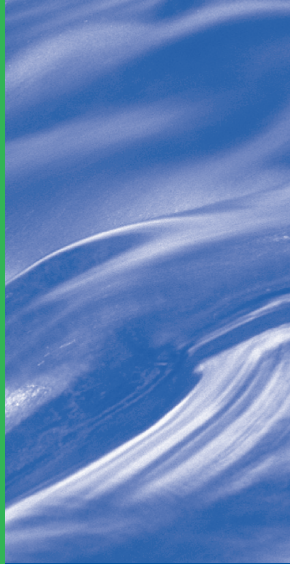
Biodiversity loss and the global water crisis



A fact book on the links between biodiversity and water security

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Wetlands International
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1 Introduction: water for life, life for water

Globally we are facing a water crisis. We use and dispose of more water than ever before: to grow food and now increasingly biofuels, for domestic use and to generate power for our homes and industries. Such activities are viewed as necessary - through them the world's poorer countries can develop and those that are already developed can become greener and more sustainable. However, the growing demand for water is diminishing the amount, quality and regularity of water available for our ecosystems. This is causing a loss and degradation of biodiversity in ecosystems of all types. It is also diminishing the ability of ecosystems to provide essential services that keep people healthy and out of poverty.

This booklet aims to highlight the links between the emerging water crisis and biodiversity loss. Both are the result of the same root causes and both problems reinforce each other.

The booklet draws on the knowledge and understanding developed by Wetlands International and its partners over many years and is supplemented with key information from other, peer reviewed studies.

Lake Natron, Tanzania is the only significant and regular breeding site for the majority of the East African population of the Lesser flamingo (*Phoeniconaias minor*), which accounts for 75% of the global population. By Andrew Burton.

2 Fresh water: a tiny but crucial resource

Water is essential for life in the sea and on land. 70% of the Earth's surface is covered by water. However, only a tiny proportion (3%) of this is fresh water, a large amount (around two thirds) of which is unavailable, being frozen as polar ice-caps or glaciers. Another large part (about a third) is stored as deep groundwater. As a result, all, non-marine, living creatures rely on less than 1% of the planet's total freshwater for their survival.

There is huge competition for this available fresh water. It is necessary to maintain biodiversity, but also to produce food, fuel, generate power, provide water for domestic and industrial uses and maintain the carbon content of ecosystems. Groundwater fulfils some of these needs but the pressure on surface water is huge.

2.1 Global fresh water picture: tiny resources supporting global life

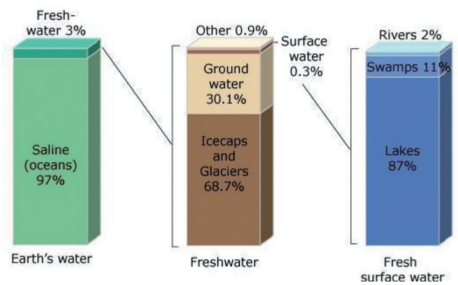


Figure 1. Distribution of Earth's water. *Source: USGS, in Nature's Special report Courtland, R (2008). Enough water to go around? Nature. doi:10.1038/news.2008.678. Can be accessed at http://www.nature.com/news/2008/080319/full/news.2008.678.html.*

2.2 Water stress and scarcity: an unequal world

Although freshwater makes up just a small fraction of the world's total water resources, it is thought that there is still enough available for the world's uses. Unfortunately water is not always found in the places where it is most needed. Many places experience water scarcity, creating water stress for different users. The concept of scarcity is a complex one; sometimes even where there is enough water, there is not enough capacity to make it available to different users. In some places water scarcity and stress fuel competition and even conflict between users.

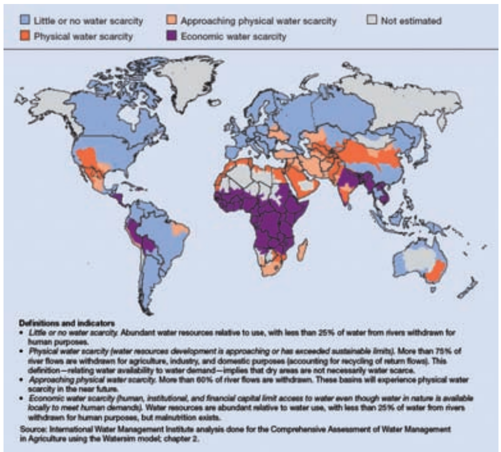


Figure 2. Areas of physical and economic water scarcity. *Source: Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture. London: Earthscan, and Colombo: International Water Management Institute, 2007. www.iwmi.cgiar.org/assessment.*

In addition there are also temporal variations in water resource availability. Seasonal variability in water availability is common in many parts of the world. In some places this seasonal water scarcity creates pressure on the quantity and quality of freshwater resources. Furthermore, changing long-term climatic patterns are creating extended periods of drought or water abundance. The climatic patterns in the Sahel are thought to be an example of this [1].

[1] Zwarts, L. 2010.

3 The water crises and biodiversity loss

3.1 Biodiversity and water security go hand in hand

Water security can be jeapordised by a number of man-made factors, including river fragmentation, overgrazing, the draining of marshlands and pollution. These problems often increase with economic development. The same factors also lead to biodiversity loss[2].

Richer countries are usually able to cope with water security problems; most commonly by addressing the symptoms (e.g. infrastructure to cope with increased flood risk or water purification to cope with pollution) rather than addressing the causes.

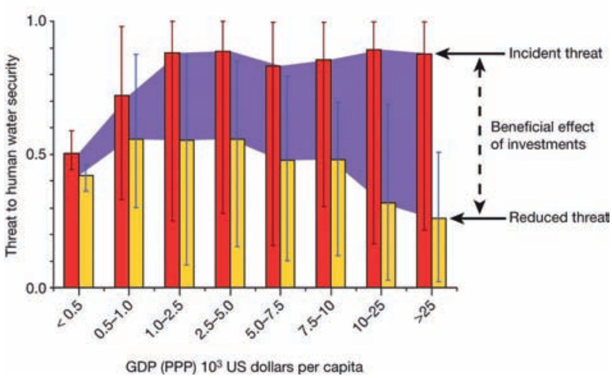


Figure 3. The correlation between wealth and threats to human water security. *Source: Vörösmarty et al., 2010. Global threats to human water security and river biodiversity. Nature Volume 467, September 2010. Management Institute, 2007. www.iwmi.cgiar.org/assessment.*

Less wealthy countries are unable to make the massive investments required and remain vulnerable to drought, floods and water pollution. Figure 4, below, illustrates this: the grey areas with few threats to biodiversity also have relatively few water security problems (grey). The red regions face biodiversity and water security problems; the richer (yellow) areas face a loss of biodiversity but are able to address the symptoms of water security problems with massive investments.

There are hardly any (brown) areas where biodiversity is doing fine and where water security is low. This thorough analysis shows that the stresses on ecosystems, which lead to biodiversity loss, are similar to the stresses that lead to water security problems. Solving water security problems also maintains biodiversity.

