EARTHWATCH INSTITUTE

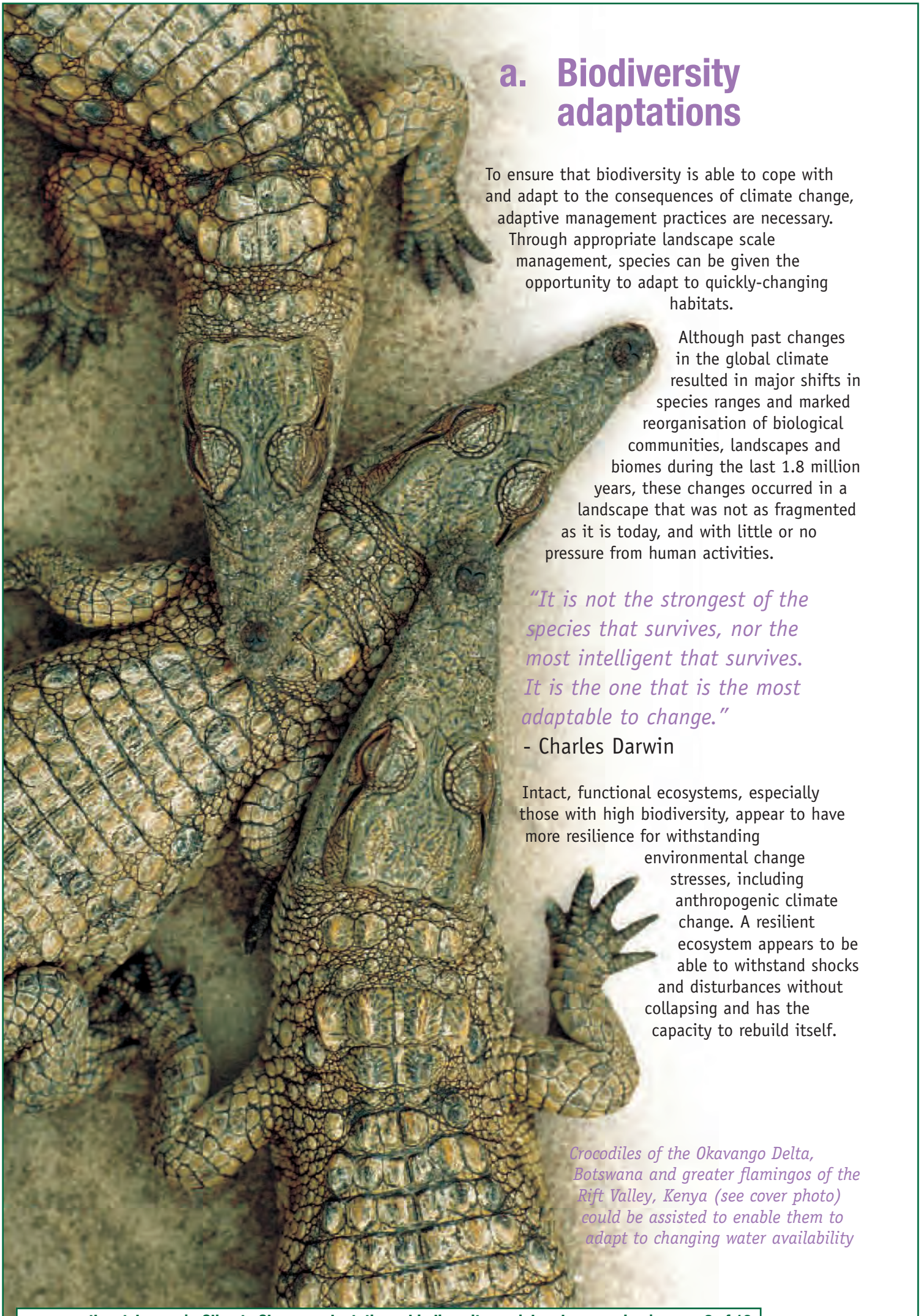
CLIMATE CHANGE:

adaptation – biodiversity, social and economic

Adaptation is increasing resilience to, and reducing vulnerability to climate change by taking pro-active action. This section discusses how adaptation can build the capacity of biodiversity, society and economics to deal with the impacts of climate change.

