltration basins, septic tanks discharge to ground and urban parks and gardens are often over-irrigated. These processes often result in increased evapotranspiration from urban vegetation and high infiltration rates to groundwaters. For instance, in Doha it has been estimated that the underlying urban aquifer receives over 87% of its recharge from park irrigation, leaking mains and discharges from sewers and septic tanks.

There is increasing attention being given to the role of biodiversity in cities. Consideration is shifting from regarding biodiversity as furniture, camouflage and decoration to embracing more functional aspects and understanding

In Santa Monica, California, it has been estimated that municipal forests comprising common species can intercept almost 80% of a summer storm event greatly helping to reduce urban flood risk.

the link between urban ecosystems and human well-being. Often the role of biodiversity in an urban area is not via charismatic or threatened species, but through the less glamorous biota. For instance, the biological action of bacteria which drive many of the nutrient cycling processes that clean the urban waste waters is still a function of biodiversity. Common and widespread grass and tree species, which populated many an urban park can still assist in moderating the hydrological cycle and providing a range of co-benefits for urban residents.

As the world becomes increasingly urban the need to understand the role of biodiversity in moderating and controlling elements within the hydrological cycle within cities becomes more urgent. The benefits which many cities already provided through processes of agglomeration and densification can be supplemented greatly by the strategic integration of natural infrastructure and the understanding of the links between biodiversity and human well-being especially in the area of the management of hydrological processes.

SOILS – THE HIDDEN ECOSYSTEM [4]

Soils and their biodiversity play a very significant, and often underestimated and unmanaged, role in the hydrological cycle. The life associated with soils is usually naturally extremely diverse, even in deserts, ranging from larger animals, such as moles and various other burrowing mammals, birds and reptiles, through mid-sized fauna such as earthworms mites, ants and spiders, to microscopic bacteria and fungi. The soil in just a square metre of forest may contain more than 1000 species of invertebrates. Pick up a handful of soil and you have more bacteria than the world's entire human population. Soil biota function collectively to support soil health including regulating (together with land cover) how water enters and remains in the soil (soil moisture) and how nutrients are redistributed throughout the soil profile and released from it. The biodiversity thereby enables soils to function properly, and so underpinning other soil ecosystem services, such as erosion regulation, nutrient cycling and carbon storage.

Biodiversity drives soil functions which support hydrological processes and underpin global agricultural and forestry production and, therefore, food security. Sustaining soil functionality is a major aspect of water security for food security.

The actual amount of water stored in soils, or rather recycled slowly through soils, is globally and locally significant. Soil is also partly, together with other sources, responsible for recharging groundwater. Degrading soils by, for example, over disturbing them, removing land cover or over applying chemicals, essentially results in the loss of these functions and benefits. However, maintaining or restoring this natural infrastructure of soils offers significant opportunities to manage water better, not just for crops, but also for other benefits in the landscape setting.

There is a high correlation between the structural quality of the soil, its organic matter content (carbon) and plant-available water. Soil organic matter promotes soil biological activities and processes, which improve stability and porosity. Directly or indirectly, these organic compounds are related to the water holding capacity. Evaporation reduction from a bare soil surface, and improved infiltration and reduced erosion, can be attained through maintaining land cover through either a coarse or disturbed layer (or mulch) overlying the wet subsoil or the introduction of cover crops. Improved water and carbon management in and on soils delivers improved nutrient cycling and retention in soils. Therefore, understanding soil biodiversity, structure and soil processes is vital to how we manage soils, and hence water. Maintaining soil biodiversity from bacteria to large scale fauna is important in ensuring effective functioning of the hydrological cycle and for carbon storage and cycling.

Most soils contain some carbon, but peat soils composed of slowly decaying plant matter are particularly rich in their carbon content. The transfer of carbon between soils, and especially peat soils, and the atmosphere in the form of greenhouse gases carbon dioxide (CO_2) and methane (CH_4) is vital for regulating the global climate. Drainage, burning, excessive tillage, overgrazing and other inappropriate land uses can all compromise the store of carbon in soils. Whilst sound soil management practices can mitigate these losses there is still uncertainty whether such management actions are sufficient to reverse carbon losses from soils.

AGRICULTURE - NATURAL SOLUTIONS FOR WATER AND FOOD SECURITY [4]

Water security for sustaining food and nutrition security is important at all levels of human organisation, from households to villages and nations to international and global levels.

Today, irrigated agriculture covers 275 million hectares – about 20% of cultivated land and five times more than at the beginning of the twentieth century. Irrigated agriculture uses approximately 70% of water withdrawals, which can rise to more than 90% in some regions and around 20% of water used globally is from groundwater sources (renewable or not). This share is rising rapidly, particularly in dry areas. Meat production requires 8-10 times more water than cereal production and the increase in demand for animal feed adds to the current pressure on water resources. Over the next 40 years global food output will need to increase by 60-70% to meet demand, but through more intensive use of water, improved efficiencies, elevated nutrient productivity, and an intensification of labour, agricultural land area is only expected to grow by 10%. The future demands more yield per hectare and more crop per drop.

> Accounting for approximately 70% of global water usage, agriculture remains the greatest single demand on water and the biggest polluter of watercourses. Water demands for agriculture and the impacts agriculture can have on water quality are key management issues in maintaining both food and water security.

Irrigation has been essential for increasing agricultural yields, feeding the increasing global population. Irrigation has also stabilised food production and prices by enabling greater production control and scope for crop diversification. Thus, irrigation has been vital to food security and sustainable livelihoods, especially in developing countries during the “Green Revolution”, through increased income and improved health and nutrition, locally, and by bridging the gap between production and demand, nationally. To keep pace with the growing demand for food, it is estimated that 14% more freshwater will need to be withdrawn for agricultural purposes in the next 25 years, but water scarcity is growing

due to overuse, greater demand per capita, increasing competition and growing uncertainty due to climate change. We, therefore, face a challenge to improve water efficiency in agriculture, adopting a more sustainable use and better management of water in the processes from field to fork, thus increasing the total food supply chain efficiency.

Farming involves converting land cover to crops and is usually accompanied by interference with soils. This potentially alters water flow in hydrological pathways and along with it delivers associated impacts on nutrient cycling, carbon storage, erosion and sediment transport through exposing bare land and increasing runoff. Most soils in all agro-ecosystems today are degraded physically, chemically, biologically and hydrologically. The main reason for this is tillage which, if not properly managed, pulverises and exposes soils, destroys soil biodiversity, and hence soil health, and has high negative economic impacts.

Most agricultural soils today have poor soil aggregate structure, exposed soil surfaces, and low levels of soil biodiversity and organic matter, having lost 25 to 75% of their original carbon pool (severely degraded soils have lost 70 to 90%). Soil organic carbon is, or is produced by, biodiversity. There is a strong relationship between crop productivity and the soil organic carbon pool, especially in low-input agriculture. Soils with adequate levels of soil organic carbon are able to adapt much better to the adversities of both drought and excess rainfall. There are numerous studies pointing to the capacity of agricultural soils as an effective carbon sink, thus for mitigating climate change. Soil carbon presents an excellent example of how climate change adaptation and mitigation responses can be mutually reinforcing. Regardless of this knowledge, agricultural land use continues to contribute to the decline of the soil organic pool in vast regions of intensive crop production. This is effectively the wholesale degradation of the natural water infrastructure of land. Unmanaged, this leads to severe land degradation and, in water scarce areas, finally to desertification. Restoring the biodiversity-water relationship in farmlands is key to achieving sustainable agriculture and food security.

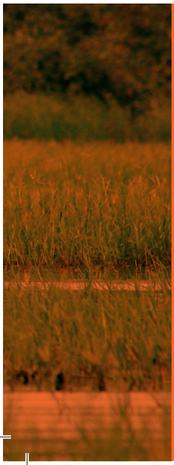
WATER FOOTPRINTS OF COMMON CROPS [7]

ESTIMATED GLOBAL AVERAGE WATER FOOTPRINTS (IN LITRES PER KG) FOR A RANGE OF CROPS (FOR THE PERIOD 1996-2005)

Cocoa beans	1993	Maize	122
Green coffee (not roasted)	1590	Apples	82
Cashew nuts	1422	Bananas	79
Green and black tea	886	Oranges	56
Lentils	587	Currants	50
Chick peas	418	Raspberries	41
Olives	301	Peppermint	29
Plums	218	Potatoes	29
Soya beans	214	Cabbages	28
Wheat	182	Cranberries	28
Rice	167	Tomatoes	21

In addition to agriculture's demand for water, agricultural practices can adversely impact upon watercourses through diffuse pollution runoff. Accelerated on-farm soil erosion leads to substantial yield losses and contributes to downstream sedimentation and the degradation of water bodies, which is a major cause of investment failure in water and irrigation infrastructure.

Across Asia, 7.5 billion tons of sediments are generated from poorly managed agricultural land and flow to the ocean annually[4].



Nutrient depletion and chemical degradation of soil are a primary cause of decreasing yields, and result in low on-site water productivity and high off-site water pollution. Some 230 million tons of nutrients are removed annually from agricultural soils, while fertilizer consumption is 130 million tons, augmented by 90 million tons from biological fixation. Secondary salinization and water logging in irrigated areas threatens productivity gains.

Understanding the causes of soil and water degradation in farming systems, and how these influence relevant ecosystem services, including nutrient cycling and carbon storage, helps identify solutions for sustainable agriculture. We need to recognise that agriculture is not simply an external user of water, but an embedded part of a broader water cycle in which natural infrastructure needs to be managed collectively in order to achieve overall water security for food security and other purposes. Efforts must be made to manage water, soils and biodiversity in more sustainable and integrated ways to minimise the impacts of agriculture.

SYSTEM OF RICE INTENSIFICATION (SRI) [4]

The System of Rice Intensification is a climate-smart, agro-ecological methodology for increasing the productivity of rice, and more recently other crops, by changing the management of plants, soil, water and nutrients. Based on the principles of early and rapid plant establishment, reduced plant density, improved soil conditions through organic matter, and reduced and controlled water application SRI has improved productivity over conventional planting practices. For instance at Sopsokhe in Bhutan, the SRI yield has been 9.6 t/ha (40% higher) compared to 6.6 t/ha with conventional rice production methods. Similar results have been achieved across the rice growing countries of the world.

Increasingly, the adoption of Conservation Agriculture (CA), which has been employed in some form since the 1930s North American dust bowl disaster, is providing a solution to the soil degradation and runoff issues caused by agricultural practices.