This can often be done at a lower cost than addressing the symptoms of water stress. For instance, maintaining the integrity of upland ecosystems reduces costs for drinking water treatment. Preserving floodplains is cheaper than building reservoirs for flood control.

3.2 The importance of freshwater for biodiversity

Just 0.3% of all global water resources are fresh surface water. In terms of area, less than 2% of the world's surface consists of lakes, marshes, rivers or other freshwater wetlands. Many species completely depend on these areas. Almost all land-dependent life, habitats and ecosystems depend on freshwater. Water flows and cycling are critically important to the maintenance of biodiversity. The importance of wetland ecosystems, in terms of global biodiversity, strongly illustrates this.

An estimated 126,000 known species rely completely on freshwater habitats. This figure includes 15,000 fish species (some 45% of all fish species), 4,300 species of amphibians, 5,600 species of dragonflies and damselflies and 5000

[2] Vörösmarty et al.; 2010

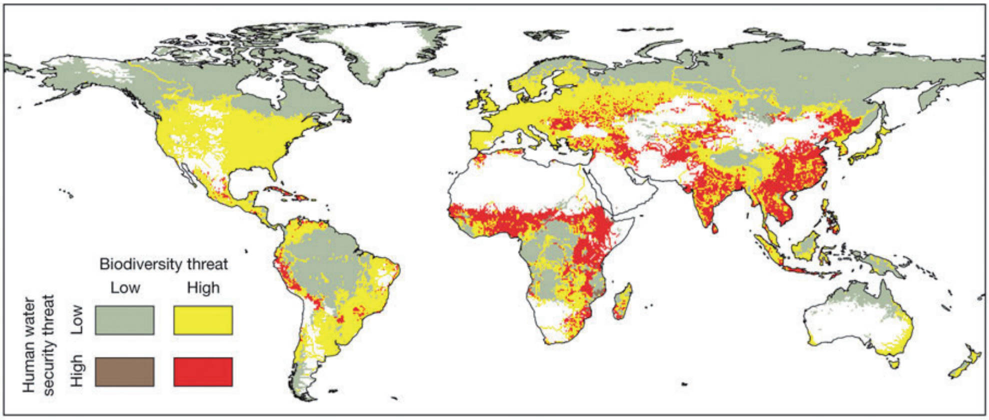


Figure 4. Threat to human water security and biodiversity. *Source: Vörösmarty et al., 2010. Global threats to human water security and river biobiodiversity. Nature Volume 467, September 2010.*

species of molluscs; it is estimated that as many as one million species rely on freshwater habitats - including all undescribed species. Some 37% of all bird species are dependent on inland waters.

3.3 Loss of wetlands and fresh water dependent biodiversity

Recent best estimates suggest that there are approximately 1,280 million hectares (1.2 million square kilometres) of wetland in the world (although this is considered to be an underestimate). There used to be many more; in parts of North America, Europe, Australia, and New Zealand more than 50% of wetlands were lost during the twentieth century. Globally habitats associated with 65% of continental freshwater discharge are moderately to highly threatened [3].

Table 1. Status of freshwater biodiversity [4].

** Freshwater fish, crabs, molluscs, dragon flies and some plants.*

Species	**Status (IUCN Red-List)** [4]
Freshwater mammalian species (145)	38% threatened with extinction
Freshwater amphibian species (4242)	Over 25% threatened with extinction
Freshwater fish in Africa	Nearly 25% threatened with extinction
Freshwater fish in Mediterranean Basin	Over 55% threatened with extinction
Freshwater species in Africa (5,167 assessed)*	Over 20% threatened with extinction
Extinct birds (136)	Over 10% freshwater dependent birds

[3] Vorosmarty et al.; 2010
[4] IUCN Red List of Threatened Species v. 2010.3 http://www.iucnredlist.org/

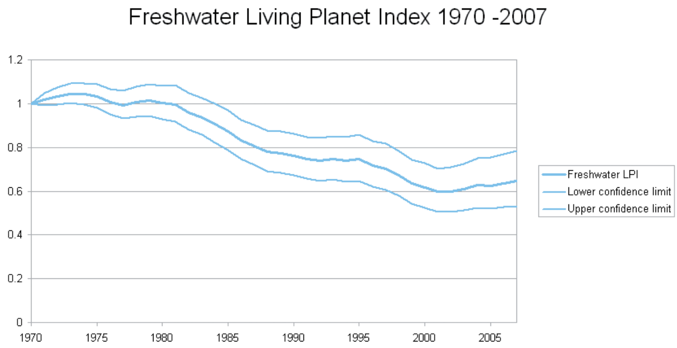


Figure 5. Living Planet Index: fresh water species are strong in decline. *Source: WWF/ZSL/GFN Living Planet Report 2010 (c) 2010 WWF (panda.org).*

Freshwater species are being lost at a much more rapid than other species. There are several reasons for this. One major factor is the vulnerability of species that depend on relatively small areas of habitat that are under pressure from increased human demand for water resources. In Africa, the first continent to have completed a major assessment of its freshwater biodiversity, the biggest threats to species stem from agriculture and pollution, water abstraction and dams.

The Living Planet Index uses a number of key indicator species to measure trends in the populations of vertebrate species. It shows a steep decline in the populations of freshwater species from the mid 1980s onwards.

Lake Naivasha, Kenya suffers heavily from drought, agriculture and related pollution, as well as water extraction for nearby Naivasha town.
By Isaac Ouma.

4 Competing for water

Ecosystems make water available to the organisms that live within them. However, ecosystems can also be considered as users in themselves, having their own needs in terms of water quantity, quality and flow. Ecosystems also provide services that support the livelihoods of millions of people and provide a basis for development.

Despite this, human demand for water generally fails to recognise ecosystems' water requirements. This is the underlying reason for the degradation and loss of wetland ecosystems. Such a lack of recognition can imply high costs for society which may then subsequently have to invest in flood control, water storage or purification.

Human pressure means that progressively less water is available for natural areas or to maintain their biodiversity. In order to approach water management in a more balanced way it is essential to understand human patterns of water use and the alarming developments within them in recent decades.