This section explores:

a. Biodiversity adaptations
b. Social and economic adaptations
c. Combining mitigation and adaptation – conclusion



a. Biodiversity adaptations

To ensure that biodiversity is able to cope with and adapt to the consequences of climate change, adaptive management practices are necessary. Through appropriate landscape scale management, species can be given the opportunity to adapt to quickly-changing habitats.

Although past changes in the global climate resulted in major shifts in species ranges and marked reorganisation of biological communities, landscapes and biomes during the last 1.8 million years, these changes occurred in a landscape that was not as fragmented as it is today, and with little or no pressure from human activities.

"It is not the strongest of the species that survives, nor the most intelligent that survives. It is the one that is the most adaptable to change."

- Charles Darwin

Intact, functional ecosystems, especially those with high biodiversity, appear to have more resilience for withstanding environmental change stresses, including anthropogenic climate change. A resilient ecosystem appears to be able to withstand shocks and disturbances without collapsing and has the capacity to rebuild itself.

Crocodiles of the Okavango Delta, Botswana and greater flamingos of the Rift Valley, Kenya (see cover photo) could be assisted to enable them to adapt to changing water availability

How can habitat management increase the resilience of ecosystems to climate change?

Habitat management is practised in many countries where ecosystems have undergone change from their natural state. Leaving nature to itself is not the approach taken by most conservation organisations (especially in the UK, where we have altered natural ecosystems over thousands of years). Biodiversity and habitats are actively managed for particular objectives, such as for rare and endangered species. Management action and decisions should be based on ecological knowledge, and include creating, restoring and managing habitats of importance for biodiversity.

The UK Biodiversity Action Plan (BAP) describes the UK's biological resources and commits a detailed plan for the protection of these resources. The BAP is the UK Government's response to Agenda 21 of the Convention on Biological Diversity which commits signatories to develop plans to conserve their natural resources.

© Emily Cantrell

Land use practices have altered natural ecosystems, so that active management is needed to maintain these habitats. Earthwatch scientists have determined habitat management strategies to restore rainforests in Vietnam

1. Protecting adequate and appropriate areas

In managing the protection of critical ecosystems it will become even more important to work at a larger, landscape scale to build in buffer zones, corridors and stepping stones to aid species migration and conserve meta-populations. Priority should be given to safeguard and manage areas which act as climatic refuges (i.e. where climate is less evident in changing the ecosystem); where there are bounded distributions such as mountain tops, low-lying

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Patches of rainforest being encroached by farmland in Queensland, Australia. Corridors between forest patches may help species adapt to spatial changes in temperature

islands, high latitudes and continental edges (i.e. where climate change effects may be more evident as there is nowhere for the species to move beyond its present habitat/site); and to provide the space for conserving the range and ecological variability of habitats and species within a broad climatic zone, and allowing space for natural geo-morphological processes to continue - particularly for river systems and coasts.

2. Understanding and controlling non-climate change stresses

Global environmental impacts such as habitat destruction, invasive non-native species, pollution and over-exploitation are already stressing ecosystems, but climate change adds another level of stress. These stressors can act synergistically. For example, rising temperatures have resulted in an epidemic of chytrid fungus infection in tropical frogs, contributing to a global decline of frogs. Many other anthropogenic impacts are more easily controllable locally than climate change effects. Where such impacts are evident, then active intervention might be appropriate to change the ecosystem.

3. Implementing adaptive management and monitoring

Although we know something about current impacts on biodiversity (see section 2), future impacts are less predictable. Even though computer-generated climate models that predict how the climate will change and how species and ecosystems will be affected by this change are becoming ever more

powerful (with the ability to incorporate multiple variables and generate various future climate scenarios and responses), predicting future climate change remains an uncertain science. Therefore, adaptive management must allow for flexibility and be open to change.

