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A warmer world
will be a sicker
world, p.13

A World of **SCIENCE**

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De-carbonizing development

The inconvenient truth about the impact of climate change is sinking into the public consciousness. As Andrew Dobson argues in this issue, a warmer world will be a sicker world, as vectors of disease extend their geographical ranges. If rising temperatures will be a boon for pathogens, they will wreak havoc among harmless and useful plant and animal species: even a rise of 1°C in Australia – a very plausible scenario – will drive the Mountain Pygmy Possum (*Burramys parvus*) of the Blue Mountains to extinction, as a case study in this issue reveals.

With the growing awareness of the threats posed to biodiversity by climate change has come the realization that it will be a daunting task to reduce the rate of biodiversity loss by 2010, the target fixed by the Parties to the Convention on Biological Diversity in April 2002. UNESCO will be hosting the twelfth meeting of the Subsidiary Body on Scientific, Technical and Technological Advice to the Convention from 2 to 6 July in Paris, which will assess the global community's progress thus far in attaining this target. Early indications are that biodiversity loss is actually accelerating.

But is all climate change-related news bad? Maybe not. On World Environment Day on 5 June, UNDP and the banking and insurance giant Fortis announced, just days before the G8 Summit in Germany, a 'carbon finance' partnership. Under this scheme, UNDP will help developing countries to conceive projects that reduce their greenhouse gas emissions while generating real, sustainable benefits for the environment and broader human development; UNDP will ensure that these projects meet the Kyoto Protocol's agreed standards. Fortis will then trade in the emissions-reduction credits generated by these UNDP projects. The proceeds from Fortis' trading in emission credits are expected to flow back to developing countries and communities to finance much-needed investment in sustainable development.

Can partnerships like that forged by UNDP and Fortis turn back the clock? Most unlikely. Can they help communities mitigate and adapt to climate change? Most likely. The climate change threat is creating hitherto unimaginable opportunities for cooperation between environmental and financial stakeholders. Current trends in cooperation are opening up new ways of bundling finance for carbon sequestration, human development and sustainable biodiversity use that can be mutually beneficial.

UNESCO's 507 biosphere reserves in 102 countries can be learning laboratories for innovative partnerships like these. Just last May for instance, UNESCO's Man and the Biosphere Programme signed an agreement with the Star Alliance, a consortium of 20 airline companies, to bring UNESCO projects for biosphere reserves combining global determination to mitigate and adapt to climate change with the need to reduce biodiversity loss and promote sustainability to the attention of the many potential partners who are also frequent flyers.

W. Erdelen
Assistant Director-General for Natural Sciences

Watchdogs of the public interest



Young street vendor of newspapers in Costa Rica

© UNESCO/R. Dominique

Talk to science journalists from Africa, Asia or Latin America and they will all tell you that the path to effective science reporting is a rocky one. A Zambian journalist, for example, complains that little information circulates on locally conducted research owing to the lack of contact between scientists and reporters. Another journalist in China bemoans the low priority accorded to media relations, most science-related policy decisions being made behind closed doors. A Brazilian journalist struggles to unearth news in her country, where few research centres have press offices to publicize their findings. Such grievances are widely shared. Notwithstanding this, there are several reasons to be optimistic about the future of science journalism in the developing world. The first to welcome this news should be the general public and the public authorities in the countries concerned; for science journalists are defenders not only of the public interest but also of effective governance, as political decisions made on the basis of wrong or distorted information will almost inevitably be bad ones.

One reason for optimism about the future of science journalism in the developing world is that professional organizations like the World Federation of Science Journalists (WFSJ) have been highlighting the needs of developing countries as one of their top priorities. Such needs figured prominently, for example, at the federation's biennial global conference in Melbourne, Australia last April.

Secondly, international aid agencies acknowledge the extent to which a robust science journalism community is essential to the success of their programmes and in particular to bridging the gap between knowledge and practice. This includes not only bilateral agencies like the Swedish International Development Cooperation Agency or Britain's Department for International Development but also international agencies like UNESCO (*see the example of the Pacific*).

Last, but by no means least, has been the growing interest within developing countries themselves in the need for robust science journalism. Across the world, young journalists who are seeking to make an impact with their writing – which can include science graduates who are turning to journalism in order to put their knowledge to good purpose – are actively seeking ways to put their commitment into effect.

An obstacle course

There are many obstacles in journalists' way. One is a lack of demand for their services, particularly from the owners of private media houses who have instructed their editors to base the criteria for selecting news stories on what sells newspapers and thus advertising space (*see the example of China, overleaf*). In some cases, this can create a reluctance to publish stories seen as 'too gloomy' – a category into which many poverty-related stories such as increases in infectious diseases inevitably fall – and to give preference to the antics of international soccer stars.

Another obstacle is simply a lack of training, either in background scientific knowledge or in journalistic skills. Various efforts are being made to combat this. The online Science and Development Network that I direct, for example, is currently working with the WFSJ to prepare a set of on-line science journalism training modules to develop key skills. But there is still a long way to go before professional levels of science journalism in many parts of the developing world approach anything like what is required.

Lastly, there is the attitude of scientists themselves. In the developed world, most scientists have now accepted that being open to inquiries from journalists is part of their professional responsibility. In the developing world, however, this awareness remains elusive and journalists face a major task in persuading scientific institutions that they should open up.



© Tsanganyi Mukwazhi/UNESCO

Geoffrey Nyarota, Editor-in-Chief of Zimbabwe's only independent daily newspaper, the Daily News, was awarded the annual UNESCO/Guillermo Cano World Press Freedom Prize for 2002. This year's prize went to Anna Politkovskaya, a columnist for the Novaya Gazeta newspaper and outspoken campaigner for human rights who was killed in the entrance to her home in Moscow (Russia) on 7 October 2006

Fostering science communication in the Pacific

Many of the challenges science communicators face around the world are exacerbated in the South Pacific, a region of small island states with highly dispersed and frequently isolated communities. One major challenge is the shortage of skilled science communicators and journalists, compounded by a steady brain drain from the small island states to their larger neighbours such as New Zealand, Australia and the USA.