A move from 'slash and burn' to 'slash and mulch' where crops are planted on rotation, maintaining a continuous plant cover on the land and replenishing the nutrients, could be the saviour of agriculture for food and water security. CA practices limit the amount of tillage, thus maintaining or restoring soil structure and biodiversity, which in turn benefits the growth of crops, increase soil water retention and limits surface water runoff. CA is now practiced on around 125 million hectares worldwide and this figure is increasing and is a core of the FAO's agricultural intensification strategy from 2011 onwards.

GLOBAL ADOPTION OF CONSERVATION AGRICULTURE [4]

CONTINENT	AREA (HA)	PERCENT OF TOTAL
South America	**55,464,100**	**45**
North America	**39,981,000**	**32**
Australia & New Zealand	**17,162,000**	**14**
Asia	**4,723,000**	**4**
Russia & Ukraine	**5,100,000**	**3**
Europe	**1,351,900**	**1**
Africa	**1,012,840**	**1**
WORLD TOTAL	**124,794,80**	**100**

Where the ecosystem services of natural infrastructure and biodiversity have been recognised within a farming context, there have been benefits in terms of water quality, water regulation, cost savings for farmers and carbon storage. The use of natural buffer strips, treatment wetlands, small scale check dams between agricultural land and water courses intercept farm drainage and act to trap sediment, remove pollutants and provide habitat for wildlife as well as providing a range of other ecosystem services, such as carbon storage.

Water and Biodiversity Management Challenges

OUTLINING THE CHALLENGES

Although, in theory, there is enough water to meet the entire global demand, it is currently managed inefficiently and there is a global imbalance in the distribution of water. The water footprints of human activities are becoming increasingly unsustainable. Water usage has been growing at more than twice the rate of population increase in the last century, and, although there is no global water scarcity as such, an increasing number of regions are chronically short of water. Sustainable water management is a key global concern and a matter of life and death for a huge number of humans. In developed countries non-point source pollution, primarily from agriculture, remains a significant challenge. Developed countries too are seeing increasing water insecurity through the increasing frequency and severity of floods.

INVESTING IN NATURAL INFRASTRUCTURE [3]

It was estimated in 2000 that the cost required for water infrastructure alone to achieve the Millennium Development Goal targets for water and sanitation by 2015 could be as high as US $800 billion per annum at a global level. Current estimates of the level of investment required to maintain water supply infrastructure in developed countries range from US $750 billion to one trillion dollars per annum. Much of the objectives of this investment can be achieved more cheaply and sustainably through wiser integrated use of natural infrastructure. The approach also delivers significant biodiversity co-benefits. Investing in natural infrastructure therefore is not necessarily about increasing investments, but re-allocating existing investments more efficiently. If only 10% of this projected investment were redirected to natural infrastructure solutions it would represent by far the single biggest source of "biodiversity financing"; considering that currently much natural infrastructure is already used in this way (e.g., protected areas to protect water supplies) it is likely already the biggest source of biodiversity financing.

Water managers need to make sure water is available in the quantities and quality needed to grow the economy, feed a rapidly growing population and deliver water services for people and must do all this while ensuring social equity and sustaining and restoring ecosystems.

There is room for hope. Because of the current inefficiencies in water use, particularly in agriculture, and the extent of degraded land and loss and degradation of wetlands, there is considerable scope to restore the natural infrastructure of land in order to achieve sustainable water security. Just as water scarcity and security are not issues confined to the water sector, but are societal issues, the role of ecosystems in ensuring the security of water supply is also a matter of societal choice. Governments and individual citizens can affect the adoption of future choices and agendas.

Investment in water management infrastructure is big business and can be a key driver of economic growth and poverty reduction. However, ecosystems are still largely left out of water economic equations. In order to correct the water management balance sheet ecosystems can no longer be ignored when formulating policies, shaping markets or rationalising investment decisions. There is a need to place water at the heart of a green economy and to recognise that working with ecosystems as water management infrastructure can be a cost-effective and sustainable way of meeting a diversity of policy, business and private objectives.

THE CHALLENGE OF A CHANGING CLIMATE

The Assessment Reports produced by the Intergovernmental Panel on Climate Change (IPCC) concluded that water and its availability and quality will be the main pressures on, and issues for, societies and the environment under climate change. The impacts of climate change occur mainly through changes in the hydrological cycle, and this is the key consideration for biodiversity, ecosystems and societies; this *includes most changes observed or predicted for terrestrial ecosystems, and many in coastal areas*. The role of water (and the hydrological cycle) in how freshwater, terrestrial and, to a large extent, coastal, ecosystems function, the intimate relationships between water and most aspects of human development (including food, drinking water, sanitation, tourism, trade, energy and poverty reduction/livelihoods), and the central role of ecosystems in these, lead to complex inter-connectivity between all these subjects. Adapting to the impacts of climate change requires a holistic ecosystem approach, and the role of water is paramount in identifying inter-linkages.

REDD+

Reducing Emissions from Deforestation and Forest Degradation (REDD+) is an effort to create a financial value for the large amount of terrestrial carbon stored in forest ecosystems, offering incentives for developing countries to reduce emissions from forested lands and invest in low-carbon paths to sustainable development. Forests also deliver water-related ecosystem services – and sustainable water availability (including groundwater) is a requirement in order to continue to store the carbon forest hold.

Twenty years of indecisive actions on climate change have led to a rise in the Earth's average temperature and there is a consensus among scientists that climate warming will intensify, accelerate or enhance the global hydrologic cycle.

Climate change is already contributing to the deaths of nearly 400,000 people a year and costing the world more than US $1.2 trillion, wiping 1.6% annually from global GDP [9].

The Climate Vulnerability Monitor: A Guide to the Cold Calculus of A Hot Planet, estimates that by 2030, the cost of climate change and air pollution combined will rise to 3.2% of global GDP, with the world's least developed countries forecast to bear the brunt, suffering losses of up to 11% of their GDP. Recent estimates suggest that climate change will account for 20% of the increase in global water scarcity. Deforestation and forest degradation, through agricultural expansion, conversion to pastureland, infrastructure development, destructive logging, fires, etc., is already accounting for nearly 20% of global greenhouse gas emissions, more than the entire global transportation sector [10].

Climate change is likely to lead to changes in ecosystems through direct impacts on precipitation and indirect impacts on evaporation (through changes to temperature and other variables). Elevated temperatures and changes in extreme weather conditions will affect the availability and distribution of rainfall, snow melt, river flows and groundwater, and are expected to further deteriorate water quality. Developing societies, who are the most vulnerable, are most likely to bear the negative consequences of these changes.

Water plays a pivotal role in mitigation and adaptation strategies with well-managed ecosystems providing a solution for today's challenges whilst providing insurance against future effects of a changing climate. Mitigation of climate change is urgent as is the recognition that adaptation is about water.

Climate change mitigation is about carbon while climate change adaptation is about water. The global carbon and water cycles are also interdependent.

THE AMAZON TIPPING POINT - LAND USE, WATER AND CLIMATE CHANGES [11]

The hot and humid Amazon forest evaporates vast amounts of water, which rises into the air and draws in the wet northeast trade winds, which have picked up moisture from the Atlantic. This process assists in controlling the temperature of the ocean; as the trade winds take up the moisture, the cooler water that is left also gets saltier and sinks. Deforestation disrupts this cycle by decreasing the rates of evapotranspiration, which drives the whole climatic circulation process. One result is that warmer Atlantic water remains on the surface and fuels the generation of hurricanes. Another negative feedback is that less moisture arrives on the trade winds, intensifying drought within the forest. Estimates suggest that approximately 20% of the Amazonian rainforest has been cut down and another 22% has been damaged by logging, allowing the sun to penetrate and dry out the forest floor. The total of these two figures is growing perilously close to 50%, a threshold that current models predict as the *tipping point* that marks the death of the Amazon and potentially unprecedented changes to both local and wider climatic systems.

Caroline Bennett / Rainforest Action Network)

Cofán Indigenous leader smells the petroleum-contaminated river near his home in the Amazon rainforest.

Working with ecosystems offers a valuable yet under-utilized approach for climate change adaptation. It does not represent an either or approach, but rather an opportunity to complement traditional engineered infrastructure development with natural infrastructure. This approach, known as “Ecosystem-based Adaptation” (EbA), works with biodiversity and the ecosystem services it provides as part of an adaptation strategy to help people and communities adapt to the negative impacts of climate change at local, national, regional and global levels.

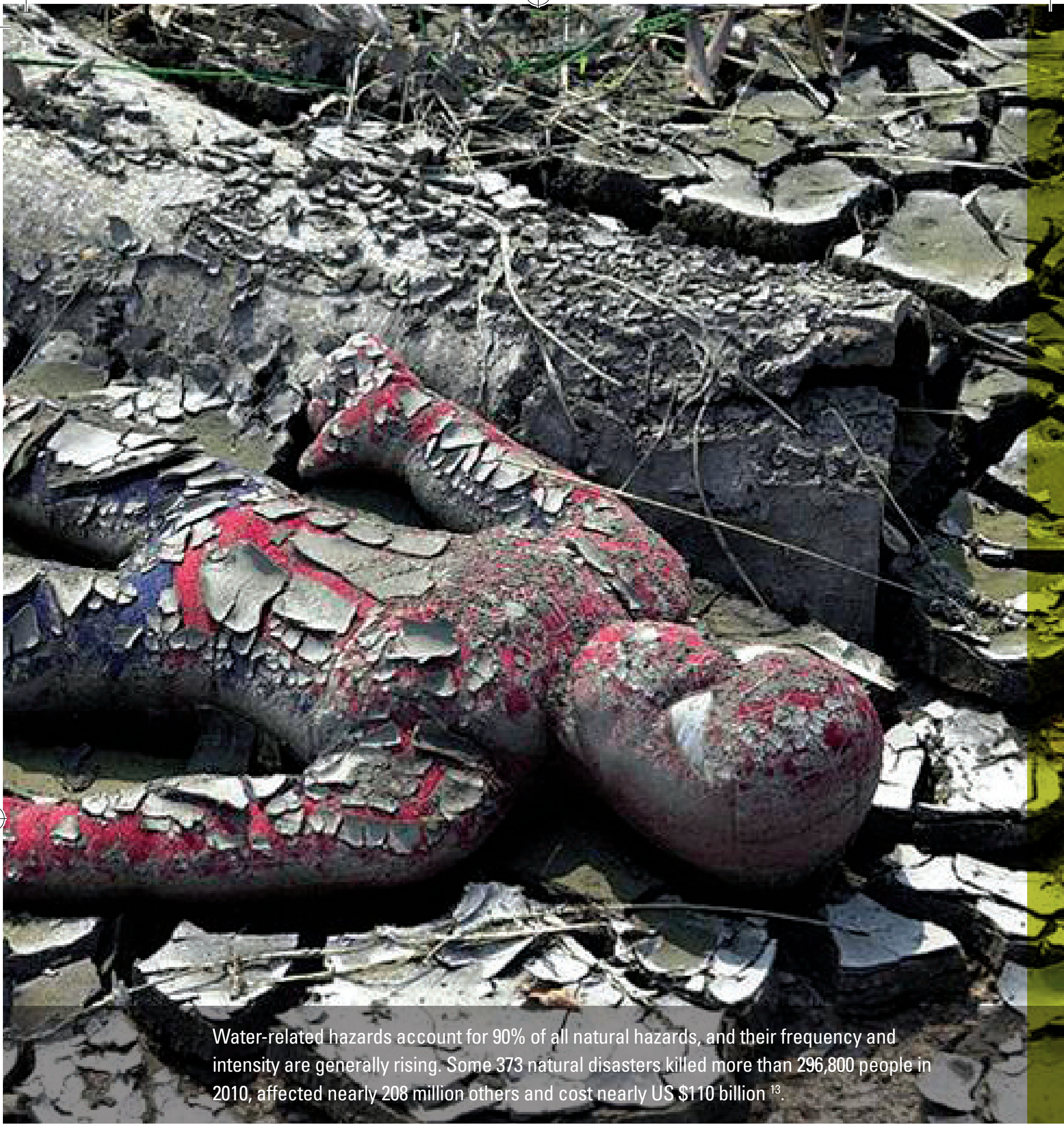
EXAMPLES OF OPPORTUNITIES FOR NATURAL INFRASTRUCTURE SOLUTIONS [4]:

- Certain floodplain wetlands can naturally store and slow down floodwater helping to protect downstream areas from destructive flooding whilst urban wetlands can reduce flood risk in our towns and cities. Flood exposure can also be reduced by restoring upland forests and soils, especially when this is combined with effective land-use planning. This also restores and secures the ecosystem services from land.
- Some wetlands, including some peatlands, mangroves and saltmarshes, can sequester and store carbon and consequently mitigate climate change. Protecting wetlands from damage or destruction can prevent the release of large amounts of carbon into the atmosphere and provide natural infrastructure to strengthen adaptation to changing climatic and weather conditions.
- Well managed wetlands in semi-arid areas can recharge groundwater and help people and wildlife to survive periods of drought.
- Protection from sea level rise, and coastal storms, can be achieved at least to some extent by managing coastal wetlands, such as mangroves and saltmarshes – providing climate change mitigation through carbon storage and climate change adaptation and securing ecosystem services.
- Restoration of soils (and land cover) in agricultural ecosystems is a primary means of increasing water security for food production, increasing carbon sequestration and reducing water-related risks downstream.
- There are also significant carbon stores in other ecosystems, such as grasslands and forests, where much of the carbon held within these ecosystems is within the soil.

In addition to protection from climate change impacts, ecosystem-based adaptation also provides many collateral benefits to society, such as maintaining and enhancing the provision of clean water and food. Furthermore, appropriately designed and managed ecosystem solutions can also contribute to climate change mitigation by reducing emissions from ecosystem loss and degradation, and enhancing carbon storage and sequestration.

The central message is that ecosystems offer a natural infrastructure to respond to a changing climate. Natural solutions will often be more sustainable and cost-effective for ecosystems, biodiversity and people than engineered infrastructure.

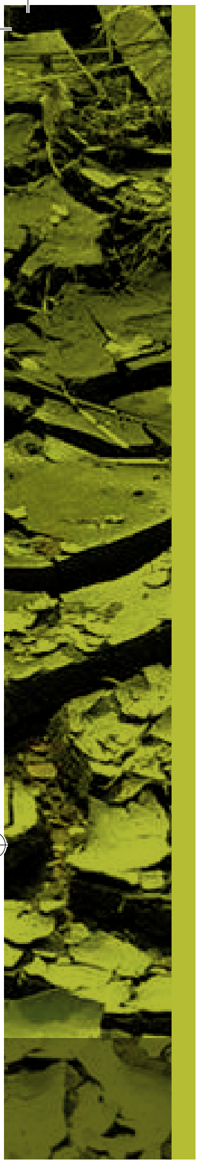
Mitigation and adaptation responses require holistic planning to integrate strategies which incorporate ecosystem management and sustainable water and carbon management in order to increase resilience. The goal has to be no less than water, food and energy security for 8 billion people in a climate-resilient world where biodiversity is safeguarded. This sounds like an impossible task; however, there is some assurance in that many of the tools and technologies needed are available. The constraints are mainly not technical, but more to do with capacity, coordination and sustained, redirected investment.



Water-related hazards account for 90% of all natural hazards, and their frequency and intensity are generally rising. Some 373 natural disasters killed more than 296,800 people in 2010, affected nearly 208 million others and cost nearly US $110 billion [13].

DISASTER RISK REDUCTION

Worldwide, more than 7,000 major disasters have been recorded since 1970, causing at least US $2 trillion in damage and killing at least 2.5 million people. Natural infrastructure can play a vital role in increasing resilience to disasters, and its degradation is often a primary cause of disasters in the first place [12].



THE MISSISSIPPI AND HURRICANE KATRINA [14]

Millions of hectares of wetlands have been lost over the years along the Gulf of Mexico coast in the southern United States. The loss has resulted from several factors including dams upstream, which interrupt sediment flow essential to sustain coastal land formation and stability, the construction of flood defence levees, canal dredging for the oil and gas industry, draining to provide land for built development, and man-made and natural subsidence. It is estimated that currently a football field area of wetlands is lost along the Louisiana coastline every 30-38 minutes. When Hurricane Katrina hit New Orleans in 2005, the impacts were felt more acutely because of the loss of coastal swamps had effectively removed the protection from storm surges. The final death toll was 1,836. Hurricane Katrina caused physical damages in the region of US $75 billion, but it is estimated that the total economic impact in Louisiana and the Mississippi basin may exceed US $110 billion. Inappropriate consideration of the relationship between ecosystems and water management lead to Hurricane Katrina earning the title of costliest hurricane ever in US history. If treated as an economic asset, the minimum asset value of the natural infrastructure provided by the Mississippi delta would be US $330 billion to US $1.3 trillion (at 2007 values) in terms of hurricane and flood protection, water supply, water quality, recreation and fisheries. Importantly, studies suggest that rehabilitation and restoration of this natural infrastructure would have an estimated net benefit of US $62 billion annually.

Disasters and the environment are inextricable linked in two principle ways. Disasters resulting from extreme natural events can generate adverse environmental consequences, which affect not only people in urban and peri-urban areas, but also the ecosystems in which they live. Similarly, degraded ecosystems can cause or augment the negative impacts of disasters. 'Healthy' and sustainably managed ecosystems both reduce vulnerability to hazards by supporting livelihoods, while acting as physical buffers to reduce the impact of hazard events and also enhancing post-disaster recovery. Because of the densities involved, and often their location, urban areas are particularly vulnerable to disasters. To build resilience and to improve human security the tripartite relationship between urban disaster reduction, climate change and ecosystem degradation needs to be understood and the implications need to be embedded in decision-making.

Many of the world's mega-cities are sited in river deltas and possibly at risk of the same fate as recorded in the Mississippi Delta, but could be protected by retaining or reinstating natural coastal infrastructure. For every mile of continuous wetlands, a storm surge can be reduced by three to eight inches. This same lack of coastal protection was evident in the 2006 tsunami that hit the fringes of the Indian Ocean. Where mangroves had been destroyed, often illegally, the tsunami waves were able to penetrate far inland, destroying homes, inundating farmland and washing away people and livelihoods. In India, Sri Lanka, and Thailand, areas with dense coastal vegetation and healthy coral reefs were markedly less damaged than areas without.

UK Department for International Development (DFID) - flickr.com/dfid

> As a result of growing concern regarding the degradation of the Marsh, in 1989 the Sri Lankan government decided to freeze all public and private sector development proposals until an environmentally sound Masterplan was developed for the Muthurajawela Marsh. The Masterplan was published in 1991 resulting in a land use strategy being proposed and

MARSHES PROTECT PEOPLE FROM FLOODING IN SRI LANKA [4]

The Muthurajawela Marsh covers some just over 3,000 hectares in the coastal area approximately 10 to 30km from Colombo, Sri Lanka. In excess of 300,000 people live in close proximity to the marsh with a further 5,000 people residing within the coastal wetland complex. The location of Muthurajawela Marsh in a rapidly developing coastal zone makes it an extremely vulnerable ecosystem. Extensive areas of the marsh system have been altered, through drainage, pollution and hydrological modification. Traditionally, land use planning processes have failed to consider the maintenance of green spaces for Sri Lanka's urban populations, and have almost always resulted in development decisions which have taken place at the cost of the few remaining urban and peri-urban conservation zones.

implemented for the future, based on dividing the Muthurajawela-Negombo area into various development and conservation zones. Essential to establish a clear rationale for land-use zonation was a credible economic assessment of the various benefits delivered by the Marsh. This analysis demonstrated that the gross annual value of the Marsh was in excess of US $8 million with the largest benefit being the regulation of coastal flooding.

In order to reduce the risk to human life and damage to infrastructure increasing efforts are being made to improve both landslide risk planning, through the engagement with local communities, scientists and planners, and ecosystem management to ensure that the implications of land-use change and habitat management, such as that resulting from deforestation, are understood in terms of reducing the potential of landslides and minimizing the consequential losses.

FORESTS AND LANDSLIDES IN INDIA [15]

The Nilgiris District in the Western Ghats, India, has experienced an increase in the frequency of landslides in recent years. In a major event in late 1978 heavy rains triggered more than 100 separate landslides resulting in the deaths of 90 people. Significant landslide events have occurred in 1993, 1995, 2002, 2007 and again in November 2009 when over 80 people died and extensive damage to property resulted. Whilst rainfall is undoubtedly a significant factor, there is increasing evidence that unplanned tea plantations and associated deforestation in the Nilgiris District may have degraded soils and ultimately increased the likelihood of landslides. One study estimated that over a quarter of all forests have been cleared in the Western Ghats between 1973 and 1995, increasing rates of soil erosion and run-off, and reducing the resilience of the ecosystems to disasters.


Water.org - flickr.com/waterdotorg

The impact of climate change is becoming more visible each year with more frequent and severe periods of drought and flooding and a greater unpredictability of hydro-meteorological events. We are now managing risks under increasing uncertainty. One implication of this is that the original design parameters for much of our existing physical infrastructure are becoming increasingly invalid. Without an effective strategy to respond to changing risks we can reasonably expect more systems to fail, generating potentially catastrophic consequences. Natural infrastructure solutions are, therefore, not just about the design and operation of new water management approaches, but also about retrofitting increased risk reduction and resilience into highly managed landscapes and river basins.