Adaptive management should also operate on the landscape scale, incorporating features such as buffer zones to provide as much connectivity as possible, to give species the most chance of adapting to uncertain changes in climate.

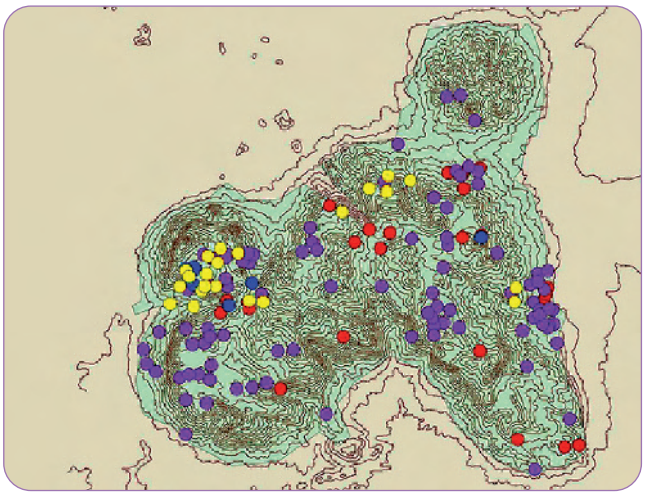
Adaptive management is experimental and should be monitored closely so that the management can be modified as appropriate. Such active intervention might include:-

- assisted migration (i.e. species translocation and reintroduction);
- control of pests and diseases;
- control of invasive non-native species;
- fire management;
- limiting nutrient enhancement;
- utilising *ex-situ* conservation through seed banks, botanic gardens, aquaria and zoos where extinction is threatened;
- breeding new plant species and crops which are more tolerant to changed climate conditions;
- increasing the adaptive capacity of natural systems by reducing other environmental stresses.

Some species may be less able to adapt to climate change than others. For example:

- species that have bounded distributions (they occur only on mountain tops, high latitudes, low-lying islands);
- those with restricted ranges;
- those with poor dispersal capability;
- those that have barriers to dispersal;
- those that have specific attributes (slow moving, slow growing, flightlessness);
- those which are susceptible to extreme temperatures, droughts, snowfall, winter temperatures, sea surface temperatures, sea level rises or floods;
- those with extreme habitat/niche specialisation such as a narrow tolerance to climate-sensitive variables;
- those with close, co-evolved, or synchronous relationships with other species;
- those with inflexible physiological responses to climatic variables.

"There are significant opportunities for mitigating climate change, and for adapting to climate change, while enhancing the conservation of biodiversity." - Convention on Biological Diversity website.



A digital image of the location of forest fires on Mount Mulanje, Malawi between 2002 and 2005. NASA satellites alert forest rangers to the occurrence of fires on the mountain in real time. The rangers are then able to put the fires out. Increased fire management such as this will help ecosystems cope with climate change.

Further research for students

- **The UK Biodiversity Action Plan:** (http://www.ukbap.org.uk/)
- **IUCN (The World Conservation Union) has produced a document about climate change adaptation:** http://www.iucn.org/themes/climate/docs/climateandnature.pdf
- **Environmental Change Institute at Oxford University Adaptation programme:** http://www.eci.ox.ac.uk/research/climate/adaptation.php
- **BRANCH (Biodiversity Requires Adaptations in North West Europe under a Changing Climate) project at the University of Oxford:** http://www.eci.ox.ac.uk/research/biodiversity/branch.php http://www.branchproject.org.uk/

A frog (of the family Microhylidae) found in the rainforests of Queensland, Australia

Earthwatch case study: Adaptation to climate change in the rainforests of Australia

The tropical rainforests in the Australian Wet Tropics bioregion are listed as a World Heritage Area (WHA) in recognition of the global importance of the incredible biodiversity of the region. With many endemic species, this diverse region is typical of tropical mountain ecosystems worldwide. Although this ecosystem is now well protected within the WHA, it is severely threatened by climate change.

What is likely to happen with increasing climate change?

Predicted warming for coastal north east Queensland is 1.4 to 5.8°C by 2100, relative to 1990. Simulations show that humidity will shift upwards on tropical mountains by hundreds of metres during the winter dry season and that cloud forests are particularly likely to display climate change effects in the very near future.