The benefits of science are not always apparent to the majority of Pacific islanders living a near-subsistence lifestyle. This fuels – and is fuelled by – perceptions that science is difficult, irrelevant and not for them. At the national level, limited resources and dependence on external aid further restrict involvement and engagement with science and its products. At the regional level, strategic oversight and planning in relation to science and technology policy are limited.

Since 2000, UNESCO's Apia Office and the Centre for Public Awareness of Science at the Australian National University (ANU-CPAS) have been tackling this problem. They have been fostering science communication in the South Pacific in three ways.

To foster public communication of science, they have run workshops for Pacific-based journalists to enhance their science reporting skills, in Canberra (Australia) in 2000 and in Apia (Samoa) in 2001 and 2002 (see photo).

To foster science education, they have run creative science teaching workshops for Pacific-based primary and secondary school science teachers in their home countries, using locally available materials and equipment. These took place in Apia in 2001 and in Suva (Fiji) in 2005. Further workshops are planned for Tonga later this year and for next year.

To foster online networking, they have designed and implemented pilot projects such as the Register of Pacific Scientists, online since 2005 and available at pacificscience.net, and the Pacific Science Exchange.

UNESCO Apia and ANU-CPAS are currently developing the Pacific Science Network (PacSciNet). This will serve as a web-based focal point for information, activities, news and success stories relating to science and its application in the Pacific, building upon the experiences of the pilot activities above. PacSciNet will also support and promote field-based activities through which scientists and communities work together to tackle energy issues and enhance community resilience to such challenges as climate change, saltwater intrusion in soil and freshwater, and natural disasters. It is hoped that PacSciNet will go online by the end of the year but funding is still being sought to make this possible.

For details (in Apia): h.thulstrup@unesco.org; www.pacificscience.net



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A public space for assessing developments

In the modern world, science journalism has a double function. On the one hand, it is the public's main source of information about inventions and discoveries that will affect our lives; it feeds the public appetite for information.

At the same time, science journalism provides a public space within which the impact of these developments – including the response of governments – can be assessed and debated, a lesson that environmental groups, with their media-attracting activities and professionally staffed public relations offices, have been quick to master.

This second role is becoming increasingly important. Within the developed world, much of this role has focused on the side-effects of rapid technological development and economic growth, the fruits of which are already being widely enjoyed. Such is the case with reporting on climate change, for example, where debate focuses on issues ranging from new energy technologies that can reduce the consumption of fossil fuels to government policies that can cut carbon emissions without reducing living standards.

In the developing world, the stakes are much higher. Here, the challenge is to find ways of using developments in science and technology to raise living standards to a level that is even minimally acceptable. At the same time, it is important to ensure that this is done in a manner that is socially, ethically and environmentally acceptable. To put it more sharply, science journalism has a key role to play in achieving the goals of sustainable development.

Better information for better decision-making

This task has several components. The first, as indicated above, is to bring to the attention of both the public and decision-makers within the developing world the scientific and technological achievements that make development possible. None of the Millennium Development Goals, whether reducing child mortality or promoting food security, can be achieved without the use of science and technology, and the capacity within developing countries to utilize both effectively.

The science journalist's second role involves paying attention to the social and political mechanisms needed to



Science reporting under threat in China

Hepeng Jia, *SciDev.Net*,
17 January 2007

Leading Chinese journalists have called for dedicated science coverage, as their field is increasingly marginalized by market-oriented media reforms. The Chinese Society of Science and Technology Journalism (CSSTJ) intends to petition China's official media watchdog, the Central Publicity Department (CPD) about the situation.

Speaking at a CSSTJ seminar in Beijing on 12 January, Li Bin, a senior science journalist at China's state Xinhua news agency, appealed for 'minimum science reporting amounts for mass media.' Xu Xiuhua, science editor of *The People's Daily Online* called for 20% of all media coverage – equivalent to science's contribution to the Chinese economy – for science reporting.

Late last year, the CPD and the China Association for Science and Technology encouraged media to report more science. But a study conducted by Wang Xuefeng, deputy editor-in-chief of Beijing newspaper *The First*, revealed increased marginalization instead. Based on 14 national and local newspapers in Beijing over six months, science accounted for just 3% of articles.

Wang said science stories were small and many articles praised individual scientists or institutions rather than the science itself. He singled out official media, often subsidized by the government, for replacing their science columns with advertising-friendly automobile or property pages. *The People's Daily* replaced its science page with culture reporting in 2005. *China Daily* has also revoked its weekly science and health pages, despite growing from 16 to 24 pages in 2007.

Cai Wanlin, a senior science reporter at China National Radio, said official media, with less pressure to earn a profit, should shoulder the responsibility of popularizing science.

ensure that development is properly sustainable. In some cases, such mechanisms will focus on preserving assets – such as clean air and water – that are essential to future generations. In other cases, they may focus on an appropriate technology policy, such as funding research into biofuels and other sources of clean energy, or on building the basic capacity in science and technology that will allow the Millennium Development Goals to be achieved by developing countries themselves.

In each case, effective science journalism needs to be based on a commitment to the idea that better information leads to better decision-making and, conversely, that political decisions made on the basis of wrong or distorted information are almost inevitably bad decisions.

To fulfil this function, journalists need to provide the facts that empower individuals to engage responsibly in social dialogue. Substantial and effective debate only takes place when those on both sides of an issue have a sound understanding of the relevant factual evidence; indeed, evidence-based decision-making is an ideal that should be aspired to at every level of society, from local communities to the top levels of government.

Trust and respect cannot be taken for granted

In the past, major institutions, whether religious, scientific or educational, were usually taken as an adequate source of such evidence. And their trustworthiness was usually taken as sufficient to guarantee informed decisions.

This is no longer the case. In modern societies, trust and respect need to be earned; they cannot be taken for granted, whether in science or any other type of social activity. That requires a number of factors, including an openness to dialogue on the part of these institutions.

Those claiming to have access to trustworthy knowledge need to come out from behind closed walls, whether these belong to the ivory towers in which scientific knowledge has traditionally been produced, or the boardrooms and corridors of power in which key decisions about the production and application of this knowledge are made.

As the UK's Committee on the Public Understanding of Science (COPUS) put it when it decided to cease operations in December 2002, 'the top-down approach which COPUS currently exemplifies is no longer appropriate to the wider agenda that the science communication community is now addressing.'