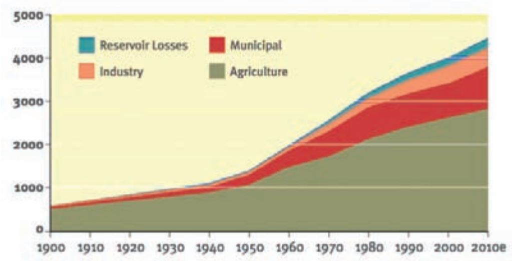


Figure 6. Increase in water use. 20th century world water use, by sector, in cubic kilometres. *Source: World Water Resources and Their Use, UNESCO, 1999. http://webworld.unesco.org/water/ihp/db/shiklomanov/part'3/_Read'me.html.*

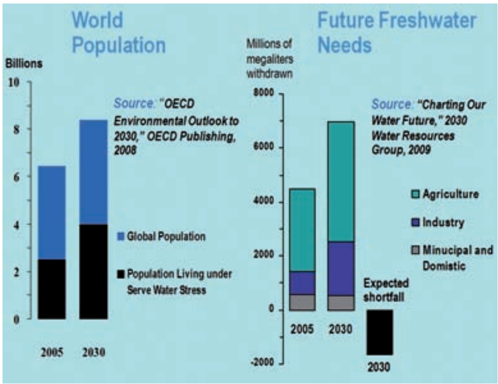


Figure 7. World population and future fresh water needs. *Source: FAO, OECD 2008, Water Resources Group 2009.*

4.1 Water for food production: the thirstiest sector of all

More mouths to feed, more water needs
Achieving food security for the world's population is one of the greatest development challenges - at present, the world's population increases by over 200,000 people per day. The number of undernourished people in the world has increased by 9% since 1990, despite a 12% rise in global food production per capita in the same period [5].

Water is a key factor for food production and availability; especially for the rural poor in parts of Africa and Asia. Currently agriculture is responsible for 70% of all freshwater use, a significant proportion of which is used in irrigated agriculture, which supplies 40% of the world's food. Fifty years ago the world's population was less than half of what it is today and agriculture used one third of the water that it does now. An assessment of the future water needs of agriculture, to feed a growing population, show that in 50 years time there will still be enough water, but it will not be in the right places. This will lead to major crises [6].

[5] Current world population ranked - http://www.xist.org/earth/population1.aspx
[6] IWMI, 2007

Agricultural intensification and its impacts on biodiversity and livelihoods: the case of Kimana, Southern Kenya

Maasai herdsmen have lived for ages on the lower slopes of Mount Kilimanjaro with their cattle, relying on the streams coming from the snow capped mountain and on the vegetation around Amboseli wetlands. In recent years a growing number of farmers have migrated to the area. They have settled upstream from the Maasai, tapped into the local rivers for irrigation and bought new equipment to convert the area to crop production.

As a result, the pastoralists have faced increased problems with water supplies, which form a lifeline for their cattle and are the mainstay of their livelihoods, nutrition and culture. Reduced flows from the mountain mean that some sections of the wetlands only receive water during the rainy season, approximately two months a year (as opposed to the normal five months of the year). In addition, the water is now polluted with pesticides. The changes have also isolated the Amboseli National Park, which has now become an island of natural vegetation in a landscape being converted to agriculture. As a result, elephants and other animals now have to cross farmlands on their traditional migrations routes, creating further conflict.

In recent dry years (2007-2009) many cattle died as wetland areas that used to remain wet, even during such a drought, dried up. Many wild animals, including the entire local hippo population, also died. As the story spread, the majority of tourists planning to visit the area cancelled their plans - so reducing local incomes. While the drought was a natural weather event, its consequences became a disaster for local people and wildlife due to mismanagement of water resources. Wetlands International works in Kimana on improving access of all stakeholders to water resources and involving them in decision-making processes.

Kenya's Kimana wetlands are converted into agricultural land, limiting access to water for wildlife and cattle. By African Widlife Foundation (AWF).

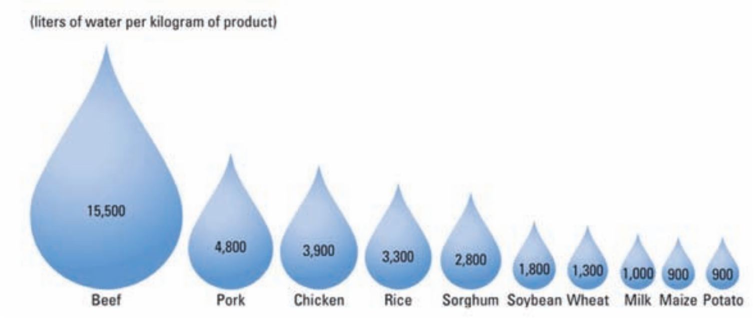


Figure 8. Water requirements for different products. *Source: Waterfootprint (http://www.waterfootprint.org), accessed May 15, 2009; Gleick 2008.*

Future food production faces a number of challenges, many of which are related to climate change. These include: increasing temperatures, declining and more unpredictable rainfall, more frequent extreme weather and more severe attacks of pests and disease [7].

More water for a changing diet

With increasing purchasing power, people change their diets. There is a continual global increase in demand for animal protein (milk, cheese, meat, and eggs). Yet livestock consumes a large proportion of the world's crops as well as a great deal of freshwater. A diet rich in animal protein leaves a much bigger water footprint than a vegetarian one.

The most common strategies for increasing food production are to increase the area of land in production, and/or establish irrigation systems. However, we already take so much water from our rivers that many can be considered closed basins - little or no water reaches the sea in areas like the Middle East, parts of South Asia and North Africa. Further exploitation of freshwater resources and land could be minimalised if the productivity of water use was raised significantly, producing *'more crop per drop'*. However, progress on this front has been minimal over the last decades.

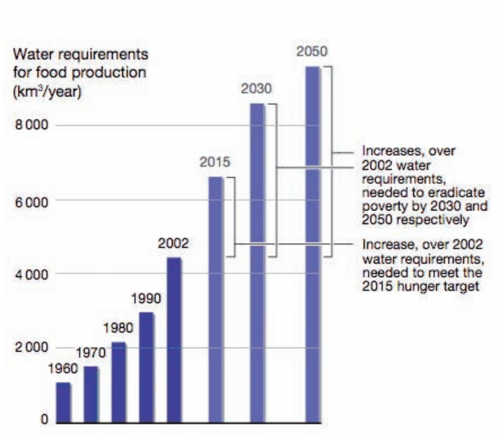


Figure 9. Water requirements for food production. *Source : UNEP/Grida http://www.grida.no/publications/rr/food-crisis/"*

[7] Parry, M.L., Canziani, O.F., Palutikof, J.P., van der Linden, P.J. and Hanson, C.E., (eds.) 2007, Kotschi, J. 2007, Morton, J.F. 2007, Brown, M.E., and Funk C.C. 2008 and Lobell, D.B., Burke, M.B., Tebaldi, C., Mastrandrea, M.D., Falcon, W.P., and Naylor R.L. 2008.

Ruoergai Plateau in China: drying up lakes threaten downstream food security

The Tibetan Plateau is the source of all the major rivers in East and South Asia, serving some 2 billion people. The Ruoergai Plateau is a mountain plateau of 10,000 square kilometres spread across the Gansu and Sichuan provinces, China, and is the upper catchment of the Yellow River. The area consists of marshes with deep peat layers with a very high water storage capacity (see table). It is estimated to store 23% of the Yellow River's annual recharge (32.3 billion m^3).