Due to this rapid climate change, the biodiversity and regionally endemic species will be under severe threat over the next few decades. Additionally, ecosystem processes and the provision of ecosystem services could be severely impacted by climate change.

Predictive analyses demonstrate a great sensitivity of rainforest vertebrates to an increase in temperature. The area of core habitat available to individual species decreases rapidly with increasing temperature, drastically amplifying extinction rates and reducing overall biodiversity in the region.

Species distribution models suggest that an increase of 3°C may result in nearly 50% of the endemic species going extinct and the surviving species experiencing dramatic declines in distribution area. On average, surviving species will be left with about 11% of their current core distribution area.

What is the Earthwatch project investigating?

Earthwatch scientists on *'Climate Change in the Rainforest'* are collecting data on the abundance and distribution of selected vertebrate, invertebrate and plant groups over the altitudinal and latitudinal gradients most likely to be affected by climate change. They then produce accurate, robust models (Geographical Information Systems maps) explaining spatial patterns of distribution and abundance of all the Wet Tropics rainforest vertebrates and many species of insects and plants. This allows them to predict the impact of climate change on individual species and determine adaptive management to assist the species survival.

What techniques do the scientists use to collect data?

The scientists sample birds, reptiles, arboreal mammals, microhylid frogs, epiphytic plants, mosses, leaf litter invertebrates and a suite of environmental and habitat features to gain an understanding of how climate change is affecting these taxa. Sampling sites are located at 200m altitudinal intervals, as it is believed that changes in abundance and distribution will be most apparent on an altitudinal gradient.

What adaptive management strategies will result from the research?

The results of this project may make it possible to alleviate the effects of climate change by defining refugial areas, creating corridors of connectivity between present distributions and future refuges and prioritising species and areas on the basis of range stability and resilience to the effects of global warming.

Most conservation management is aimed at the preservation and protection of selected conservation areas. This, however, is a static strategy. It does not allow for a changing world. The Wet Tropics World Heritage Area is very well protected, but it is still severely threatened by a changing global climate. If this unique area is to be conserved, future impacts of these changes need to be predicted and management policies that will attempt to minimise these impacts in a changing climate need to be designed.

These concerns apply equally to rainforests in south-east Asia, Africa and South America.

Further research

- **Climate change and rainforests in Australia article:** http://www.newswise.com/articles/view/522193/
- **The Wet Tropics World Heritage property: description and map:** http://www.deh.gov.au/heritage/worldheritage/sites/wettropics/

Statistical tasks for students

1. **Click here** for three sets of example data from the Earthwatch project *'Climate Change in the Rainforest'*.
2. Analyse the data using graphs or charts and relevant methods of statistical analysis.
3. Summarise the reasons for concerns about the impacts of present-day climate change on rainforests generally and in Queensland in particular.

b. Social and economic adaptations

Managing and adapting to future climate changes will be critical for the welfare of humans and non-humans globally. This adaptation may take the form of advising businesses of future impacts, or of exploring the current adaptation of societies or ecological communities determining how and why some societies or communities adapt to changes more readily than others. Critical issues focus on questions of water, food and energy at local, national and international scales. Successful adaptation will depend on climate scientists and social scientists working together to implement wide-ranging solutions that build our capacity to adapt to future climate change.

Social adaptations

People have always adapted to variations in their climate by making preparations based on their resources and knowledge accumulated through experience of past weather patterns. Periodically, they have also been forced to react to and recover from climate extremes and surprises such as floods, droughts and hurricanes. The majority of the world's scientists agree that the Earth's climate is changing. This means communities' past experience alone can no longer provide a reliable guide to the future. Accordingly, securing economic and social well-being of vulnerable people will increasingly require communities, scientists and policy-makers to work together to consider the implications of a changing climate. For example, the 1992 United Nations Framework Convention on Climate Change (UNFCCC) contains provisions mandating all countries to take action to prepare for the potential impacts of climate change (as well as mitigation action - see section 4).