Making sure people are well informed: the example of public health

The emerging alternative to the top-down approach is the concept of empowerment. Providing people with information about modern science and technology enables them to participate directly in political debates over how both should be used responsibly. Thus, even though journalists rarely engage directly in dialogue, they can promote and stimulate it through their reporting – and indeed eagerly report on it when it takes place. Conveying facts accurately and in an accessible manner is a powerful way for the journalist to assist in the empowerment process.

This comes with the responsibility of pointing out when the publicly stated positions of those on whom they report is not grounded in the current state of scientific knowledge, as many effectively did, for example, when South Africa's health minister, Manto Tshabalala-Msimang, suggested that a good treatment for HIV/AIDS was to eat garlic and beetroot.

The issue of bird flu provides another example of where the responsibility of good science journalism lies. With the threat that the H5N1 virus could spark a global pandemic of human flu that could cost million of lives, effectively communicating accurate information about the disease will be essential to efforts to contain it. Sound information must lie at the centre of containment

efforts and governments need an accurate picture of the disease and the way it spreads if they are to make sensible decisions about the allocation of the human and financial resources needed to combat it. But the public also needs to be well informed. Some of the reasons are purely practical. For example, it is important to know that cooking food properly appears to destroy the virus and that washing hands before preparing food also helps avoid infection. Both bits of knowledge, which can be easily communicated through articles in newspapers, can help restrict the spread of the diseases. At the same time, there are strong political

reasons for ensuring that information about the disease is reported accurately in the media. For example, politicians must be persuaded to take quick action when this is needed. But they must also not feel pressured into over-reacting for the sake of calming public panic, whether by allocating resources to ineffective measures or by aiming at the wrong targets (*see box overleaf*).

In all such circumstances, journalists must ensure the information they disseminate is as accurate as it can be. This does not mean that what they report has to be

Science gains exposure in the Brazilian popular press

Luisa Massarani, *SciDev.Net*, 28 March 2007

Science is a major topic in Brazilian newspapers aimed at low-income social classes, along with football and crime, according to a new study. Research released this week (26 March) analysed coverage in the newspapers *Extra*, which has one of the biggest circulations on Sundays in Brazil at 428 000 copies, and *O Dia*, which sells 238 000 copies on Sundays.

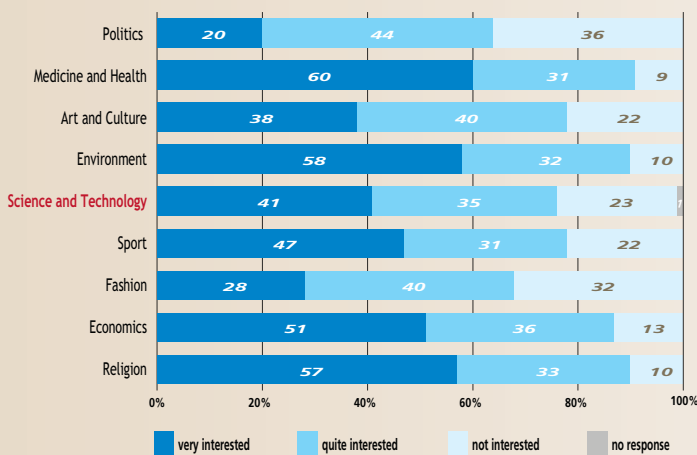
The research was conducted by science journalist Wagner Barbosa de Oliveira, who works for the Oswaldo Cruz Foundation, as part of his Masters thesis at the Federal University of Rio de Janeiro. He found that, during a six-month period between 2005 and 2006, science stories appeared on 74% of days analysed. Furthermore, 86% of these stories were published in highly visible areas, such as the top or middle of the page.

Journalists preferred to write about health issues, which represented 54% of the total. Only three in ten stories were related to research in Brazil. Oliveira praised their use of 'reliable' sources of information. 'A third of the stories explicitly mention universities and research centres as a source and peer-review journals, even in English, are mentioned as sources in 14% of cases,' he told *SciDev.Net*.

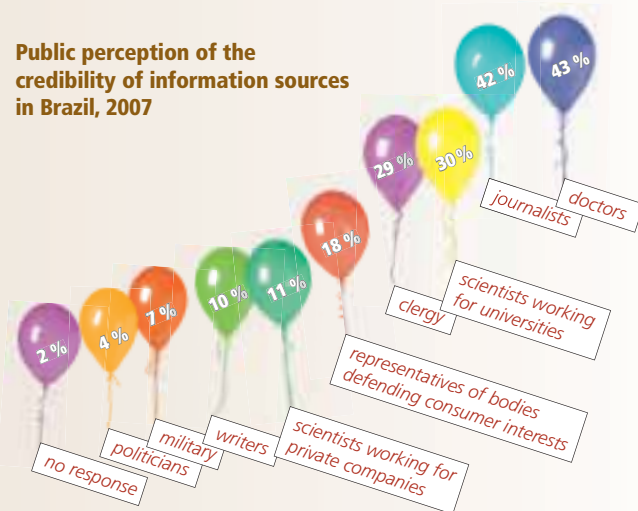
However, Oliveira criticized the extent to which science stories were sensationalized and also that science was presented as an established 'truth' — mirroring common practices in newspapers targeting more 'elite' audiences.

The study also shows that scientists do not write for newspapers aimed at the low-income classes. 'This is a sign of the low importance given to popular newspapers by scientists, which is a mistake in my opinion, since they are not considering that low-income classes are 80% of the country's population,' Oliveira said.

Public interest in science in Brazil, 2007



Public perception of the credibility of information sources in Brazil, 2007



Source of statistics: Public opinion survey published by the Brazilian Ministry of Science and Technology in April 2007: www.mct.gov.br/upd_blob/0013/13511.pdf

When the Brazilian technical commission on biosecurity approved the genetically modified (GM) corn seed LibertyLink on 16 May, most of the major national and regional newspapers picked up the story. These included *O Globo*, *Folha de São Paulo*, *Estado de São Paulo* and *Correio Braziliense*. Produced by the German company Bayer CropScience, LibertyLink corn is tolerant to a pesticide containing glufosinate ammonium, used to kill harmful grasses. Marina Ramalho reported for *SciDev.net* on 23 May that LibertyLink corn was the third GM seed to be authorized for planting and commercialization in Brazil, following Monsanto's Roundup Ready soybean (2004) and Bollgard cotton, resistant to insects (2005); 11 other GM seeds are currently awaiting the biosecurity commission's approval. Brazilians follow the transgenic seed debate avidly in their country, both from a biosecurity angle and an economic angle. This appetite for information extends to science and technology in general, according to a recent public opinion survey (see graphics above) which also reveals that Brazilians perceive journalists as being more reliable sources of information than either scientists or members of the clergy!