Water storage (managing and storing floodwaters to provide a resource during drought periods) is increasingly in demand and being driven not only by climate change, but other factors, including global and regional economics and demographics. One approach has been to increase our use of hard infrastructure, such as dams. The amount of water impounded behind dams has increased by 400% since 1960, and now the amount of water held in reservoirs is three to six times that in natural rivers[3]. Often upstream land use changes, such as deforestation or overgrazing, result in increased erosion and sediment delivery compromising the effective life and functioning of a dam.

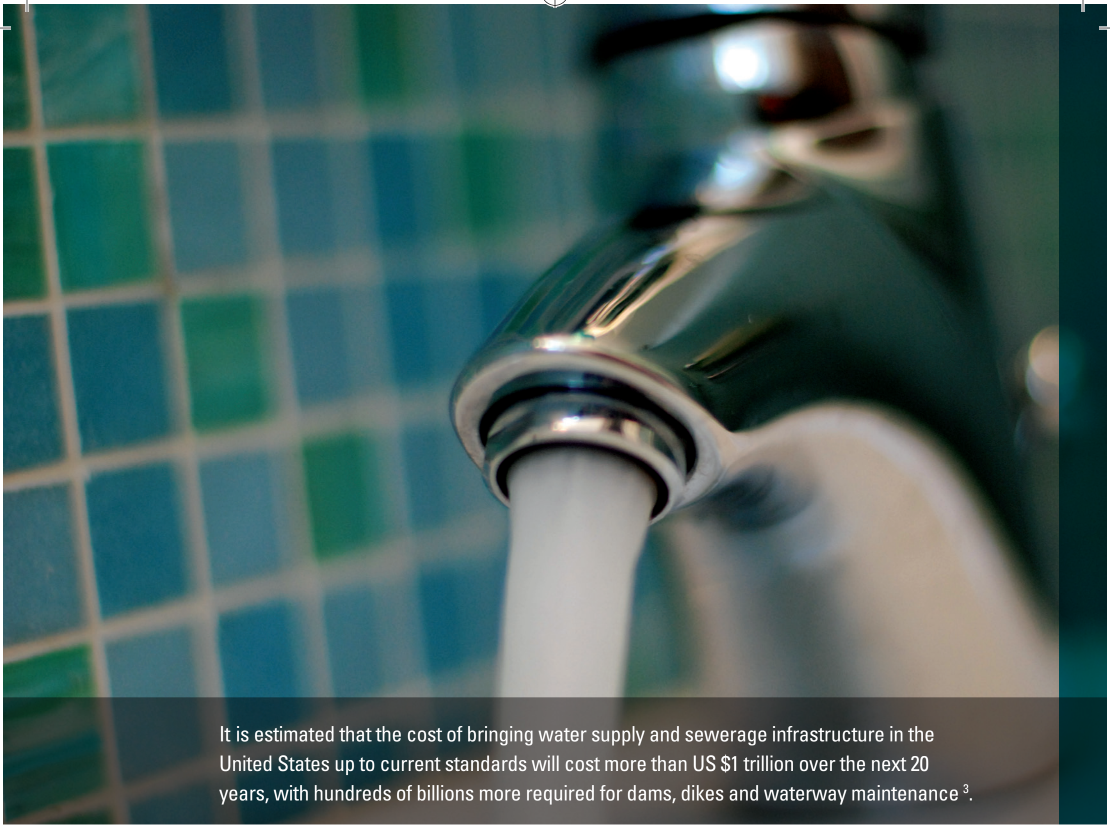
Economic Advantages of Natural Infrastructure

Using natural infrastructure, and the ecosystem services that biodiversity provides, to manage water sustainably is not a new idea, but there is a growing willingness to consider such approaches by an increasingly diverse range of stakeholders, such as agriculture, business, drinking-water supply engineers and urban authorities. What stimulates this interest is the increasing evidence base for the approach. For instance, UNEP's The Economics of Ecosystems and Biodiversity (TEEB) has produced many reports lending credence to the local and global economic value of well-managed ecosystems and there is a growing list of examples where a monetary value can be accurately assigned to the benefits. The economic advantages include reduction in capital and maintenance costs for hard infrastructure; reduction in insurance premiums and damages from flooding and storms; boost to fisheries, aquaculture and agriculture; reduction in cost of damage from carbon emissions; and boost to tourism. The TEEB approach has recently been applied specifically to water and wetlands.

THE ECONOMICS OF ECOSYSTEMS AND BIODIVERSITY: WATER AND WETLANDS [16]

TEEB Water and Wetlands provides a synthesis of the interfaces among water-wetlands-ecosystem services and demonstrates the importance of water and its role in underpinning all ecosystem services, and the fundamental role of wetlands in global and local water cycles. It is about the "values" of nature, which can be expressed in qualitative, quantitative or monetary ways. TEEB Water and Wetlands contributes towards the wise use of wetlands through creating better understanding of ecosystem service values and benefits and their integration in decision-making at all levels. Its main messages include:

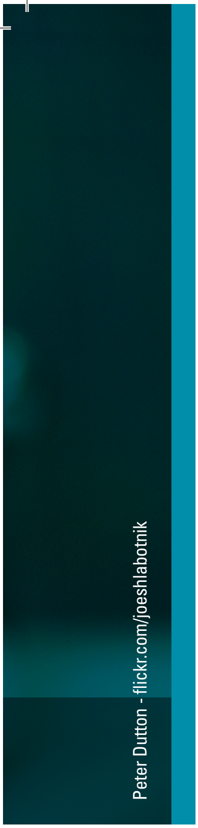
- Water security is a major and increasing concern in many parts of the world, including both the availability (including extreme events) and quality of water.
- Global and local water cycle are strongly dependent on wetlands.
- Wetlands are solutions to water security – they provide multiple ecosystem services supporting water security as well as offering many other benefits and values to society and the economy.
- Values of both coastal and inland wetland ecosystem services are typically higher than for other ecosystem types.
- Wetlands provide natural infrastructure that can help meet a range of policy objectives.
- Maintaining and restoring wetlands in many cases also lead to cost savings when compared to manmade infrastructure solutions.
- Wetlands and water-related ecosystem services need to become an integral part of water management in order to make the transition to a resource efficient, sustainable economy.
- Action at all levels and by all stakeholders is needed if the opportunities and benefits of working with water and wetlands are to be fully realised, and the consequences of continuing wetland loss appreciated and acted upon.



It is estimated that the cost of bringing water supply and sewerage infrastructure in the United States up to current standards will cost more than US $1 trillion over the next 20 years, with hundreds of billions more required for dams, dikes and waterway maintenance [3].

Water is high on the public and political agenda. The required investment in water infrastructure worldwide by 2030 has been estimated at US $22 trillion. Moreover, hard water infrastructure deteriorates over time, with loss rates (leakage) of 50% not uncommon in urban distribution systems. However, the economic impact of not investing in water is also huge. The following figures have been estimated for countries in Africa: flood and drought in Kenya between 1998 and 2008 has cost $ 4.8 billion - a 16% reduction in GDP; floods in Mozambique in 2000 caused a 23% reduction in GDP and a 44% rise in inflation; and Ethiopia has suffered a 38% decline in GDP due to inability to tackle hydrological variability, with a projected 25% increase in poverty between 2003 and 2015. Therefore, managing natural infrastructure, both at the catchment and local scales, is critical to water security including as a pre-requisite for sustained economic growth. Managing high elevation ecosystems could conserve water resources for entire subcontinents.

Cities are highly motivated to manage water better, and many are open to solutions that demonstrate cost-effectiveness through an integration of natural infrastructure in their planning. Central to this is to see cities as ecosystems



Peter Dutton - flickr.com/joeshlabotnik

themselves, and hence their problems amenable to ecosystem-based solutions. Increasingly, measures are being introduced to increase water efficiencies to work with biodiversity and manage urban water issues; reduce their impact on the hydrological cycle; mitigate and adapt to climate change; and produce water sensitive urban design solutions. Cities are increasingly and successfully addressing catchment-based solutions; for example through payments for ecosystem services schemes. There are widespread examples including forest restoration to manage upstream erosion, wetland restoration to reduce flood risk, and multiple interventions for improving the quality of water delivered by ecosystems to cities. In New York City, for example, it proved around six times more cost effective for the authorities to pay landowners in the Catskill Mountains to improve land management and to prevent waste and nutrient runoff reaching watercourses, instead of building a new water treatment plant. The cost of paying landowners was US $1-1.5 billion, whereas the cost of building a new treatment plant would have totalled US $6-8 billion plus US $300-500 million annual running costs [3].

Working for Water, South Africa [17]

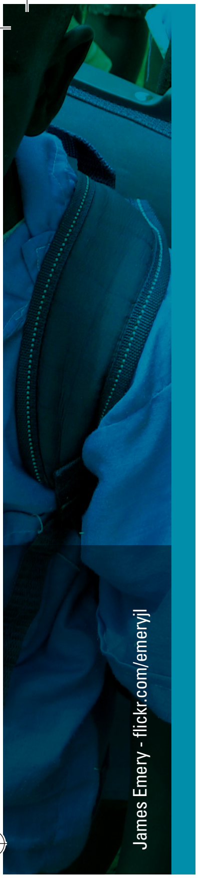
The economic benefits to rural areas of managing natural infrastructure could arguably be considered even higher due to the higher dependence of rural populations on their immediate environment. In 2006 the Working for Water (WfW) public works programme invested US $115,000 to restore the Manalana wetland in Mpumalanga, South Africa. It was estimated that the total economic benefits provided by the rehabilitated wetland was US $243,000; that the value of livelihood benefits derived from the degraded wetland was just 34% of what could be achieved after investment in ecosystem rehabilitation; and that the provisioning services now provided by the rehabilitated wetlands have an economic value of US $396/household per year. In addition, the Manalana wetland acted as a safety net for poor households during periods of economic difficulties, such as high unemployment.

ECONOMIC BENEFITS OF FLOODPLAIN RESTORATION IN CAMEROON [18]

The Waza floodplain, Cameroon, was damaged in the 1970s by the construction of a large irrigated rice scheme. It was calculated that engineering works to reinstate the flooding regime over 8,000km², would cost approximately US $11 million. The economic effects of flood loss in the 20 years since the scheme was constructed were almost US $50 million, including direct economic losses of more than US $2 million/year through reduced dry season grazing, fishing, natural resource harvesting and surface water supplies. The costs of restoring the flood regime would be covered by the benefits in less than five years and would bring around US $2.3 million additional income per year to the region.