Developing countries and adaptation

The ability of communities to adapt to climate change is determined by their level of development, their access to resources and their scientific and technical capacity. The impacts of climate variability create challenges for the world's poorest communities as their livelihoods are likely to be more sensitive to climate change (since they have a greater immediate dependence on natural resources).

Development efforts, focused on poverty reduction and securing sustainable livelihoods, have provided an important means to reduce vulnerability to climate change, but have tended to neglect the impact of climate extremes and surprises. In these situations, where coping capacities have been exceeded, humanitarian aid has been the dominant response. However, because the potential risks associated with ignoring climate change are so pervasive, addressing current and future climate vulnerabilities and incorporating adaptation into development is an urgent task.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Education can help communities in developing countries to adapt to climate change

Adaptation can adopt a variety of forms, such as better education, training and awareness of climate change, and more technical measures like drought-resistant seeds, better coastal protection and improved irrigation systems. For many communities, the direction of climate change remains uncertain, so focus is also placed on increasing their adaptive capacity in relation to key sectors such as agriculture and health. To lessen the impact of climate change on a country's development, people are working to integrate adaptation into mainstream development policies.

Earthwatch case study: Water and Community Health

In the Samburu region of Kenya, Earthwatch scientists are studying water resources used by local communities and wildlife. Water can be considered the single most critical resource in this semi-arid region. Annual mean rainfall is only between 250mm and 500mm (most parts of the UK receive an average of 100mm per month). The only permanent river in the region is the Uaso Nyiro and numerous ephemeral lakes and natural ponds contain water only during the wet seasons (March to May and October to December). Man-made dams for harvesting rainwater augment the water resources available for domestic, livestock and wildlife use. Depending on the severity of the dry season, these sources of water will dry up as the season progresses. Due to water scarcity, only 8% of the district is considered to be of high to medium potential in terms of agricultural sustainability.

Most of the inhabitants of the area are Samburu pastoralists who rely on cattle, sheep, goats and camels for their livelihoods. The diversification in domestic animals allows the Samburu to take


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Maasai children in the Samburu with their livestock at a waterhole

advantage of both grazing and browsing opportunities. Herds are typically moved to where there is good pasture (reliant on water). Most of the movement takes place between wet and dry season grazing areas. Wildlife migration follows a similar pattern. During the wet seasons when water availability is not as limited, animals tend to be dispersed. With the onset of the dry season, animals tend to migrate to areas with adequate forage and water.

Competition between humans and wildlife for water resources intensifies as the wet season ends. As the standing bodies of water start to dry, there will be a corresponding change in water quality - the concentration of dissolved solutes will increase. Such conditions, coupled with high temperatures, favour the development of cyanobacteria. Some members of this taxon produce toxins (hepatotoxins and neurotoxins) that can be fatal to livestock, wildlife and humans.

© Carly Seller

Earthwatch is studying the conflict between zebras (Equus sp.) and local communities surrounding water resources in the Samburu, Kenya

Climate change is likely to extend periods of drought and make them more frequent, putting more stress on water resources and increasing competition between humans and wildlife.

Earthwatch scientists are studying the temporal and spatial distribution of water resources in the Samburu region, with emphasis on water quantity and quality, and human use and potential for conflict with wildlife. Determining the spatial and temporal distribution of water resources and the quality of the water will allow for future water resource management. Data on water and other natural resources are incorporated into a comprehensive Geographic Information Systems (GIS) database. Maps are created from this data which will be shared with local communities to inform adaptive management plans for settlement, grazing and conservation lands. This important outcome is consistent with U.N. Millennium Development Goals, especially Goal 7, which includes ensuring sustainable access to improved water sources.