The seasonal regime of the river is critically important for downstream agricultural production. A recent study[9] assessed the value of the different services that Ruoergai provides, such as grazing land, water regulation and carbon storage. It showed that only 4% of the ecosystem's value is derived from its grazing role. The remaining value is mainly related to its carbon storage and water regulation services. This is quite a remarkable statistic, given that the Ruoergai is estimated to have half a million head of cattle and to be one of the largest rangelands in China.

Table 3. Water storage capacity of Ruoergai per land cover. ***Source: Zhang, X.Y., Lu, X.G., Multiple criteria evaluation of ecosystem services for the Ruoergai Plateau Marshes in Southwest China, Ecol. Econ. (2009), doi:10.1016/j.ecolecon.2009.05.017.***

Type	Available soil water capacity[a] ($g \cdot m^{-3}$)	Area (hm^2)	Volume (10^6 m^3)	Water storage capacity ($10^4 t$)
Sandy land	60.98	9220.97	46.10	0.028
Meadow	382.6	1,172,521.20	5862.61	23.922
Marsh	626.9[b]	307,331.57	1536.66[c]	12.707
Lakes and rivers	1000.0	9854.52	49.27	0.493
Total				37.150

Ruoergai's peatland water level is estimated to have lowered in recent years by 1-2m. Drainage, both planned and unplanned (the latter due to overgrazing which has lead to gullying and the lowering of water tables) has strongly diminished the water storage of this area. Wetlands in the Ruoergai are now seasonally as opposed to perennially saturated.

Out of 17 lakes surveyed in 1985, 6 have completely dried up, and 11 have shrunk. Gahai Lake, which covers 480 ha in Lugu County, dried up in 1995, 1997 and 2000 and the Musuo Lake in Ruoergai County has completely dried up. The impacts on the Yellow River are not yet fully understood but it is believed that the flows are slowly being affected, with the risk of disruptions to the environment and food security further downstream. Further ecological deterioration has diminished the productivity and quality of the grassland. As this is one of the biggest rangelands in China this will also affect production and the food supply of many millions of people in China.

[9] Zhang, X.Y., Lu, X.G., 2009

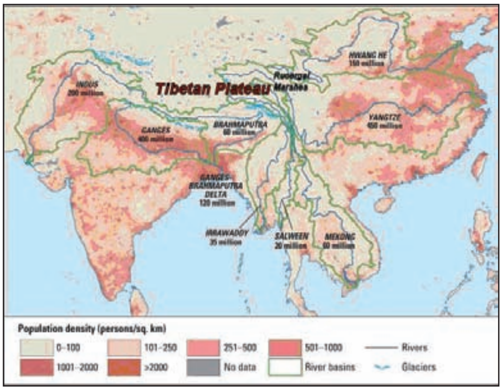


Figure 10. Importance of the Tibetan marshes for Asian rivers. *Sources: Center for International Earth Science Information Network, http://sedac.ciesin.columbia.edu/gpw/global.jsp (accessed May 15, 2009); Armstrong and others 2005; ESRI 2002; WDR team.*

4.1.1 Ecosystems supporting food security at a distance

Food production depends on water availability at certain times of the year. Significant investments are made in hard infrastructure (such as barrages, dams and other storage and regulatory structures) to ensure this. However, it is often overlooked that the water available within these systems is also controlled by the *'natural infrastructure'* upstream. The lakes, swamps and peatlands at higher altitude regions store and release the water that our food production depends on. Loss or degradation of these ecosystems will change the availability of water for downstream agriculture and ecosystems. One clear example is the peat swamps of the Tibetan Plateau; the source of many Asian rivers (see box page 13).

Table 2. The water demand of biofuels and fossil fuels, per unit of energy [8]. *Source: R . Dominguez-Faus et al., 2009. The Water Footprint of Biofuels: A Drink or Drive Issue? Environmental Science & Technology 43, 3005-3010. http://pubs.acs.org/doi/pdfplus/10.1021/es802162x.*

Fuel type	**Litres of water per Megawatt Hour (L/MWh) of energy**
Petroleum extraction plus refining	90 - 190
Corn ethanol under irrigation	2,270,000 - 8,670,000
Soybean bio-diesel under irrigation	13,900,000 - 27,900,000

4.2 From fossil fuels to biofuels: thirsty cars

Biofuels: a major contribution to the agricutural water needs of the future

Despite much publicity, biofuel use is still rather marginal; accounting for just a small percentage of all the fuels used in a few countries and regions (the EU region, the United States and Brazil). But, it is already having a very large impact on land and water use, one that is anticipated to grow in the coming years.

In some areas, with sufficient rainfall, the impacts of biofuel production are limited to land conversion to grow the source crops and deterioration of water quality due to pesticides. However in regions that already suffer from water shortage the growing market for ethanol and vegetable oil is having an impact on water availability and contributing to the water stress experienced in these areas (see box page 15).

[8] Figures from AidEnvironment 2008

Kenya - Tana River Delta falling victim to biofuel conversion

A striking example of the potentially destructive impact of the recent surge in the production of biofuels can be found in the Tana River Delta, a mosaic of floodplain wetlands, grasslands, savannah woodlands and mangroves on the northern part of the Kenyan coast. The area is very important for waterbirds and 22 species have been recorded in numbers exceeding the 1% level for international importance. These include many colonially nesting species, but also include three long-distance migrants Little Stint, Marsh Sandpiper and Lesser Sandplover.

Encouraged by the Kenyan government, investment from as far away as Canada, the Middle East and China is being made in the area to plant vast acreages of sugar cane for biofuel production. This will place large demands on water resources, which are already under pressure from upstream and from the east of the Tana Delta. In the Tana River District there are plans to convert some 90,000 hectares to growing jahtropa - another source crop for biofuel. And further upstream there are plans to build a hydropower plant - the High Grand Falls power generation project near the head of the Athi and Tana basins. This project will also divert water for agricultural irrigation. Together these projects are likely to substantially reduce the water flowing into the delta, disrupt its wildlife and ecology and threaten the ecosystem services it provides to local inhabitants.

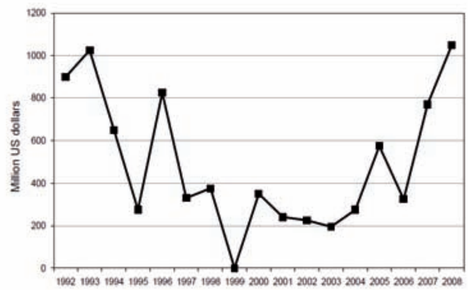
Tana River Delta, Kenya - home to thousands of White-faced Whistling Ducks (*Dendrocygna viduata*) - is being converted into plantations for biofuels. By Oliver Hamerlynck.