Africa's bird flu preparations must involve the media

Tom Egwang, Chief Executive Officer, Uganda Media for Health
Julie Clayton, consultant, SciDev.Net
8 February 2007

Avian flu has hit international news headlines again. Nigeria has reported the first human death in sub-Saharan Africa [Ed: confirmed by the government on 31 January 2007], the United Kingdom is going through its first outbreak among poultry and, in Southeast Asia, avian flu continues to simmer, with ongoing outbreaks and human deaths. The agent responsible – the H5N1 influenza virus – could spark a pandemic to rival those of the last century that killed millions of people.¹

Africa is where Southeast Asia was three to four years ago. Outbreaks of avian flu in poultry are repeatedly reported in Nigeria and Egypt. Other outbreaks in Niger, Cameroon and Djibouti have fortunately been contained but neighbouring countries like Togo, Ghana and Chad are still at high risk.

Until recently, the African media has been ill-prepared to report effectively on outbreaks of avian flu. The first African H5N1 outbreak, among poultry in Nigeria last year, led to sensational media headlines causing public alarm and panic.

Like any soldier going into battle, the media needs to be fully briefed about the enemy to take part in a well-coordinated assault. This means not simply reporting about deaths and outbreaks but being more proactive with up-to-date information on, for example, stories about how other countries have dealt with similar outbreaks.

It is not just about relaying information but also influencing governments. 'Media stories are usually followed by policy decisions,' said William Mbabazi from WHO, at a media-training workshop held in Kampala, Uganda, in January this year. Organized by Uganda Media for Health, the workshop aimed to familiarize journalists from across Africa with the threat of avian flu, broaden their understanding and provide useful information. It was a starting point for new lines of communication between the media, health and veterinary experts and government officials. This and a similar workshop in Nigeria have resulted in a new determination among African journalists and editors to produce more and better-quality avian flu coverage.

Similar efforts are underway elsewhere. In Nigeria, a new government communications strategy is encouraging better links between health officials and the media. The initiative has enrolled community leaders and town criers, according to Marcus Amanzi, a Nigerian news editor.

The Ugandan government plans to involve the media in a forthcoming simulation exercise, as part of its national pandemic preparedness plan. This will include the real slaughter of poultry on a farm. But unless the media are fully engaged beforehand, the exercise could lead to confused reporting and spark panic among the public. In Ethiopia and Mauritius, for example, a lack of coordination with national journalists during similar drills led to a misinformed public that stopped buying chickens despite the absence of a real outbreak. On the other hand, in Kenya and Egypt, where the media were more involved and the public better informed as a result, simulation outbreaks and control operations have proceeded far more smoothly.



'scientifically proven'; sometimes that may be technically impossible. But it should be consistent with what is either known and proven, or is considered by those scientists most familiar with the field in question to be likely, as is the case with the scientific consensus that human activity is the most likely cause of global warming.

Such arguments are applicable across the world. However, they are particularly important in the developing world, where the relatively low level of both medical and scientific infrastructure has reduced the ability of governments to meet the challenge of rapidly spreading epidemics, such as dangerous new strains of tuberculosis, and makes effective public communication even more important.

It is significant that the countries in Africa that have been most effective in combating HIV/AIDS have not been those with the most sophisticated medical infrastructure but those, like Uganda, that have been most open in communicating about the disease.

Patrolling the boundaries between state and citizen

Ensuring that policy is appropriately based on sound scientific evidence and that such evidence is made widely available is not the only contribution that science journalists can make to good governance. Equally important is the way that journalists can act as watchdogs of the public interest, patrolling the boundaries between state and citizen.

Journalists can highlight areas where strong regulation is needed to ensure that scientific developments are handled in a socially responsible way. They can also draw attention to gaps between the regulations and what happens in a practice.

For example, where pharmaceutical companies have carried out clinical trials on populations in developing countries that appear to contravene international rules on what is regarded as ethically acceptable, it is often journalists who have brought it to public attention, as the *Washington Post* did in the USA in a series of articles a few years ago.

Indian science journalists played a significant role in 2003 in bringing research to the attention of politicians which suggested that bottled soft drinks, including those made by the US-based companies Coca-Cola and Pepsi, contained dangerous levels of pesticides. The Centre for Science and Environment (CSE), an independent public interest organization based in New Delhi, found that pesticide levels in the companies' Indian products were more than 30 times greater than European Union guidelines. CSE acknowledged that all Indian soft drink brands were likely to contain high levels of pesticides, owing to the presence of these chemicals in the country's

groundwater, but chose to target Coca-Cola and Pepsi because these companies accounted for the majority of bottled soft drinks consumed in India. Although Coca-Cola and Pepsi disputed the findings, these were sufficiently convincing to persuade a parliamentary committee to launch its own research – which confirmed the CSE’s original findings – and demand an overhaul of the country’s food safety regulations.

Journalists can play an important role in exposing the misuse of authority – even inside the scientific community – particularly where this verges on corruption. The media often covers such stories but usually focuses on prominent public figures, such as politicians and businessmen. But science reporters in countries like China have highlighted the fact that the problem also exists in the scientific community, where scientists have been caught faking results to obtain promotion. And it was the Republic of Korea’s press, not its scientific community, that was responsible for the downfall of stem cell researcher Hwang Woo Suk last year, by exposing his false claims to have cloned human embryos.

Journalists can also expose circumstances in which individuals may seek to distort public perceptions of science-related issues. For example, the UK *Financial Times* revealed in April this year that a senior official at the World Bank, Juan José Daboub, a former finance minister from El Salvador who had been appointed by former president Paul Wolfowitz as one of his deputies, had sought to water down statements in a report about combating the effects of climate change, substituting words such as ‘climate variability’. The moves were robustly resisted by the bank’s chief scientist (and climate change expert), Robert Watson; but they contributed to the atmosphere of distrust in Wolfowitz’s leadership that eventually led to his resignation in June.