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Scientists collecting water samples from a community water hole in the Samburu, Kenya

Economic adaptation

Effective adaptation will reduce the costs of some of the impacts of climate change (such as the costs of extreme weather events like heat waves, storms and floods). Examples of adaptive measures to prepare businesses, industries and infrastructure are described below:

- There may be some positive economic gains from climate change if adaptive measures are put in place. For example, agriculture can be adapted to changing growing conditions (new crops and wine could be produced in northern latitudes), while some areas could develop their tourism industry as climates warm.
- Infrastructure is vulnerable to flooding and storms that are predicted to increase with time. Climate change may cost the UK £10 to £30 million a year in flood damage over the next 80 years (Stern Review: Economics of Climate Change). Venice is already feeling the effects of climate change with damage to historical buildings. St Mark's Square in the city will suffer daily floods by the end of this century. Italy has developed plans for flood gates to separate the city from the sea when floods occur.
- Water shortages should also be addressed by improved water use efficiency, planning for alternative water sources, such as treated wastewater, and making changes to water allocation and pricing to combat water shortages.
- The insurance industry has a key part to play in encouraging society and the economy to adapt to climate change. By accurately putting a price on the risks associated with climate change, businesses, governments and individuals will be forced to introduce adaptive measures to reduce these costs to themselves.

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An Earthwatch scientist measuring the quality of water samples from the Samburu, Kenya

© Sharon Williams

A water storage container in the Samburu, Kenya, which will help communities cope with water shortages that are predicted to increase with climate change

c. Combining mitigation and adaptation - conclusion

Since climate change is unavoidable, mitigation efforts alone will not reduce the multiple impacts outlined in sections 2 and 3. Current CO_2 increases have committed the Earth to increased temperatures and changing weather patterns, which means that adaptation is also needed to build the capacity of humanity and biodiversity to cope with current and future changes. Changes to the way we each live, as well as effective and equitable international collective action, are required to lessen the impacts of climate change now and into the future. By improving understanding of the issues to guide action and decision-making, developing and investing in technologies to both mitigate and adapt to climate change, increasing the resilience and reducing the vulnerability of people and ecosystems most at risk, creating effective mitigation and adaptation policies, and engaging the entire global population to encourage action, will all contribute to an Earth that is better able to cope with climate change.

- Just as adjustments to urban environments can increase energy efficiency and mitigate climate change, adjustments can also be made to infrastructure and buildings to adapt to the predicted effects of climate change. Buildings can be made more resilient to floods and hurricanes, for example.
- Land use planning is another area in which adaptive measures taken now can reduce future financial costs. For example, the UK government outlined plans to build 200,000 new homes by 2016 to reduce pressure on the existing housing stock. However, most of the areas earmarked for new housing developments are flood risk areas. Building houses outside of flood plains will reduce the flood damage costs from new houses by 50% (Association of British Insurers).

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The survival of blue and yellow macaws (Ara ararauna) in the Amazon (see previous page) and cheetahs in Namibia could rely on effective climate change mitigation and adaptation measures

Further research for students

- **Agricultural adaptations:** http://www.gcrio.org/CONSEQUENCES/summer95/agriculture.html
- **Stern Review: The Economics of Climate Change - adaptations:** http://www.hm-treasury.gov.uk/media/8A8/40/Chapter_19_Adaptation_in_the_developed_world.pdf
- **Excellent website on social, economic and technological adaptation:** http://www.eldis.org/climate/adaptation/introduction/index.htm
- **Technological adaptations to flooding in India article:** http://news.bbc.co.uk/2/hi/south_asia/6401353.stm
- **Technologies for adapting to the impacts of climate change:** http://www.rtcc.org/2007/html/dev_adaptation_unfccc.html
- **Information about industry adaptations:** http://www.tyndall.ac.uk/research/theme3/theme3_project_list.shtml
- **Adaptation:** http://www.iied.org/CC/index.html
- **Combining mitigation and adaptation measures:** http://www.iied.org/CC/documents/JessicaAyersworkingpaper.pdf

For discussion

- Summarise how adaptive management of biodiversity can increase resilience and reduce vulnerability to climate change.
- Examine the potential for adaptation to climate change in developed and developing countries.
- Discuss the importance of combining mitigation and adaptation measures to increase resilience and reduce vulnerability to climate change.

Earthwatch is an international environmental organisation which promotes the understanding and action necessary for a sustainable environment.

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