COST-EFFECTIVE FLOOD RISK REDUCTION IN CALIFORNIA [19]

The Napa Valley, California, has suffered major repetitive losses due to frequent flooding in populated areas. A major flood in 1986, which forced the evacuation of 5,000 residents and the loss of three lives, cost US $ 100 million in damages. The present value of property within the floodplain is in excess of US $ 1 billion. In order to avoid and mitigate floods in the Napa River Basin, a US $ 400 million project was initiated in 2000, with the objective of increasing the capacity of the wetlands adjacent to the river to handle floodwaters, while maintaining and restoring its original



James Emery - flickr.com/emeryjl

shape and alignment. Extensive private investment in property development totalling another US $ 400 million has occurred since the approval of the flood project. Flood insurance premiums for 3,000 properties will either be lowered or eliminated when the regulatory flood maps are changed through the Federal Emergency Management Agency (FEMA).

The benefits of restoring peatlands can be measured in several ways, including the conservation of rare and threatened species, but potentially more relevant to economic arguments is the reduction of carbon emissions. The drainage and destruction of peatlands impacts on the hydrological cycle and subsequently causes the release of stored carbon into the atmosphere, contributing to climate change processes.

RESTORING HYDROLOGY RESTORES CARBON IN IRELAND

A peat restoration project in Ireland, centred partly on restoring hydrology, re-established the carbon sink function of natural peatland habitat, estimating that the benefits in terms of carbon restoration were worth on average €1,506 per hectare for the avoided carbon loss (75 tCO_2 equivalent per hectare based on a carbon price of €20 tCO_2 equivalent) and €118 per hectare per year for the average net carbon sequestration (5.9 tCO_2 equivalent per hectare per year).

Aivar Ruukel - flickr.com/soomaa

Restored peatlands also generate additional benefits for biodiversity, providing habitat for native animal and plant species, which in turn increases attractiveness as a destination for nature-based ecotourism and brings with it additional economic advantages to the local economy. Further income may be generated through extensive grazing, production of reed or sphagnum mosses (to be used as building material, biofuels and in horticulture) and the growth of alder forests (to produce high quality furniture). This allows for the production of commodities whilst maintaining the natural functions of the ecosystem in the hydrological cycle.

The economic benefits are becoming more clearly visible as experts both recognise the values provided by ecosystem services and, where possible, attach a monetary value to these benefits. What is clear is that we must incorporate the values of natural infrastructure alongside hard infrastructure in decision-making processes, and seek ways to restore degraded or create additional new natural infrastructure in order to meet our global sustainable development needs.

Cooperation and Partnerships

WHO MANAGES WATER?

It is easy to consider water management as being the responsibility of water companies or government regulators and agencies. However, we are all water managers. Every time we turn on a tap or buy food we are responsible for a small element of the much larger water management cycle. Therefore, the responsibility to manage water extends across sectors, governments, nation states and individual citizens and should be considered as an activity that requires cooperation and integration from local to international levels. Similarly, the appropriate management and protection of biodiversity has a shared responsibility.

PARTNERSHIPS – BUILT AND NATURAL INFRASTRUCTURE WORKING TOGETHER

Natural infrastructure cannot always replace built infrastructure. Built (physical) infrastructure has, and can still, where well sited and planned, deliver significant benefits. But in most areas water is already intensively managed through built infrastructure set in a highly managed landscape. More often the choice is not one or the other, but to use the best that each approach has to offer in partnership.

The fragmentation of governance and sectoral interests increases risks to the sustainability of water resources and can result in unintended negative consequences, and compromises the delivery of ecosystem services.

BUILT & NATURAL INFRASTRUCTURE WORKING TOGETHER [4]

The important Itaipu Dam in Brazil is one of the largest dams in existence. The Itaipu watershed includes deep red ferralsols, with good fertility potential, located in a humid subtropical climate characterized by hot, humid summers and mild winters. There is high agricultural productivity within the watershed, but intense rain storms result in high erosion and flows of sediments and nutrients into Itaipu Lake. Eutrophication and sedimentation reduce the productivity of the dam. This situation is being addressed through the community-based *"Cultivando Água Boa"* (Cultivating Good Water) programme, supported by the Brazilian Federation of No Till Farmers Associations (FEBRAPDP), supported by *Itaipu Binacional* (Itaipu Dam Enterprise). Success is being achieved by simply transforming agriculture from tillage-based to no-till conservation agriculture. When the dam was built, its estimated working life was 60 years, but by managing soils as natural water infrastructure the life expectancy of the dam has increased tenfold, and farmers benefit through improved crop productivity and sustainability.

World Resources Institute – flickr.com/worldresourcesinstitute

IMPROVED PARTNERSHIPS TO MEET GOVERNANCE CHALLENGES

Managing water requires appropriate governance arrangements. Increasingly this requires that decisions regarding water management move from the margins of government to the centre of society. On national and local scales, appropriately funded infrastructure and adequately funded robust governance mechanisms are required to protect water resources and ensure sustainable development and, with this, greater equity in the distribution of water-derived benefits.

Water resources and biodiversity are usually managed in separate sectors with each focused on meeting specific objectives, rather than as part of an overarching and strategic framework that balances different water or biodiversity uses in order to optimize and share its various benefits across society and the economy. Cross-sectoral working and systematic thinking is required to consider and initiate the use of natural infrastructure in order to achieve water security including becoming climate resilient and rebalancing water distribution.

Improving local scale water resource management can often be a governance issue. Whilst the devolvement of responsibilities to local stakeholders is increasingly common, policy makers and governmental institutions do not always provide the resources to support local governance, thereby undermining it. Good governance structures that engage all the relevant stakeholders and equip them with the resources to participate in decision-making or programme/project design are the key to achieving effective and equitable local scale water management strategies.

Dani Blanchette – flickr.com/goingnomadic

THAT LUANG MARSH, VIENTIANE, LAO PDR [21]

That Luang Marsh, on the edge of Lao PDR capital city, Vientiane, is an excellent example of how poor governance has been turned around through the WAstewater Treatment through Effective wetland Restoration (WATER) project. These marshes were drastically altered through urban expansion and conversion to agriculture and support the livelihoods of more than 40,000 people. The wetlands provide a range of products such as food and also a range of other ecosystem services, including urban flood control and wastewater treatment for industry and all the residents of Vientianne.

The flood risk reduction and water quality improvement benefits provided by That Luang Marsh in Vientiane, Lao PDR, have an estimated value of US $2.8 million per year and US $71,000 per year respectively.

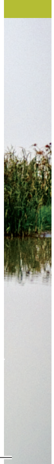
Suffering from poor governance, a range of government departments (agriculture, environmental protection and urban development) and national and international NGOs established WATER, chaired by the vice mayor of Vientiane, for the management of the marsh. This allows direct communication between the different departments, enabling the identification of conflicts and solutions. Wetland monitoring, design and build of wetland treatment systems and the development of a management plan and stakeholder engagement is undertaken by a technical team that includes representatives from all of the relevant government departments.

There are many examples where poor governance has been restored through the development of authorities that bring together different departments and NGOs for the sustainable management of wetlands, forests and other ecosystems, which all have natural infrastructure as at the core. It is essential that there is recognition at all governance levels that the maintenance of natural infrastructure and biodiversity is key to maintaining water resources. This principle needs to be adopted within in all policies, agreements and management approaches that are directly or indirectly related to water.

Sound water management is complex and requires an integrated, multi-sectoral and multidisciplinary approach, recognising the cross-cutting nature of water resources and the biodiversity which supports them. There is a wide and diverse range of government agencies, civil society organisations, private sector concerns and individuals involved in water management. Decision makers need to work in a more integrated way with policy and practice being better linked, reflecting the realities on the ground. This can be achieved through the adoption of principles and processes which incorporate issues of equity, efficiency and environment.

PARTNERSHIPS – INTERGOVERNMENTAL DIMENSIONS

In a recent global survey carried out by UN-Water as a contribution to the Rio+20 Summit, 80% of countries reported that they have embarked on reforms to improve the enabling environment for water resources management based on an application of integrated approaches. This has already led to better water resource management practices and demonstrated important social and economic benefits; however, much more needs to be done to ensure there is long term water and food security. There is not one solution that will fit all situations, especially where climate and hydrological regimes are changing rapidly. However, the knowledge to address many of the challenges exists and countries, communities and all other stakeholders need to build capacity to develop solutions for their individual, unique circumstances. Adaptive management processes which engage stakeholders and build on the achievements and successes of the past in order to deliver a virtuous spiral of progress and adaption in the future are essential tools for achieving sustainable economic, social and environmental outcomes. Processes, such as Integrated Water Resource Management (IWRM), where incorporating natural infrastructure solutions, can be used to expand the dimensions of water management to ensure that the complexities are embraced, rather than ignored or used as an excuse to prioritise investment decisions away from protecting natural infrastructure.



CONVENTIONS & OTHER INTER-GOVERNMENTAL PROCESSES

The three Rio Conventions – the Convention on Biological Diversity (CBD), the United Nations Framework Convention on Climate Change (UNFCCC) and the United Nations Convention to Combat Desertification (UNCCD) – derive directly from the 1992 Earth Summit held in Rio de Janeiro. Each Convention represents a way of contributing to the delivery of sustainable development goals. Key within these goals is the management of water and biodiversity. For climate change – water is central. Desertification is, by definition, about water. Biodiversity is central to regulating water across all dimensions.

In addition to the Rio Conventions, other intergovernmental initiatives pursue similar objectives. For instance, the Ramsar Convention on Wetlands adopts the "wise use" approach, to safeguard and enhance the livelihoods and needs of people who live in and around wetlands, thus protecting water resources for this and future generations. Similarly, the UN Water, Alliance for Water Stewardship (AWS), was established in 2008 by the Water Stewardship Initiative (now Water Stewardship Australia), The Nature Conservancy and the Pacific Institute to endorse good organizational water stewardship. The aim was to establish a global water stewardship programme, based on a stakeholder endorsed standard, credible verification, market recognition and a multi-stakeholder governance regime.

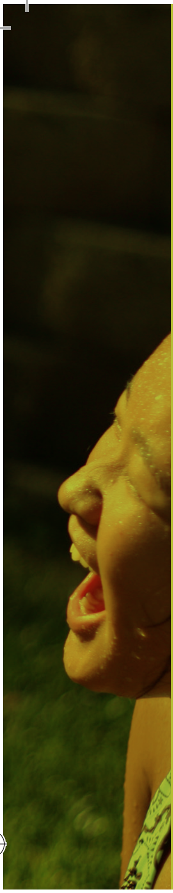
COOPERATION AS A CATALYST FOR CHANGE FOR THE BETTER

Access to water from the local to the transboundary scale can be a source of conflict. However, cooperation on such a vital issue as water management can also be a catalyst for change, building peace across social, political and religious divides. Universal access to drinking water and sanitation is fundamental human need and a key target of the UN Millennium Development Goals and likely to remain so post-2015. In designating 2013 as the International Year of Water Cooperation, the United Nations General Assembly recognised that water underpins all economic activity, and cooperation can lead to more efficient and sustainable use of water resources. However, cooperation needs to include in particular the management of the biodiversity, which maintains key hydrological processes and is crucial to the sustainable supply of water for human society.