Science journalists can also highlight government failure to meet public commitments in science-related areas. In China, for example, pressure from journalists has forced the government to take steps to ensure that bio-medical researchers adhere to ethical standards. And in Malawi, media reports that the government was cutting back on commitments to increase science spending led to a reversal of the decision in March.

A vital role

In conclusion, science journalists have a vital role to play in promoting sustainable development and good governance in three separate ways. Firstly, they can bring to the attention of both policy-makers and the public the many ways in which science and technology can contribute directly to achieving the Millennium Development Goals. They can also highlight the policies required to make this possible.

The Coca-Cola bottling plant in Plachimada (Kerala, India) was forced to shut down operations temporarily in March 2004 then again in August 2005 because of community opposition. The community blames Coca-Cola’s bottling operations in the area for falling water levels and pollution of groundwater and soil. Binayak Das from India entered this photo taken in Plachimada on 27 January 2006 in the competition run for alumni this year by the UNESCO-IHE Institute for Water Education to mark its 50th anniversary. He commented that ‘samples of water and wastes sold by Coke as soil conditioner but used by local farmers as fertilizer contained dangerous levels of heavy metals such as cadmium and lead. The State Pollution Control Board [which ordered the plant closure] confirmed that Coke’s bottling plant at Plachimada had been polluting the groundwater and agricultural land in and around its plant’



Secondly, through responsible reporting on key areas in which science and technology can make an impact – both positive and negative – on society, science journalists can help to create a robust space within which public debate on these issues can take.

Thirdly, through critical and, if necessary, investigative reporting, science journalists can hold governments, private companies and public officials – including scientists themselves – accountable for their actions, by exposing misdeeds and the lack of transparency that may have hidden these actions from public scrutiny.

David Dickson²

1. Ed.: Spanish influenza killed more people worldwide in 1918–1919 than the First World War, with estimates of 20–40 million victims. From samples of lung tissue taken recently from victims of the virus, including a woman buried in the Alaska permafrost in November 1918, molecular pathologist Jeffrey Taubenberger and his team in the USA were able to piece together the eight gene fragments of the virus. Their analysis revealed that the Spanish flu had come directly from a bird virus before gradually mutating and moving into humans. Moreover, four of the eight genes in the H5N1 strain contain mutations seen in the Spanish flu, suggesting that H5N1 too might be able to mutate to the point where it can spread between humans
2. Director of the Science and Development Network, whose free-access website (www.scidev.net) uses science journalists and researchers across the developing world to provide news, information and analysis about ways in which S&T are contributing to sustainable development



Textile workers in Adwa in 2005. Textiles and leather goods are the two largest manufacturing sectors in Ethiopia

A new science policy for Ethiopia

Ethiopia unveiled a new national science and technology (S&T) policy in Addis Ababa on 26 June. The launch marked the end of a review of existing policy undertaken by the government with UNESCO support. The review recommended that S&T policy be seen as part and parcel of the country's overall development plan and that research in the social sciences be integrated in national development priority programmes. It also recommended that at least 1.5% of GDP be allocated annually to research and development (R&D).

Ethiopia has gone through intensive administrative decentralization, restructuring and privatization. The 1993 science policy set out to transform an agricultural economy into an industrial one, using agriculture as a springboard to develop the other sectors. The current review sets out to develop a clearer vision of how the country can achieve socio-economic development in the next 10–20 years and to align policy objectives more on needs.

Ethiopia's population of 73 million is among the poorest in Africa. The population is growing rapidly (2.8% per annum), even as life expectancy has dropped from 48 years in 1998 to just 38 years today owing to HIV/AIDS. There are insufficient hospitals (115) and just 62% of the urban population and 6% of the rural population has access to basic sanitation. Per capita electricity consumption is extremely low (39 kWh in 2001) and is put mainly to household use: agriculture consumes just 0.2%, transport 1.2%, industry 1.3% and services 3.5%.

The review recognizes that most of Ethiopia's socio-economic problems are deeply rooted in the absence of a well-established S&T base. The agricultural sector, which accounts for 45–50% of GDP, 63% of export earnings and nearly 85% of employment, has a low level of mechanization and fertilizer use. Ethiopia has more livestock than any other African country but productivity is low. Some 19% of land is not utilized and recurrent drought, combined with a significant loss of soil due to environmental degradation, has led to persistent poverty and famine. The country possesses rich biodiversity however and diverse geographic and climatic conditions.

Ethiopia's mineral resources are underexploited. There is tangible evidence of petroleum, natural gas, platinum, copper, nickel, iron ore, tin, zinc, coal and potassium but the quality and quantity of most mineral deposits are not fully known. The Geological Survey is engaged only in routine mapping and exploration.

Industry – excluding mining – accounts for about 11% of GDP, 10% of employment and 22% of foreign exchange. The sector remains dominated by light manufacturing and agro-processing. Other enterprises are active in food processing, timber and wood products, paper and printing, and chemicals. Engineering produces mainly equipment destined for the transport sector and machinery.

With industrial R&D still in its infancy, much of the review focuses on way of stimulating technological innovation. It recommends stronger linkages between

engineering institutions like universities, industry and end-users, with feedback mechanisms to policy-makers. It advocates tax incentives for private firms wishing to invest in R&D, including the removal of duties on all equipment and materials imported for the purposes of R&D, to help companies acquire technology. It recommends developing business and technology incubators and a national framework to facilitate effective protection of intellectual property rights. It advocates making greater use of the media, exhibitions and other forms of outreach to disseminate locally produced technologies and 'useful imported' research results.

The review calls for research institutions to be strengthened and for a results-based research management system to be put in place. It also recommends setting up research centres in the water, industry, mining and energy sectors.

The new policy was unveiled by the Minister of Industry, Girma Biru, and the Director-General of the Ethiopian Science & Technology Agency, Zerihun Kebede, at a launch attended by about 150 organizations, including UNESCO.

Ethiopia used the methodology adopted by UNESCO to prepare the first draft of the policy document, which was then reviewed by UNESCO's science policy team in Paris, in tandem with the representative of the Ethiopian authorities, Ali Osman from the Ethiopian Science & Technology Agency. Mr Nirya, a UNESCO consultant, undertook two missions to Ethiopia and, as the review was nearing completion, UNESCO's Addis Ababa office helped the Ethiopian government to organize a national conference of stakeholders.