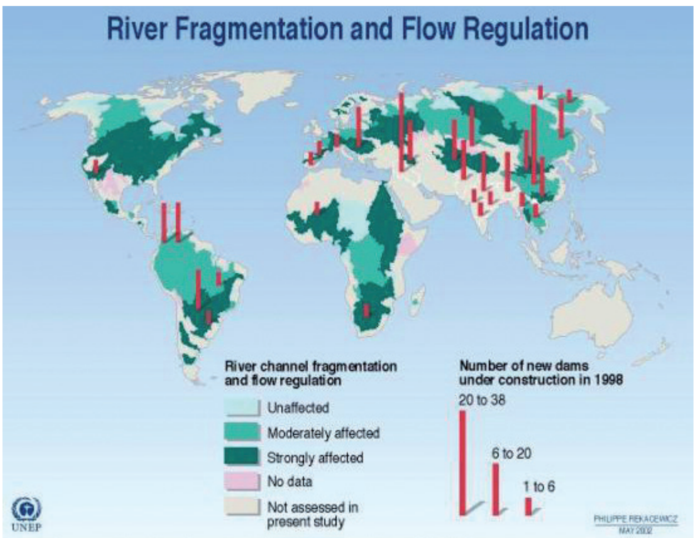
4.3 The impact of hydropower dams

Developing countries need energy for their development. There are many potential sources of energy but hydropower has long been seen as a relatively clean and sustainable source. In countries with significant water resources and limited fossil energy resources, it can appear as a cheap and accessible option. For many years these assumptions have been challenged. The World Commission on Dams highlighted many of the potential pitfalls in hydropower development. Ten years later, a review of the progress in implementing the main findings of this report found that many of the same issues remain unsolved.

Figure 11 shows the significant fluctuation in investment in dams over twenty years, which steeply dipped in the 1990s but has since risen again. Figure 12 shows the locations of dams under construction at the end of the 1990s and areas where river channels are subject to fragmentation and flow regulation.

Figure 11. Global investment in dams 1992-2008 (adapted from World Bank 2009).





Source: Revenga et al., World Resources Institute (WRI), Washington DC, 2000.

Figure 12. River fragmentation and dam construction. *Source: World Bank (2000).*

The impact of dams on ecosystems: the Mali case

Dams on the upper reaches of the Niger are causing very significant changes for people living downstream in the Inner Niger Delta Area who are dependent on fisheries, grazing lands for their cattle and agriculture. The dams, which are used to generate power and provide irrigation water upstream, are magnifying the effects of lower rainfall in an environment where life literally depends on water. Over time the seasonally inundated area in the Inner Niger Delta is becoming smaller - reducing the size of the grazing lands and areas suitable for agriculture.

There is always a trade-off between the positive and negative impacts of a dam project. The benefits in this case can be found around the Markala dam where there is now more irrigated agricultural land, and the electricity supplied by the Sélingue dam. These edams have also created new wetland habitats, which have attracted populations of waterbirds. Yet at the same time, as shown in Table 4, downstream users have experienced significant losses, in fishery and rice production and the number of grazing cattle. In addition, lower river flows have made navigation on the Niger increasingly difficult and seasonal. It is estimated than more than 1 million downstream inhabitants have lost out from these schemes.

The issues are particularly pertinent at present when there are plans in the pipeline to construct a further hydropower dam on the Niger at Fomi. The redistributive effect and the cumulative effects of this project need to be closely considered. Wetlands International works to ensure environmental and socio-economic impacts of new infrastructure are well considered in policy and planning, but also works on flood prediction and livelihood improvement in the Inner Niger Delta.

Table 4. Annual costs and benefits of the dams for several regions in Mali and Guinea.

Value for :	Sélingue dam	Office du Niger dam	Fomi dam
Agriculture	€ 152,439.02	€ 36,280,487.80	€ 6,250,000.00
Livestock	€ 152,439.02	€ 0.00	– € 1,981,707.32
Fisheries	– € 4,268,292.68	– € 1,219,512.20	– € 9,146,341.46
Biodiversity	– € 457,317.07	€ 0.00	– € 5,030,487.80
Transport	€ 304,878.05	– € 152,439.02	– € 152,439.02
Electricity	€ 10,670,731.71	€ 0.00	€ 17,987,804.88
Total benefits	€ 6,707,317.07	€ 34,756,097.56	€ 7,621,951.22
Total costs	€ 3,963,414.63	€ 22,256,097.56	€ 27,743,902.44
Net value	€ 2,743,902.44	€ 12,500,000.00	– € 20,121,951.22

Derived from: Zwarts et al (2005) The Niger - a lifeline. Riza, NL

Peatlands in Central Kalimantan, Indonesia are being logged, drained and burned, which causes huge CO_2 emissions. By Marcel Silvius.

[10] IPCC 2001, Working Group 1, the scientific basis.
[11] Hans Joosten, Greifswald University 2010

Table 4. Peatlands and carbon emissions: a global overview.

Global peatland carbon stock	**450 Gt carbon**
Percentage of all terrestrial carbon	40%
Global peatland area	3,813,553 km²
Percentage of all land	2.5%
Of which drained	426,381 km²
Peatland emissions (decomposition, fires)	2 gigaton CO_2
Percentage of all global CO_2 emissions	6%

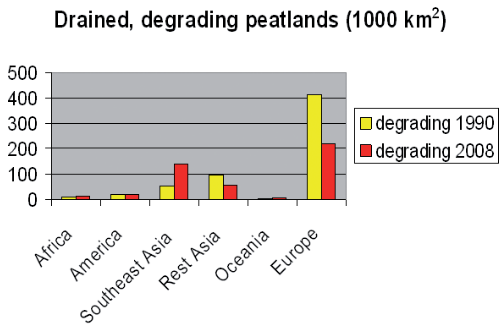


Figure 13. Drained, degraded peatlands per continent. *Source: Joosten 2010: The Global Peat CO_2 Picture.*

4.4 The critical role of water in maintaining the carbon content of peatlands

It is estimated that, globally, more than one thousand gigatonnes of carbon are stored in ecosystems. This is a combination of 654 Gt of plant biomass [10] (roughly half of which is stored forests) and 450 ton of peatsoil carbon [11]. In total, this is more than all the carbon (CO_2 and NH_4) in the atmosphere.

These carbon pools are rapidly being degraded. Deforestation is responsible for about 20% of annual global carbon emissions. The release of carbon from peatlands occurs mostly through wetland drainage and the loss of vegetation cover. Degrading peatlands release about 2 Gt of carbon dioxide per year. In addition, the degradation of wetlands causes methane emissions of an unknown magnitude. Some peatland is drainage is done deliberately, for example peatlands in Malaysia and Indonesia are being drained to establish palm oil and paper pulp plantations. In other areas, it is an unplanned process, as is the case in the Tibetan Plateau where the degradation of peat swamps is due to overgrazing.

Mujib River Basin: biodiversity loss due to a lack of water for the ecosystems

Jordan is an extremely dry country, with soaring temperatures in summer and an average annual precipitation of around just 150 mm. A growing population is using more and more water. The story of one of the last rivers in this region shows how increased water stress and biodiversity loss go hand in hand. The Mujib River draws its water from the Jordan Highlands and Plateau, a total drainage area of 6,600 km^2, at elevations of 700 to 900 m above sea level. The river plunges down into gorges towards the Dead Sea; about 410 m below sea level. Today the river is just a very small and shallow stream which, in many places, can be easily crossed without getting one's knees wet.