Partnerships are essential to bring together biodiversity and water, and to deliver sustainable solutions. Cooperation can take place from the local to national to the intergovernmental level. At the local level, restoring vegetation such as trees in the local landscape in sub Saharan Africa

requires villagers to cooperate for the common good. At the regional scale, the Arab Ministerial Water Council has adopted the Arab Strategy for Water Security in the Arab Region to meet the challenges of delivering sustainable development. The strategy highlights the need for regional cooperation for the management of shared water resources and the need for improvements in land management (and therefore its natural infrastructure) and groundwater resources to secure sustainable access to water supply and sanitation services.

> It is essential to balance needs and priorities across different social groups, economic sectors and national governments for the present and future generations.



Cooperation and partnerships for the sustainable management of biodiversity and water must operate at the appropriate scale and require collective effort and leadership in order to be successful. The exclusion of any stakeholder in water management issues can result in the cooperation chain being broken generating adverse impacts on human well-being and wider economies.

An integration of the values of ecosystem services into investment decision-making aspects of water management and climate change adaptation is within both development planning and disaster risk reduction. Whilst these various components have their own sets of stakeholders, goals and objectives, many synergies exist which ultimately, when considered and evaluated appropriately, deliver more integrated solutions and drive a transformation to sustainable outcomes. Ecosystem-based disaster risk reduction draws together the ecosystem management, development planning, climate change adaptation and disaster risk reduction, all of which strive for sustainable development and improved human well-being, into an integrated approach.

TRANSBOUNDARY COOPERATION

Both water management boundaries and ecosystems rarely conveniently align with geopolitical boundaries. Approximately 40% of the world's population lives in river and lake basins straddling two or more countries and over 90% lives in countries that share basins. Globally there are 263 shared surface water basins which hold 60% of freshwater supplies, involving 3 billion people in 145 countries. As well as shared basins, there are many transboundary aquifers, wetlands and lake systems. In Africa the problem is acute with 60 transboundary rivers and international water basins covering 60% of the continent. Globally, 2 billion people rely on groundwater and there are an estimated 300 transboundary aquifers [3].

All transboundary waterbodies create hydrological, social and economic interdependencies between societies, which present a series of challenges, impacts and potential sources of conflict. These issues are a challenge not just between countries in shared basins, but within countries with federal systems. Depending on how national legislative frameworks are set up, much of the decision-making responsibility relating to water, land use and wetlands can be at sub-national level. In such situations, just the same challenges occur as between sovereign states. Upstream water consumption for agriculture, industry, energy and for use in settlements can

result in water conflicts with downstream communities putting pressure on water resources and jeopardising the maintenance of ecological character and the provision of a range of ecosystem services.

Transboundary water resource management agreements and governance structures involving all parties and stakeholders, often delivered through IWRM, are essential for resolving conflicts and reaching agreements on water management. The good news is that, at the international level, water appears to provide reasons for transboundary cooperation rather than conflict with 105 of the 263 shared water basins having some form of cooperative management agreement. The integration of natural infrastructure solutions to managing water will be an essential ingredient of successful and sustained transboundary water management.

The Ramsar Convention plays an important role by emphasizing the need to manage wetlands at the basin level with the Convention providing countries with the necessary tools to achieve this. The Ramsar Convention also formally addresses the need for countries that 'share' Ramsar sites by designating them as transboundary sites, which they manage jointly in a coordinated way and involving collaboration across borders with sharing of information and expertise, and development of joint management planning processes. The Second Assessment of Transboundary Rivers, Lakes and Groundwaters conducted by the UN Economic Commission for Europe (UNECE) region in 2011 included a major innovation through the collaborative assessment of 25 Ramsar sites and other wetlands of transboundary importance. The assessment recognised that, despite national and international efforts, wetlands continue to be among the world's most threatened ecosystems. Advocacy messages within the assessment stated that wetlands should be recognized as natural infrastructure essential for the sustainable provision of water resources and related ecosystem services and that transboundary cooperation is crucial where functional units of wetland ecosystems stretch across national (or administrative) borders.

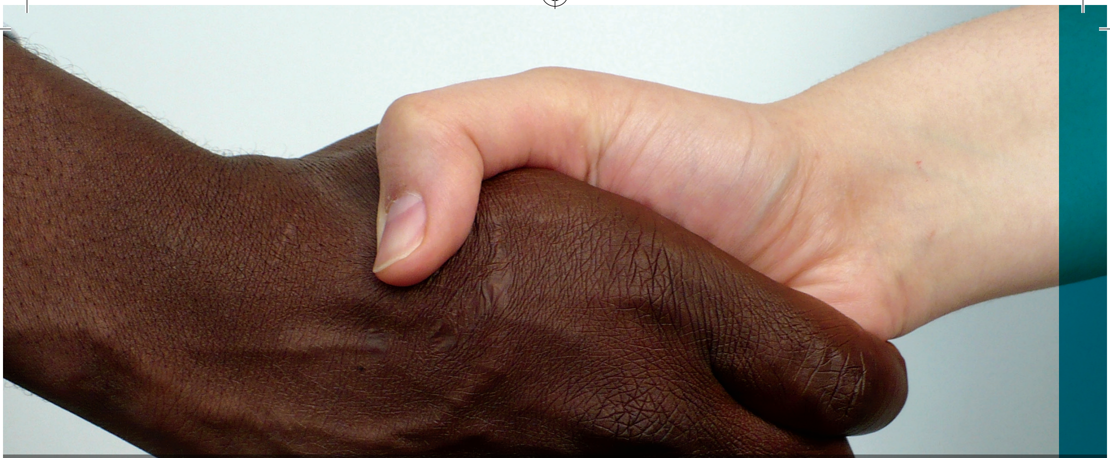
What Can We Do?

OURSELVES AS INDIVIDUAL WATER MANAGERS

We all have a responsibility to manage our water resources and to understand the role of biodiversity. Local actions to conserve and reuse water are the basis of sustainable water management and play a direct role in the delivery of broader water management, through domestic initiatives, such as rainwater harvesting and water-friendly garden design or simply reducing water usage or enhancing local ecosystems. Similarly, stakeholders are encouraged to ensure that their experiences and concerns are integrated into water management decision-making. The power to change through grassroots advocacy and action should not be underestimated.

Water managers and agencies need a greater appreciation of the socio-economic values and co-benefits provided by natural infrastructure, such as the regulation of flooding, sustaining of fisheries and aquaculture and other wider socio-economic impacts. Successful water management remains an integrated, holistic and cooperative activity.

Whilst minimising our impact on the environment and limiting resource use is the best course of action, there are a growing number of initiatives that allow individuals and companies to fund mitigation projects.



CORPORATE INVESTING IN ECOSYSTEM RESTORATION IN GERMANY [24]

MoorFutures is a German initiative, which offers the opportunity to invest in peatland restoration for offsetting carbon emissions. In addition to storing water, restored peatlands also generate additional benefits for biodiversity, providing habitat for native animal and plant species. This increases the attractiveness of the region as a destination for nature tourism and can generate additional income.

BUSINESSES AS WATER MANAGERS

All businesses should aim to reduce their operational water footprint and consider how their activities impact on ecosystems. Many businesses are already setting examples for others to follow in this field. It is also vital to consider the supply-chain water footprint, which is often much larger than the operational one. The key water management philosophy should be: reduce, recycle and treat before disposal. Managing water is not just a matter of accounting for cubic metre consumption; companies face a major challenge to define a sustainable water management strategy, which aligns with their business strategy and does not compromise the very ecosystems, which contribute to sustainable water management. Many businesses are already considering their environmental footprint and have ISO14001 accreditation in recognition of their commitment to their Environmental Management System (EMS), and there are a number of businesses across a range of sectors that have developed solutions to assist in reducing water usage.

With good planning, stewardship and management, all businesses should ensure sustainable use of water and biodiversity across all their activities. The tools are available so that they can take control of their water footprint and be a driving force in sustainable environmental, social and economic development for current and future generations.

CATCHMENT MANAGEMENT APPROACH BY WATER COMPANIES [25]

United Utilities supplies water to seven million people, and 200,000 businesses, in North West England. The Sustainable Catchment Management Programme (SCaMP) – *from hilltop to tap,* is a £10 million investment developed with a NGO, initially for a ten year period 2005-2015. SCaMP applies an integrated approach to catchment management across nearly 56,500 hectares of land owned by United Utilities, which benefits water quality and wildlife. Around 30% of the managed land is designated as protected habitats, which incorporate nationally significant areas for plants and animals, are integral to SCaMP's success. Healthy functioning ecosystems, such as the blanket bog and moorland characteristic of the area, provide natural water treatment and storage throughout the catchment before water arrives in the reservoirs. Habitat restoration and land management practices, including diversification and alternative grazing regimes and livestock options, were implemented with farmers, tenants and landowners. Significant multiple benefits are now delivered on a landscape scale, with a combination of land management for agriculture and leisure. In addition to protecting and improving water quality, the benefits include: reducing or delaying the need for additional capital expenditure for water treatment; enhancing and protecting the natural environment, including delivering Government targets for nature conservation; ensuring a sustainable future for the agricultural tenants; allowing moorland habitat to become more resistant to long term climate change; and allowing healthy upland peat moors to absorb significant volumes of atmospheric carbon.

WATER REDUCTION EFFORTS IN THE BREWING INDUSTRY [26]

Brewing is one of the most intensive users of water, from tiny microbreweries to mammoth bottling plants. In the United States alone, beer has a US $300 billion market and is often brewed in regions of water scarcity. Many beer companies succeed with sustainability efforts from energy efficiency to the reuse and recycling of ingredients and packaging, but the most important and yet challenging reduction is in the water footprint. An estimated 300 litres of water is required to make one litre of beer. SABMiller, one of the world's largest beer producers, in partnership with WWF, is working in Peru, South Africa, Tanzania and Ukraine to understand its water footprint, investigate how pollution and water scarcity are affecting its local business and other local water users; reducing water risks through collective action with local people, companies and agencies, and spreading good practice to influence wider change. MillerCoors, a SABMiller subsidiary, has partnered with The Nature Conservancy and works with barley farmers in Idaho, USA, to streamline irrigation technologies and establish best practice for water conservation. Simple natural infrastructure, such as planting trees along the creeks to keep them cool, vegetation along the stream banks to prevent soil loss and pollutants entering the water, and retrofitting of irrigation pumps that disperse water closer to the ground at a low pressure, has resulted in saving 1.7 million litres of water per day and increased trust and support from the surrounding communities.