For details (in Addis Ababa): n.satti@unesco.org; on Ethiopia, see also A World of Science, April 2006

Manual alerts children to plight of dolphins

An educational campaign and manual promoting the conservation of dolphins and their habitats was launched at a press conference at UNESCO in Paris on 2 May.

All about dolphins! is a multilingual educational manual for children aged 6–14 years. It has been produced by UNEP, the UN Convention on Migratory Species,

UNESCO and others as part of the 2007 Year of the Dolphin campaign.

The manual comes in two multilingual editions: English, German, Italian, French and Spanish; and English, German, Turkish, Greek and Arabic. It will be distributed around the world by UNESCO's Associated Schools Network, via UNEP channels and in major tourist destinations.

The Year focuses on educating children and adults about dolphins and building awareness of the threats they face. How many people know, for instance, that there are 38 species of dolphin, or that dolphins can be frightened or harmed by underwater noise pollution from shipping traffic, wind farms, seismic surveys or military sonars? The Year will also be providing information to decision-makers and involving local communities in the campaign. For all these reasons, it has been incorporated in the UN Decade of Education for Sustainable Development, administered by UNESCO.

The dolphin campaign also makes a tangible contribution to meeting international targets endorsed by the world's governments to reduce the loss of biodiversity by 2010. It involves the United Nations, governments, IGOs, NGOs and the private sector. UNESCO itself actively promotes marine biodiversity through its 70 coastal marine biosphere reserves in over 30 countries.

For details of the Year: www.yod2007.org

Biosphere Connections takes to the sky

On 14 May, the global airline coalition Star Alliance joined forces with UNESCO-MAB, the Ramsar Convention on Wetlands and the World Conservation Union to support the conservation of biodiversity within a new Biosphere Connections programme.

Under the scheme, the Star Alliance will assist field workers from the three environmental bodies with transport to relevant meetings, conferences and events. 'The programme will help field staff and managers of biosphere reserves in particular to attend training courses and workshops designed to build their skills in conserving biodiversity in their regions,' explains Natarajan Ishwaran, Director of UNESCO's Division of Ecological and Earth Sciences. 'Biosphere Connections will also help to raise awareness among governments, businesses, civil society and the media of the important work done by field staff and biosphere managers, by featuring information on Biosphere Connections during in-flight programmes and in in-flight magazines.'

In return, the three environmental bodies will help the airlines within the Star Alliance to fulfill the Environmental Commitment Statement they have all signed, in terms of communicating and working



Photo: Synchro

Dolphins are threatened by pollution, habitat destruction, overfishing, climate change and underwater noise pollution caused by humans. Each year, an estimated 100 000 are killed for commercial purposes and an additional 300 000 perish after becoming accidentally entangled in fishing nets

with customers, governments, local communities, employees and suppliers to identify and resolve environmental issues.

Another way of helping airlines to improve their environmental performance could include joint work to mitigate the contribution airplanes make to climate change via the emission of greenhouse gases by developing and funding bio-carbon offsetting projects. 'Over time,' Ishwaran says, 'UNESCO will identify projects in biosphere reserves that could offset carbon emissions and which may be of interest to airlines and their customers.'

One example of the type of carbon emission-offsetting project which could be envisaged is carbon sequestration via the capture of carbon by biomass, such as through forest conservation and rehabilitation. In addition to mitigating climate change, these projects will also serve to conserve biodiversity and foster rural development in tandem with local communities. Carbon emissions could also be cut back in biosphere reserves by such measures as the development of new technologies, improvements in energy efficiency and greater use of renewable energies.

Through these carbon schemes, countries could participate in carbon trading, a mechanism permitted under the Kyoto Protocol by which developed countries are entitled to buy certificates from developing countries. This creates cost-effective win-win situations.

The World Network of Biosphere Reserves is also home to 59 Ramsar wetlands and scores of World Heritage sites. Many biosphere reserves are located in countries serviced by the Star Alliance network³, which offers more than 16 000 flights daily to 855 destinations in 155 countries.

For details: www.biosphereconnections.com;
www.unesco.org/mab/biosphereconnections/bc.shtml

3. Its members are Air Canada, Air New Zealand, ANA, Asian Airlines, Austrian Airlines, British Midlands Airlines, LOT Polish Airlines, Lufthansa, Scandinavian Airlines, Singapore Airlines, South African Airways, Spanair, SWISS, TAP Portugal, Thai Airways, United and US Airways, Adria Airways (Slovenia), Blue1 (Finland) and Croatia Airlines. Air China, Shanghai Airlines and Turkish Airlines have all been accepted as future members

International **rock stars** meet to map the world

Between 12 and 16 March, the British Geological Survey hosted a kick-off event for perhaps the most ambitious mapping project yet. Over the next two years, geologists will be putting together the details of a global project which will ultimately see each nation providing data on the Internet about the rocks from their territory, effectively putting together the biggest jigsaw puzzle ever.

OneGeology involves leading scientists from national Geological Surveys in more than 55 countries and is supported by UNESCO and 6 other global umbrella bodies. The project will map dynamic geological data across the surface of the Earth which will then be converted to a new international standard: a geological exchange language known as GeoSciML. Greater use of this language will allow geological data to be shared and integrated across the planet. It will also transfer valuable know-how to the developing world, shortening the digital learning curve.

'All geologists know well that geology and rocks don't respect man-made political frontiers,' comments Ian Jackson, who is leading the project for the British Geological Survey. 'Nor do the environmental problems and natural resources that go with them. With our changing climate, there is even more urgent need for good quality and more complete data about our environment to be available for those who need it. By contributing to OneGeology, each nation can do something locally to make a huge difference globally.'

OneGeology will be making a tangible contribution to the International Year of Planet Earth, which gets under way officially on 1 January within a partnership involving UNESCO, the International Union of Geological Sciences and national Geological Surveys. The Year will demonstrate why the Earth sciences are indispensable for society.

UNESCO is organizing an exhibition on this theme in Paris from 16 October to 3 November during its General Conference. The exhibition will cover the origins of the Earth, plate tectonics, natural hazards, biological and geological diversity, indigenous knowledge, climate change and sustainable development.