The river is also the lifeline for a large area, including the Mujib Nature Reserve. It has an ecological importance and is home to two endemic fish species: Doctor Fish *Garra rufa* and a species of ray-finned fish *Nemacheilus insignis*. On a larger scale, the river is also vital for amphibians, reptiles and large mammals such as the Nubian Ibex *Capra Ibex nubiana* which needs a regular and consistent source of drinking water. Many bird species, such as the resident passerines, use the vegetation alongside the river for nesting.

In 2003 a dam was built to regulate the flow of the main stream of the river. Its main purpose is to provide electricity to Amman, (the capital of Jordan), tourism destinations by the Dead Sea and to the mining and processing industries around southern Ghor. A secondary purpose is to provide irrigation water to the Ghor Mazra'a area (approx. 2 million cubic metres a year).

This development is now threatening much of the life that depends on the river. The dam totally blocks water from going downstream, except when the dam is full. The other tributaries to the river, fed by small springs, only provide a very small flow of water. The species that depend on the river are now very vulnerable, the more so since the concentrations of fertiliser and pesticides within the river are now much higher. The seasonal river flood has also been greatly reduced. The flood is a trigger for fish, amphibians, and invertebrates to start breeding. Controlling the annual flooding is disrupting the natural life cycle with potentially devastating consequences on local wildlife populations. Another impact of controlling the flood is the absence of reed-washing processes in the river. A further threat associated with the dam is the introduction of the alien species Blue Tilapia *Oreochromis aureus*. This species is known to have a destructive impact on native species and habitats. The species has been introduced into the dam lake and has not yet found a way into the Mujib River. However, if it does manage to escape and colonise the river there is a strong chance that it may wipe out the unique endemic fish of the Mujib River. The only sustainable solution for saving the biodiversity of the Mujib River is addressing the root cause. The citizens of Jordan benefit from extremely low water prices (particularly for such a dry country).

Increased water prices are needed to reduce the demands from a water intensive agriculture, wasteful patterns of domestic water use and water intensive industries. Wetlands International supports the Royal Society for the Conservation of Nature to help farmers change towards less water intensive agriculture, with less fertiliser and pesticides.

The Mujib River, Jordan is nowadays just a very small stream, although endemic biodiversity depends on it. By Alex Kaat.

4.5 Water for biodiversity

Thousands of species rely on water-rich areas and healthy water flows for their survival. If these species are to survive it is essential to preserve these areas. This makes biodiversity a *'stakeholder'*, with a valid claim on the world's limited fresh water resources.

The relatively small surface of the world that is covered by freshwater is home to almost one third (31%) of the planet's vertebrate species. This in itself is justification for allocating a fair share of water to maintaining biodiversity; even in areas with water shortages, such as the Middle East (see text box below). In addition to this, healthy and biodiverse ecosystems provide direct and indirect economic benefits, food, tourism, water storage and purification. According to the Millennium Ecosystem Assessment, the services provided to society by wetlands in the developed world can be valued as being worth $15 trillion annually. This includes their water supply function, on which an estimated 1.5-3 billion people depend.

5 Climate change: changing the patterns of water availability

Climate change adds to the pressure on freshwater ecosystem functions, threatening to further damage the ecological services they provide and the biodiversity they contain. Climate change is anticipated to lead to increased water scarcity along with more frequent and more extreme flooding. It will also have a direct effect on biodiversity, changing the distribution ranges of some species and affecting the habitats and niches of others.

defence (see Figure 14). Recent decades have seen the retreat of almost two thirds of these glaciers, due to a range of factors. Further global warming is expected to increase the rate of glacial melting, which is likely lead to higher summer flows in some rivers for a number of decades (in the case of very large glaciers, this increased run-off may persist for a century or more, substantially increasing the available regional water resources[12]. However once the glaciers are gone water flows along these rivers will become much more erratic,

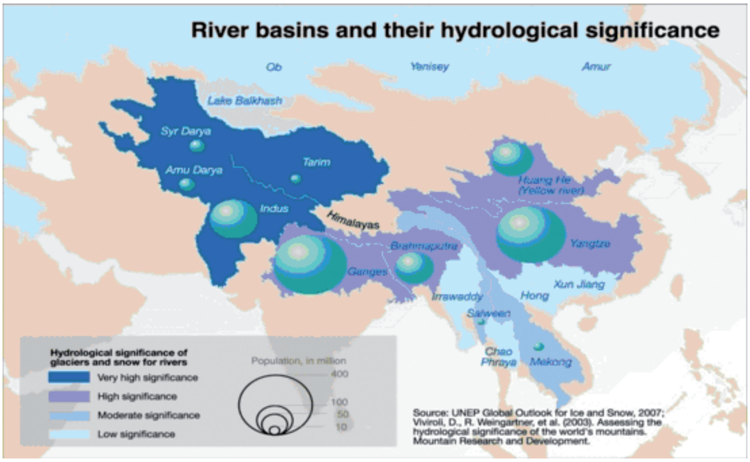


Figure 14. River basins and their hydrological significance.

5.1 Losing our 'water towers': the Himalaya case

Higher temperatures are accelerating glacial melt. Glaciers and other icecaps regulate and provide a steady flow of water, regardless of extremes in precipitation (snowfall). This important role is reduced when the size of snowcaps and glaciers is reduced.

A large number of rivers of Asia are fed by snow and glacial-melt from the Himalayas, which contain almost 1500 glaciers. A large percentage of the population of China and the Indian sub-continent are dependent on the regulatory role of these glaciers for their agriculture and flood

with more pronounced peaks and troughs - and serious implications for agriculture and flood protection.

Figure 15 shows that the Himalayan glaciers are retreating at a far more rapid rate than glaciers elsewhere in the world (by 15% between 1960 and 2008). Research shows that these Himalayan glaciers are retreating by between 0.3 and 1 metre per year [13]. Although the impacts of this need further investigation, it is likely to be significant since more than 2 billion people in South,