UNDERSTANDING WATER FOOTPRINTS IN THE PAPER INDUSTRY [27]

The UN Global Compact's CEO Water Mandate that assists businesses in the development, implementation and disclosure of water sustainability policies and practices is open to companies of all sizes and sectors, and from all parts of the world. One paper company, UPM, has joined this initiative and the main objective is to look at sustainable use of water and really understand the full water footprint of its Nordland mill, split into green, blue and grey water footprints. The green water footprint represents the volume of forest evapotranspiration during tree growth and is by far the biggest water management leverage. The blue water footprint, freshwater lost in the mill production process, is relatively small. The grey water footprint consists of the water needed to assimilate the mill's effluent pollutants to an acceptable natural quality. The company also carried out a local sustainability assessment to identify water scarcity hotspots and compare water footprints to actual water availability. It is important that before implementing water footprint reduction plans, businesses have a really good understanding of their overall water usage to ensure the right measures are implemented for long term sustainability and economic benefits, environmentally and socially.

THE CONVENTION ON BIOLOGICAL DIVERSITY AND WATER AND BIODIVERSITY

Detailed consideration of the linkages between biodiversity and water were undertaken initially at CBD COP-10. In decision X/28, the Parties to the Convention noted:

i. the role of biodiversity and ecosystems in providing services that reduce vulnerability to the impact of some natural disasters, in particular water-related impacts such as flooding and drought, and that current global changes are anticipated to increase disaster vulnerability and risk;

ii. that water provisioning, regulation and purification:

  (a) are critically important services provided by ecosystems, underpinned by biodiversity, and essential to sustainable development;

  (b) are essential for the continued functioning of terrestrial, inland and coastal ecosystems and the existence of biodiversity within these;

iii. that there is a clear scientific and technical basis to strengthen attention to water across all relevant interests and programmes of work of the Convention; and

iv. making full use of the opportunities presented by the recognition of the role of biodiversity in water provisioning, regulation and purification, and hence sustaining water resources, urged Parties, other Governments, and relevant organizations to mainstream biodiversity into all sectors and levels of government and society as a contribution to the achievement of the objectives of the Convention.

In parallel, these topics were incorporated into the Strategic Plan for Biodiversity and the Aichi Biodiversity Targets, also adopted at CBD COP-10 (decision X/2).

AT CBD COP-11, PARTIES:

i. Recognized the importance of the water cycle, including its groundwater component, and the influence of climate change upon it, to most areas of work of the Convention and to achieving most of the Aichi Biodiversity Targets, and urged Parties, other Governments and relevant organizations, and requested the Executive Secretary, to give due consideration to the water cycle, as a cross-cutting theme, when implementing the Strategic Plan for Biodiversity 2011 - 2020; and

ii. *Requested* the Executive Secretary, and *invited* the Secretary General of the Ramsar Convention on Wetlands, in consultation with relevant organizations and initiatives, to develop a cooperative partnership to promote awareness of, and capacity building for, ecosystem based solutions for water resources management as a means to enhance the implementation of the Strategic Plan for Biodiversity 2011 - 2020 by the broadest range of stakeholders, as a contribution to sustainable development and to the United Nations International Year of Water Cooperation (2013).

BIODIVERSITY & WATER & THE SUSTAINABLE DEVELOPMENT AGENDA AND GOALS

There is presently much discussion on achieving the current development goals, in particular the Millennium Development Goals, and ongoing work towards an agreed international agenda for the Sustainable Development post-2015.

In this dialogue many stakeholders are promoting greater attention to water as such in the post-2015 Sustainable Development agenda. Within such a setting there is significant opportunity to better reflect the roles that biodiversity and ecosystem services play to help us achieve a more water secure world and thereby helping to underpin sustainable development.

The United Nations Conference on Sustainable Development (2012), popularly referred to as "Rio+20", was one major event discussing this topic. This conference recognised the importance of water in the sustainable development agenda. Most significantly, paragraph 122 of the outcome document of the conference (*"The Future We Want")* [28] makes a very significant statement regarding the topic of biodiversity and water:

> "We recognize the key role that ecosystems play in maintaining water quantity and quality and support actions within respective national boundaries to protect and sustainably manage these ecosystems."

This represents the required significant paradigm shift (as referred to above) from considering biodiversity as the "victim" of development activities (i.e., looking at impacts of water on biodiversity) to regarding biodiversity as a tool or solution to help us achieve sustainable water management and water security (i.e., thinking about how biodiversity impacts water).

This is also a significant opportunity. By operationalizing the above paragraph, through articulating appropriate response actions (or goals and targets), biodiversity can be further mainstreamed across the sustainable development agenda, enhancing the contribution of the Strategic Plan for Biodiversity 2011 - 2020 and the Aichi Biodiversity Targets to sustainable development.

STRATEGIC PLAN FOR BIODIVERSITY 2011-2020 AND THE AICHI BIODIVERSITY TARGETS

VISION

The vision for the Strategic Plan is: *"Living in Harmony with Nature" where "By 2050, biodiversity is valued, conserved, restored and wisely used, maintaining ecosystem services, sustaining a healthy plant and delivering benefits essential for all people."*

MISSION

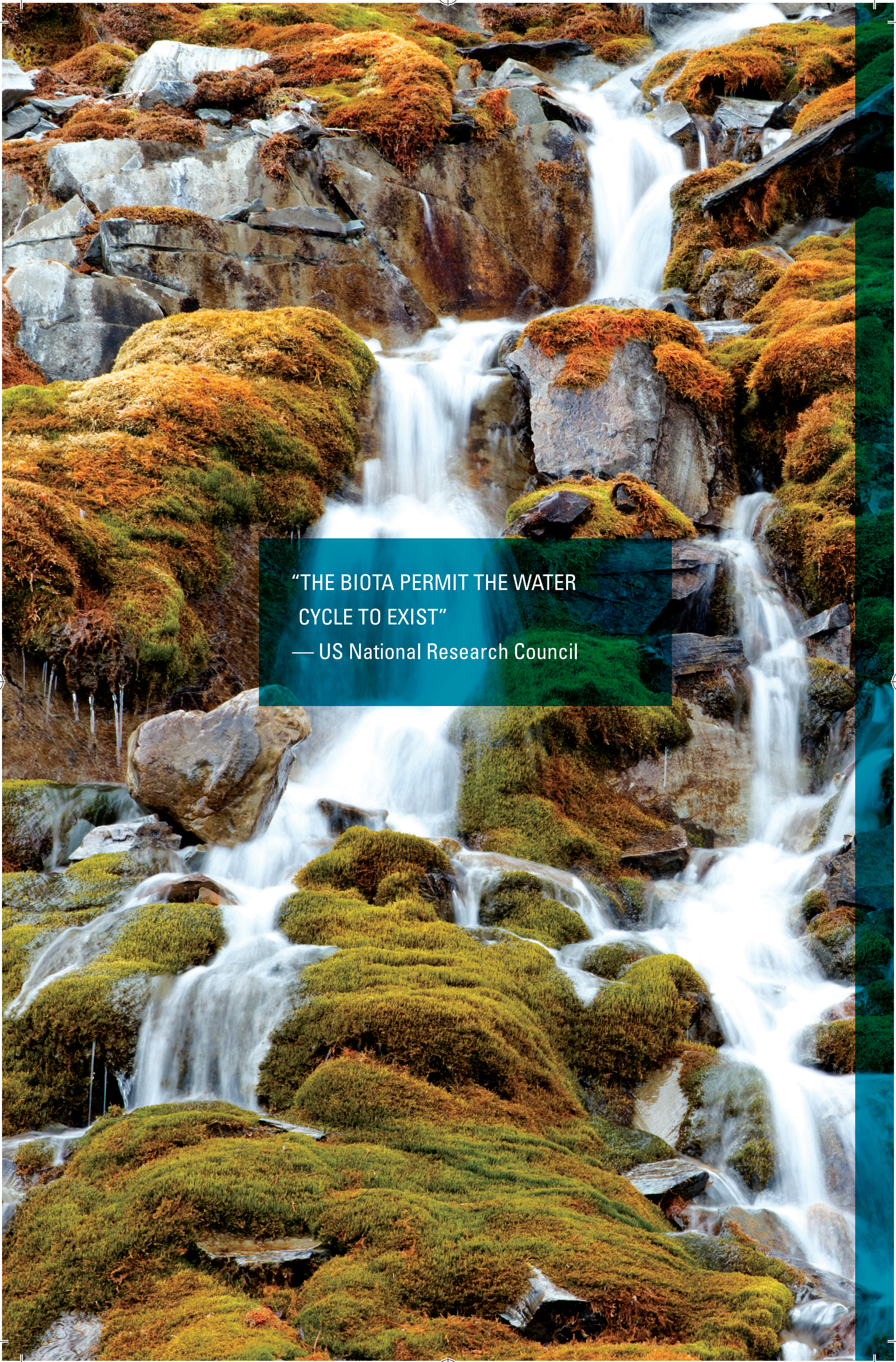
The mission of the Strategic Plan is to *"take effective and urgent action to halt the loss of biodiversity in order to ensure that by 2020 ecosystems are resilient and continue to provide essential services, thereby securing the planet's variety of life, and contributing to human well-being, and poverty eradication. To ensure this, pressures on biodiversity are reduced, ecosystems are restored, biological resources are sustainably used and benefits arising out of utilization of genetic resources are shared in a fair and equitable manner; adequate financial resources are provided, capacities are enhanced, biodiversity issues and values mainstreamed, appropriate policies are effectively implemented, and decision-making is based on sound science and the precautionary approach."*

STRATEGIC GOALS AND THE AICHI BIODIVERSITY TARGETS particularly relevant to water and biodiversity

Because water underpins all life, the topic of water and biodiversity is relevant to all strategic goals and targets. Some examples where water and biodiversity is relevant include:

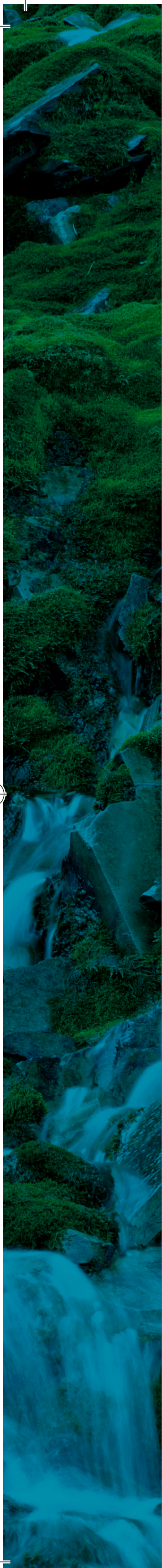
STRATEGIC GOAL A: Address the underlying causes of biodiversity loss by mainstreaming biodiversity across government and society

All targets. Because of the very high profile of water on the government and society agendas the role of biodiversity in achieving water security is a major means to mainstream the values of biodiversity.