For details of the project: mtc@bgs.ac.uk; www.OneGeology.org; and of the exhibition: a.candau@unesco.org

Photo contest

UNESCO's International Geoscience Programme (IGCP) is launching a photo contest on 1 September on the theme of The Changing Face of the Earth, to raise awareness among youth of the state of the planet. The competition is open to 15–20 year-olds around the world and there are 40 prizes to be won. Entries close on 31 January 2008.

Each contestant is invited to submit a single colour photo depicting his or her personal testimony of the Earth's rapidly changing landscape in a positive or negative way. The photo should illustrate one of the ten themes from the International Year of Planet Earth (see *list*). Photos may portray rural or urban scenes and should depict changes to the landscape caused by natural phenomena or resulting from human intervention.

Each of the winning contestants will receive a copy of two UNESCO books: *Explaining the Earth* and *The Changing Face of the Earth*. The names of the 40 winning contestants will be announced in the April 2008 issue of *A World of Science* and on UNESCO's science portal.

How to enter

Contestants should include the following information with their entry:

- Theme of your photo (*from the list on the right*);
- First and last names, and age;
- Full postal address and, if possible, an e-mail address;
- Descriptive caption placing the photo in context in 2 or 3 sentences;
- Language in which you wish to receive the books (English or French).

If sending in your entry electronically, place a high resolution photo (300 dpi, 700 KB minimum) bearing your name as an image file in UNESCO's server: <ftp://ftp.unesco.org/upload/sc> (User name: ftp-sc, password: /*ftpsc!*) in the **Photo contest 2007** folder. Send a confirmation e-mail to photocontest@unesco.org giving the entry details (see *the list above*). Photos sent through the ftp server will be kept there for only five days to avoid overload, so do not delay in confirming your entry by e-mail.

If sending in your entry by post, address the envelope to: Changing Face of the Earth Photo Contest, Editor, *A World of Science*, UNESCO, 1 rue Miollis, 75732 Paris, France.

All entries will be made accessible from the science portal as of March 2008 and may be reproduced by UNESCO in other ways, with due acknowledgement of the photographer. No entries will be returned.

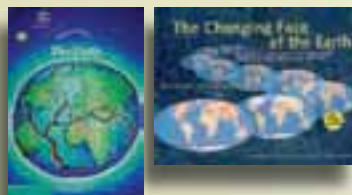


Photo contest website: www.unesco.org/science; contest themes: www.esfs.org



Jayanta Shaw captured his changed surroundings in this poignant photo of a rickshaw puller making his way through a flooded Calcutta street in July 2006. Shaw entered this photo in the UNESCO-IHE Institute for Water Education photo contest, ultimately won by Prasanta Biswas, also from India. To see all entries: www.unesco-ihe.org

The ten themes of the Changing Face of the Earth photo contest:

- Soil – Earth's living skin, Planet Earth in our hands
- Groundwater – towards sustainable use
- Hazards – minimizing risk, maximizing awards
- Earth and health – building a safer environment
- Climate change – the 'stone tape'
- Resource issues – towards sustainable use
- Megacities – going deeper, building safer
- Deep Earth – from crust to core
- Ocean – abyss of time
- Earth and life – the origins of diversity

The prize

Explaining the Earth describes basic aspects of the Earth sciences: our planet's place in the Universe and in our Solar System, the Earth's structure, plate tectonics, the role of the atmosphere and hydrosphere, the formation of reliefs, the ice ages and natural hazards. It was published by UNESCO in 2006.

In ten steps, *The Changing Face of the Earth* traces continental shift since the Pangaea, a single supercontinent, began breaking up 250 million years ago. Published in 2003 by UNESCO and the Commission for the Geological Map of the World, it comes with maps and a CD-ROM.

A virtual campus for teacher training in Egypt

The Egyptian Ministry of Education gave UNESCO the green light on 13 June for the launch of the Egyptian Virtual School Campus. The campus will be put in place over the next four years and will ultimately train Egypt's one million teachers.

The project will build on the experience of the Internet-based Avicenna Virtual Campus put in place by UNESCO in the Mediterranean basin between 2003 and 2006 in cooperation with the European Commission.

Teachers will be trained using 'blended' learning, a method combining distance learning and conventional instruction. They will have access to the Virtual Library and all the other teaching resources shared by the partner universities within the Avicenna Virtual Campus (see *A World of Science*, October 2006).

Some 27 e-learning centres will be set up across Egypt. Within a year, these should be capable of providing training and tutoring in the e-learning concept, quality control, course production and online teacher training. These centres will form a national network which could serve as a model for the African and Arab regions.

Egypt's education system is one of the largest in the world, according to the World Bank, with 16 million students in the 6–18-year age bracket and 41 000 schools. Population growth has slowed in recent years but still stood at 1.9% in 2005 (Egypt State Information Service), meaning that Egypt's population will soon hit the 80 million mark.

Egypt has achieved full primary and secondary enrolment, according to this year's *Global Education Digest* published by UNESCO. Providing quality education remains a challenge however. Moreover, the sheer numbers of teachers needed for the growing school rolls makes it urgent to incorporate the e-learning concept in teacher training.

The Egyptian Ministry of Education will contribute about one-fifth of the US\$20 million budget for this extrabudgetary project. The remainder will be provided by UNESCO and donors such as the African and Arab Development Banks, and the European Commission.

In June last year, the Egyptian government addressed an official request to UNESCO's Director-General for the establishment of a virtual school campus in Egypt. Consequently, Mohamed Miloudi from UNESCO's Division of Science Policy and Sustainable Development prepared a feasibility study, followed by a technical project document, in consultation with UNESCO's Cairo and Beirut Offices, and in cooperation with Prof. Gamal Darwish, Director of the Egyptian Avicenna Centre in Cairo.

For details: t.miloudi@unesco.org;
<http://avicenna.unesco.org>

Systematic measures needed to end poaching in DRC

UNESCO Director-General Koïchiro Matsuura wrote to Joseph Kabila, President of the Democratic Republic of the Congo (DRC), and Jean-Marie Guehenno, UN Under-Secretary-General for Peacekeeping Operations, on 12 April asking for urgent, systematic measures to stop the poaching and killing of endangered animals in the DRC's five World Heritage Sites.