[12] Ramsar, 2002
[13] Wetlands International, Trisal C.L. and Kumar, R. 2008

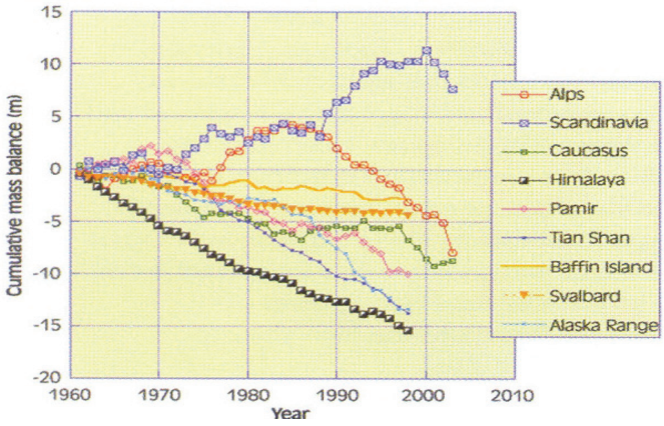


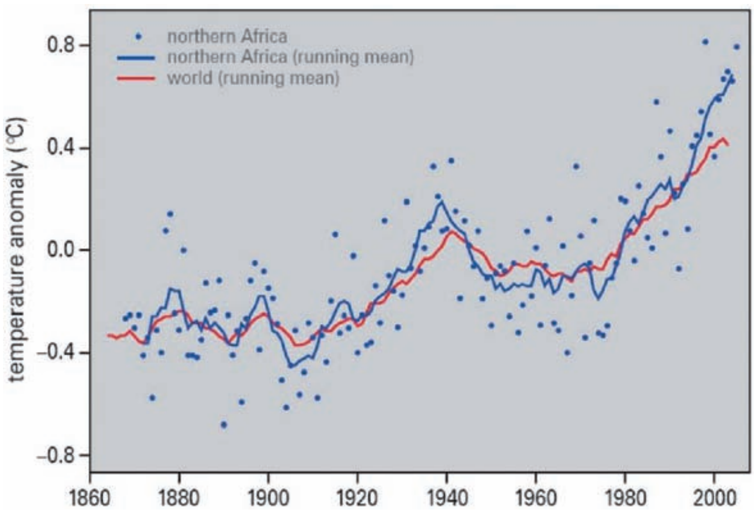
Figure 15. Rapid retreat of greater Himalayan glaciers in comparison to the global average. *Source: Dyurgerov and Meier 2005 in Trisal and Kumar. 2008.*

Southeast and East Asia rely on glacial melt water. Higher glacial melt rates in the Himalayas in the coming two to three decades will increase water availability (and this may mean more water is available to agriculture). But at the same time it is likely to increase flooding, this in some of the most densely populated areas on earth. This will be followed by decreased river flows which may have catastrophic effects on the mega-delta at the mouths of some of these rivers. In some mega-deltas, flooding from the rivers could cause crop yields to increase up to 20 per cent in East and Southeast Asia, while they could decrease up to 30% in Central and South Asia by the mid-21st century [14].

5.2 The dry regions get drier: the Sahel

The expected warming due to climate change is - generally - a global phenomenon. The northern half of Africa does not escape this trend. The six warmest years in northern Africa since records began in 1860 have all occurred since 1998. In the

Figure 16. The average temperature given as departures from the 1961-1990 average in northern Africa (0-40°N, 20°W-60°E) and worldwide. (*Source: www.metoffice.gov.uk/research/hadleycentre/CR_data/Monthly/HadCRUG.txt). The trends show the running mean calculated over an interval of 9 years (4 year before - 4 years after the year concerned).*



[14] IPCC 2007

Sahara-Sahel zone the rise in temperatures since 1970 has been faster than the global average, with a 0.2°C rise per decade in the 1980s, which increased to 0.6°C per decade by the end of the 20th century.

Global Circulation Models predict a further warming of Africa in the 21st century, which could vary between 0.2 and 0.5°C per decade [15]. The rate of increase is expected to be even greater in the Sahel, where temperatures may rise by 2-7°C over the next 80 years. This will have an enormous impact on evaporation and increase water stress.

Several studies confirm that Africa is one of the most vulnerable continents to climate variability and change because of the multiple stresses and a low adaptive capacity. It is estimated that by 2020 between 75 and 250 million people in Africa will be exposed to an increase of water stress due to climate change. Agricultural production will be severely compromised. In some countries yields from rain fed agriculture could be reduced by up to 50% by 2020; local food supplies will be negatively affected by decreasing fisheries resources in large lakes due to rising water temperatures, which may be exacerbated by continued over-fishing [16].

Global Circulation Models also provide predictions about rainfall. Given the important role that ocean surface seawater temperatures exert on rainfall in Africa, it is to be expected that a continuing warming of the tropical oceans will lead to a further reduction in rainfall. However, global warming may also change the temperature gradient within tropical and subtropical oceans, which would complicate predictions about rainfall patterns in Africa in the future.

A report commissioned by Wetlands International shows how the effects of climate change and dams reinforce each other and reduce water availability. The report which focused on the Inner Niger Delta in Mali showed how the water needs for dams for hydropower and irrigation schemes are taking an increased share of less rainfall. This means less water is flowing into the Inner Niger Delta, reducing the extent of seasonal flooding, which is essential for downstream agriculture, for rejuvenating grazing lands and maintaining wetland habitats and biodiversity [17].

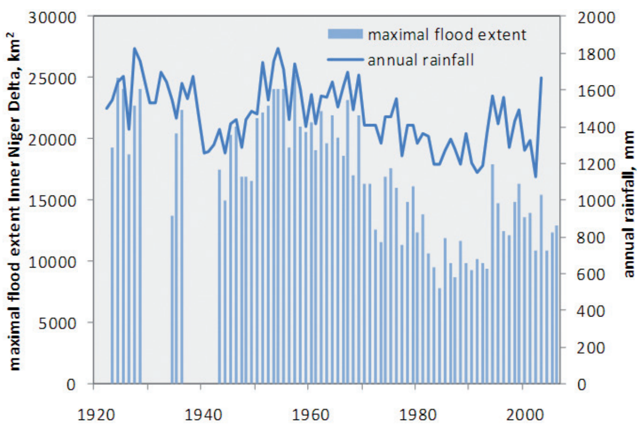


Figure 17. Flood extent in the Inner Niger Delta, Mali compared to rainfall.

[15] Hulme et al. 2001; Caminade et al. 2006.
[16] IPCC 2007. Climate change 2007
[17] Zwarts, L. A&W 2010

The Markala Dam in Mali has negative implications for the annual flooding of the downstream Inner Niger Delta. By Wetlands International Mali.

6 Looking to the future: drought, floods, famine and biodiversity loss

The increased pressures on water resources and wetlands, combined with climate change and ecosystem loss provide a grim outlook for the future. Wetlands International believes that this does not need to be our future.