"THE BIOTA PERMIT THE WATER CYCLE TO EXIST"

— US National Research Council



STRATEGIC GOAL B: Reduce the direct pressures on biodiversity and promote sustainable use

TARGET 7: By 2020 areas under agriculture, aquaculture and forestry are managed sustainably, ensuring conservation of biodiversity.

One of the key mechanisms to achieve sustainable agriculture is to restore the natural infrastructure of land cover and soil biodiversity and functions in farming systems, to rehabilitate water cycling, improve water availability to plants (thereby reducing water use), simultaneously improving nutrient cycling and reducing soil erosion thereby reducing off-farm impacts.

TARGET 8: By 2020, pollution, including from excess nutrients, has been brought to levels that are not detrimental to ecosystem function and biodiversity.

The natural infrastructure of soils helps regulate nutrient cycling and hence reduce water pollution. Wetlands and forest buffer zones can be used as natural infrastructure to recycle pollutants and prevent them entering and polluting water supplies.

STRATEGIC GOAL C: To improve the status of biodiversity by safeguarding ecosystems, species and genetic diversity

TARGET 11: By 2020, at least 17 per cent of terrestrial and inland water, and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes.

Water-related ecosystem services are among the most important social and economic reasons for establishing protected areas. A large proportion of protected areas sites are specifically established to protect water supplies whilst delivering other benefits.

STRATEGIC GOAL D: Enhance the benefits to all from biodiversity and ecosystem services

TARGET 14: By 2020, ecosystems that provide essential services, including services related to water, and contribute to health, livelihoods and well-being, are restored and safeguarded, taking into account the needs of women, indigenous and local communities, and the poor and vulnerable.

The Strategic Plan itself notes that the paramount importance of water should be highlighted in the technical rationale of target 14.

TARGET 15: By 2020, ecosystem resilience and the contribution of biodiversity to carbon stocks has been enhanced, through conservation and restoration, including restoration of at least 15 per cent of degraded ecosystems, thereby contributing to climate change mitigation and adaptation and to combating desertification.

Water is essential for ecosystems to store carbon. In turn carbon, as for example trees or soil organic matter, contributes to water regulation and cycling. Many ecosystems, and particularly land, are degraded because they have lost the ability to store and regulate water. Water-related benefits provide one of the most important social and economic motivations for restoring ecosystems. Desertification, by definition, is due to water loss from land.

www.cbd.int/sp

FURTHER READING

The following are some key references regarding water and biodiversity; they also contain further references and sources of many of the facts and points contained in this booklet.

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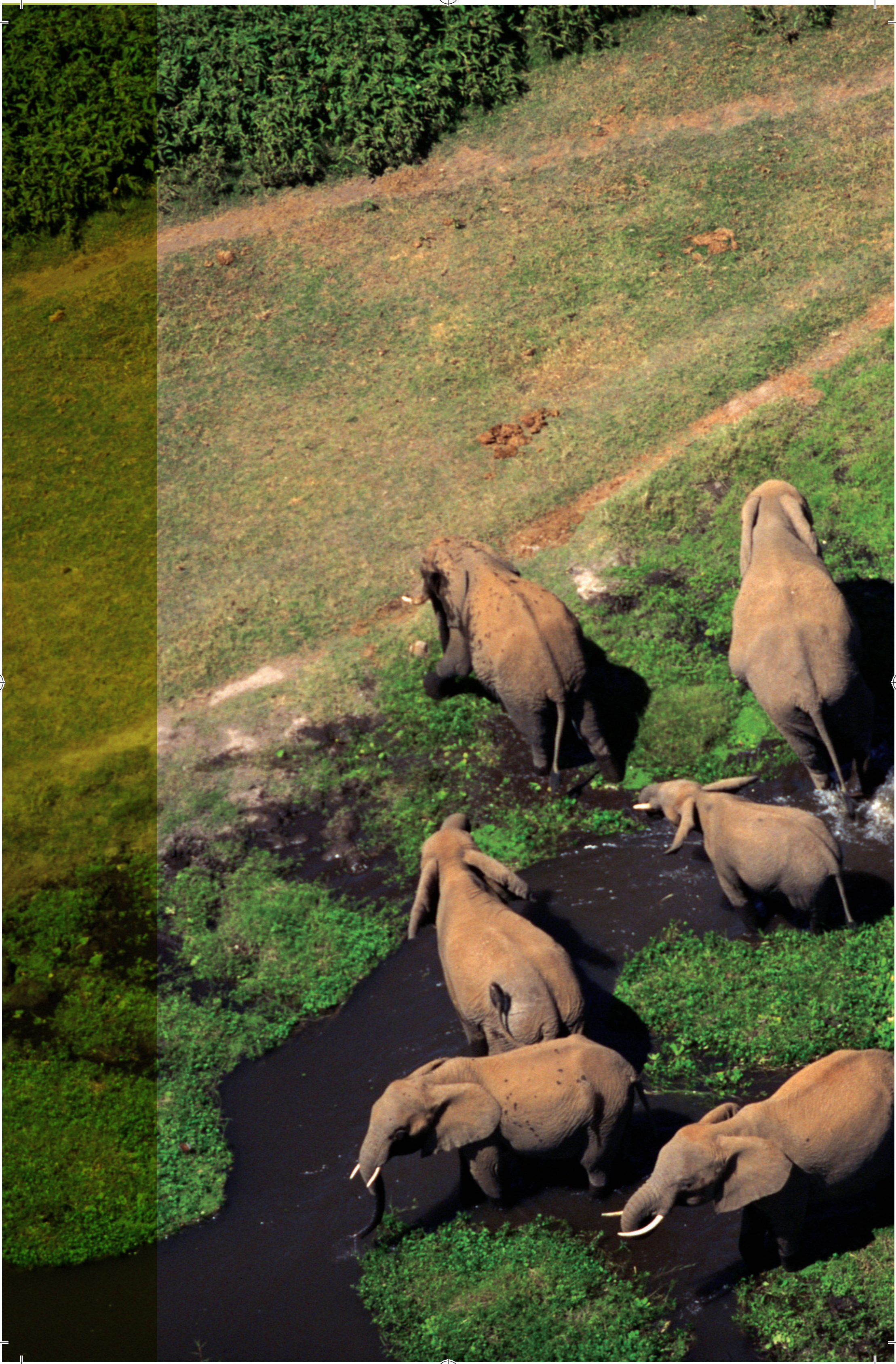

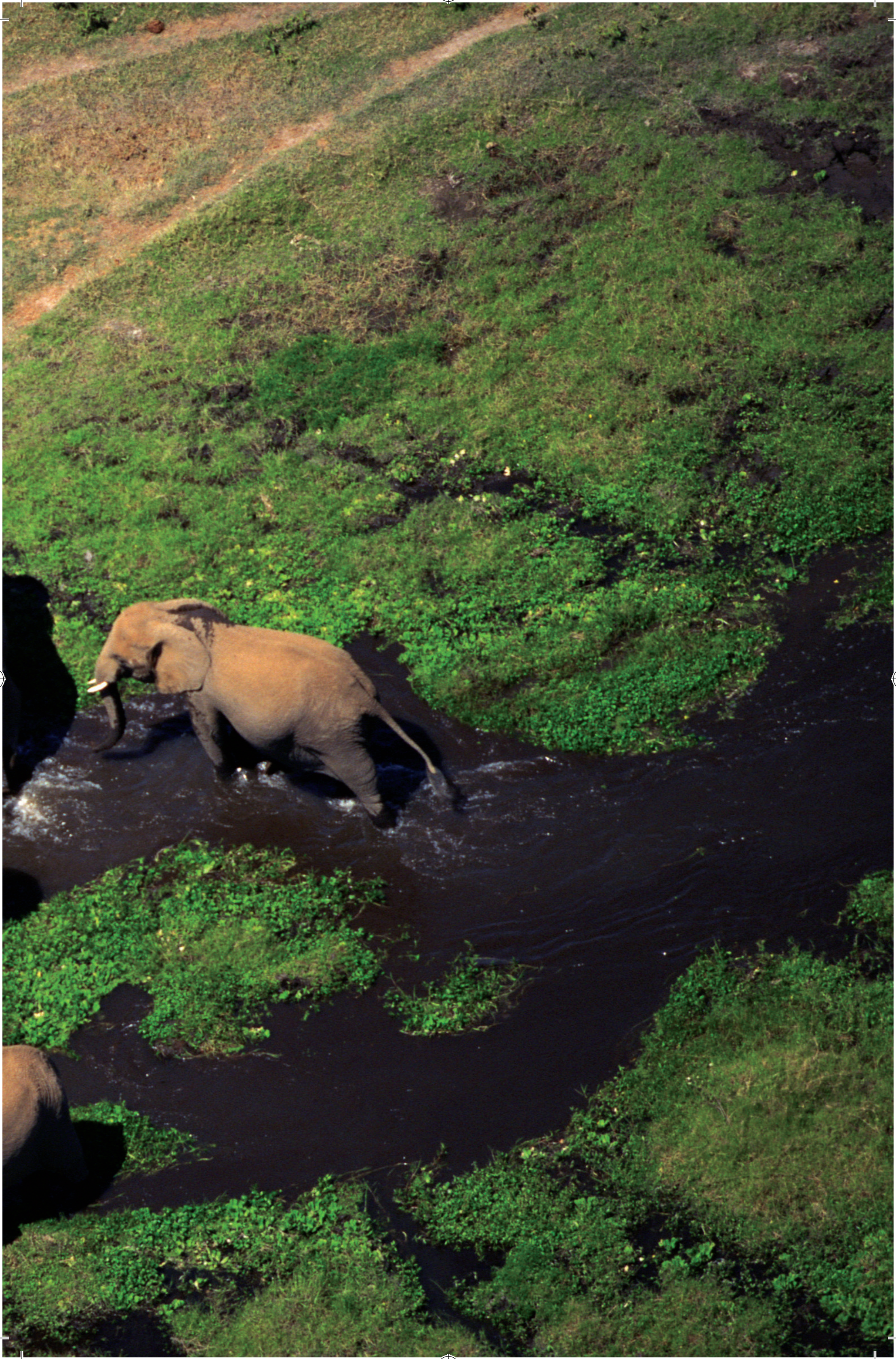

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Secretariat of the Convention on Biological Diversity
413 Saint Jacques Street, Suite 800, Montreal, Quebec, Canada H2Y 1N9
Tel: +1 514-288-2220 Fax: +1 514-288-6588 Email: secretariat@cbd.int