6.1 Increasing water shortages

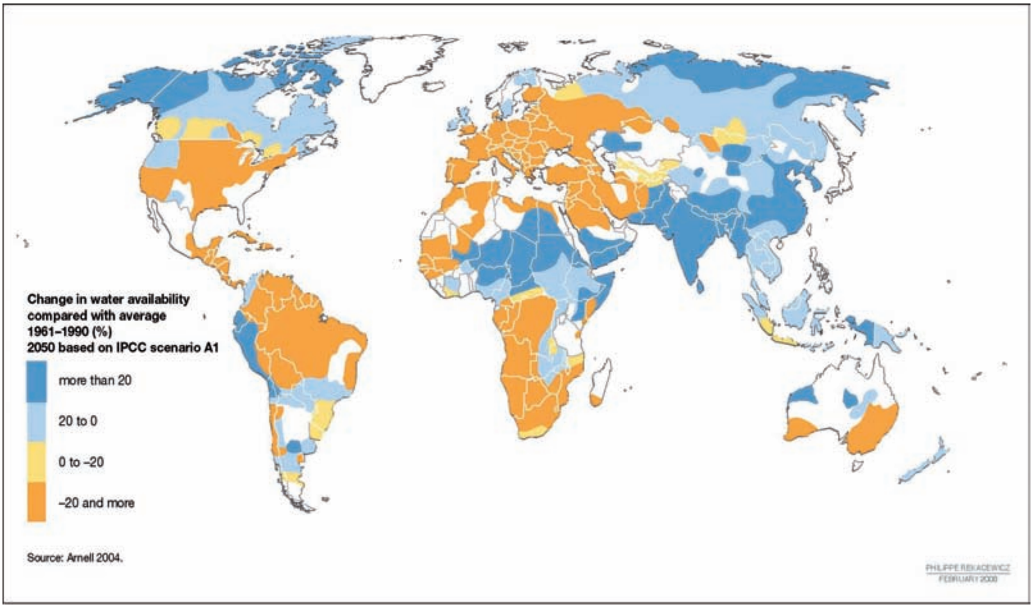
It is expected that by 2025 more than 2.8 billion people in 48 countries will face conditions of water stress or scarcity. Forty of these countries are in the Middle East, North Africa or southern Africa. Over the next two decades, population increases and growing demands are projected to push all the Middle Eastern countries into water scarcity conditions. By 2050, the number of countries facing water stress or scarcity could rise to 54, with a combined population of four billion people - about 40% of the projected global population of 9.4 billion [18]. A large number of African countries, with a combined population of nearly 200 million people, are already facing serious water shortages. By the year 2025, it is estimated that nearly 230 million Africans will be facing water scarcity, and 460 million will live in water-stressed countries [19].

6.2 More floods

The number and extremity of floods is expected to increase severely in the coming decades. This is in line with the exponential increases in flood frequency experienced globally over the past fifty years (see Figure 19). Future trends are likely to intensify owing to more extreme weather conditions, combined with lower water retention capacity (due to the loss or degradation of ecosystems) and the melting of glaciers (causing increased runoff. These floods are also likely to have more serious human consequences due to high population pressure and poor in infrastructure in many areas most vulnerable to floods.

[18] Gardner-Outlaw T. and Engleman R. 1997
[19] Falkenmark M., 1989.

Figure 18. Change in freshwater availability: 2050 and 1990.



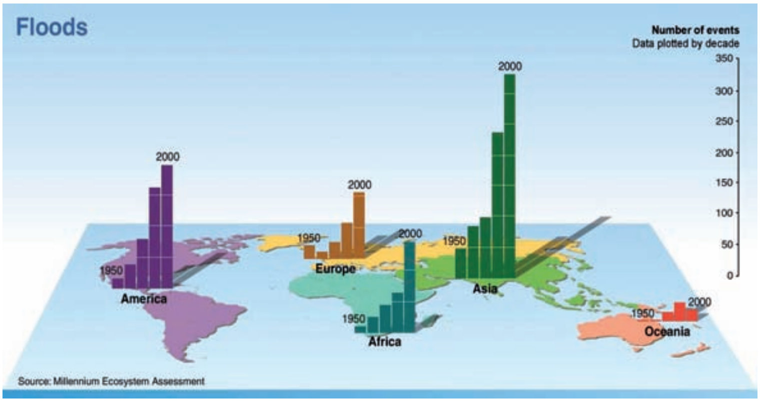


Figure 19. Number of floods per decade from the year 1950 to 2000.

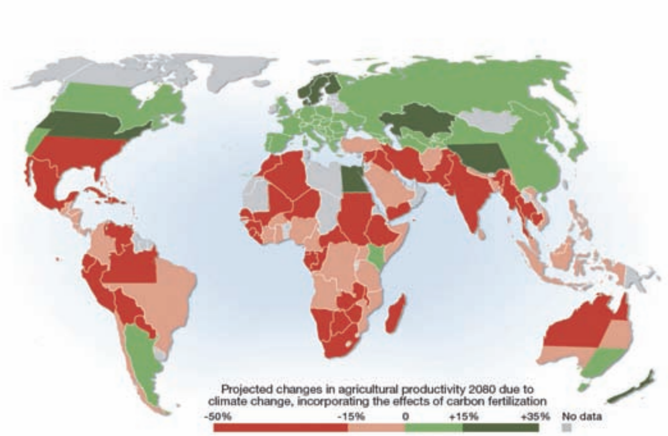
6.3 Less food

It has been projected that by 2080, the 40 poorest countries, located predominantly in tropical Africa and Latin America, could lose between 10 and 20 percent of their grain growing capacity due to drought (Kotschi 2007). The biggest problem for food security will be the predicted increase in extreme weather events, such as droughts and floods (Morton 2007).

By 2025, 1.8 billion people will live in countries or regions with absolute water scarcity. By then, if current trends continue unabated, sub-Saharan Africa will have lost seventy five million hectares of land currently used for rain fed agriculture. This in turn will lead to a decline in domestic agricultural production of up to 8% in sub-Saharan Africa. A similar pattern is predicted in Asia where agricultural production is predicted to fall by 4% Asia. This in turn will increase demand for irrigation (by a predicted 5% to 20% worldwide), making further demands on an already scarce natural resource and perpetuating a cycle.

These pressures, which are leading to a rapid increase in water use and biodiversity loss, need to be addressed. Governments should realise that many types of developments are limited by water availability. This is particularly true of the use and production of biofuels, the shift in our diets towards animal proteins and the expansion of hydropower for our energy needs. Through guiding economical development, it is possible to arrive at more sustainable solutions that are less likely to have a negative influence on those with vulnerable livelihoods.

Figure 20. Changes in agricultural productivity in 2080 due to climate change.



7 How to overcome the crisis

Many ecosystems that play a key role in meeting our water security needs and maintaining biodiversity have already been damaged. But experience also shows that these ecosystems can be restored, often profitably, as shown by many of the demonstration projects of Wetlands International (see www.wetlands.org).

Young fisherman at the Mahakam river, East Kalimantan, Indonesia with his latest catch, an Ikan Toman or Giant Snakehead (*Channa micropeltes*). By Nyoman Suryadiputra.

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Mission:

To sustain and restore wetlands, their resources and biodiversity for future generations.

Biodiversity loss and the emerging water crisis go hand in hand. Both are the result of the same root causes and each problem reinforces the other. The stress from sectors that are increasingly using fresh water and wetlands, combined with climate change and ecosystem loss provide a grim outlook.

70% of the Earth's surface is water. However, only 0.3% of all global water is fresh surface water.

In terms of area, less than 2% of the world's surface consists of lakes, marshes, rivers or other freshwater wetlands.

An estimated 126,000 described species rely directly on freshwater habitats.

Only the preservation of water rich areas and healthy water flows ensures the survival of thousands of species.

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