The Director-General's initiative followed reports that several hundred hippopotami and at least two mountain gorillas had been killed in recent months in the Virunga National Park, inscribed on the World Heritage List in 1979 and on the World Heritage List in Danger in 1994. The DRC's four other World Heritage sites, the national parks of Garamba, Kahuzi-Biega, Salonga and the Okapi Wildlife Reserve, are all inscribed on the World Heritage in Danger List.

Mr Matsuura acknowledged the quality of the conservation work carried out by the Congolese Institute for Nature Conservation but observed that the presence of armed groups at these sites, including Mai Mai and Rwandan rebels, presented a threat to the parks which rangers of the Congolese Wildlife Authority were unable to contain. Rangers and their families have been targeted by militias, resulting in loss of property, injuries and even death.

The Director-General asked that the mandate of the UN Organization Mission in DRC (MONUC) be extended to include the protection of the DRC's World Heritage sites and other protected areas.

For details: www.unesco.org/mab/grasplhome.shtml;
<http://whc.unesco.org/en/statesparties/ld>



Mother and child mountain gorillas in Rwanda. Two mountain gorillas at least have been killed in the Virunga National Park in the DRC in recent months. UNESCO and UNEP coordinate the Great Apes Survival Project

A first geopark for Southeast Asia

Langkawi Geopark in Malaysia officially became the 52nd member of the Global Network of National Geoparks on 1 June. Launched by UNESCO in 2004, the Geoparks initiative is now present in 17 countries.⁴

The tropical Malaysian archipelago owes its membership of UNESCO's Geoparks Network to its rich natural geological and biological diversity. So far, 90 geoheritage sites have been identified throughout the Langkawi Geopark, nine of which feature on the National Geological Heritage List of Malaysia. Given the general paucity of geological outcrop in tropical regions, where the vegetation cover is dense, Langkawi makes an ideal open-air classroom for edutourism at all levels.

Some geoheritage sites in the archipelago have been studied in greater detail than others and are grouped together within a larger conservation unit called a 'geoforest park'; others are classified either as geological monuments or protected geosites.

Langkawi Island owes its status as Malaysia's premier tourism destination largely to two factors: its declaration as a Duty Free Island in 1987; and the inception of the Langkawi Development Authority (LADA) in 1990, which has brought development to the archipelago by promoting it as both a national and international destination for ecotourism. The aim now is to turn Langkawi into a premier ecotourism destination in Southeast Asia.

Langkawi Geopark enjoys strong support from Malaysia's central government and the Kedah state government authorities. It also counts among its patrons the Kedah Royal Family and the former Prime Minister,



© M. Patzak/UNESCO

Langkawi Island Geopark includes Kilim Geoforest Park, pictured here, which combines geological and biological features. The plant growing in crevices on the limestone cliff-face is unique to this ecosystem: vaguely resembling a miniature palm or tree fern, the cycad (*Cycas clivicola*) has large, divided leaves and grows in full sunlight; it is classified as nearly threatened on the IUCN's Red List. Langkawi Island Geopark consists of 99 islands, the largest of which is about 50 km in diameter. The archipelago is situated on the western side of the Malayan peninsula in the State of Kedah in northwest Malaysia, adjacent to the border with Thailand. It is easily accessible by sea and by air.

Tun Dr Mahathir Mohammad. The close cooperation between LADA and the wider tourism industry could serve as a model for many of the more established members of UNESCO's Geoparks Network.

For details: www.unesco.org/science/earth/geoparks.shtml; m.patzak@unesco.org

4. Austria (2), Brazil (1), PR China (18), Croatia (1), Czech Republic (1), France (2), Greece (2), Germany (6), Iran (1), Italy (3), Malaysia (1), Norway (1), Portugal (1), Ireland (1), Romania (1), Spain (4), UK (6)



UNESCO pays tribute to Pierre-Gilles de Gennes

Nobel laureate for Physics in 1991, Professor Pierre-Gilles de Gennes died in Orsay (France) on 18 May at the age of 74. UNESCO pays tribute to this exceptional researcher, who had presided the International Jury for the L'OREAL–UNESCO Awards for Women in Science in material sciences since 2003.

In parallel to his demanding research workload – he received the Nobel Prize for work on liquid crystals which paved the way for today's popular flat television screens, among other applications – Professor de Gennes was a staunch defender of the right for all to access science. In consenting to participate in the L'OREAL–UNESCO Prize promoting women in research, he also wished to encourage girls to embark on an adventure close to his heart.

Pierre-Gilles de Gennes presided over this year's award ceremony on 22 February, which recompensed five women from as many continents. He will be sorely missed by the community of laureates, the jury members and his collaborators at UNESCO and L'OREAL.

Andrew Dobson



A warmer world will be a sicker world

In its report released on 6 April on *Impacts, Adaptation and Vulnerabilities*, the Intergovernmental Panel on Climate Change (IPCC) predicts that 20–30% of species will become extinct if the mean global temperature rises by more than 1.5–2.5°C this century. The IPCC similarly predicts that these higher temperatures will cause a considerable shift in the range of species and increase the burden from infectious diseases.

Andrew Dobson is an ecological parasitologist in the Department of Ecology and Evolutionary Biology at Princeton University in the USA. He argues that, in a world where climate change may allow vector-transmitted diseases to extend their geographical range, it may be sensible to conserve biological diversity for the purely selfish reason of protecting human health.

In 2002, you co-authored an article in *Science* describing the increase in climate-sensitive outbreaks of disease. What factors are favouring these outbreaks?

Even slight increases in moisture and temperature stimulate bacteria, fungi, viruses and the insects that are vectors of infectious disease. This is because longer, warmer summers enable pathogens to extend their range. Similarly, milder winters are not cold enough to reduce the number of pathogens and insect vectors. This means that it is not only going to be a warmer world, it is going to be a sicker world.

We are seeing disease outbreaks sensitive to climate in corals and oysters and, on land, in plants, animals, birds and humans. Some species even share certain diseases. Humans and animals – such as cattle and goats – are both susceptible to malaria for instance and there are many forms of avian malaria. Take the example of honeycreepers, which are forest songbirds that evolved only in Hawaii (USA). They are being decimated by malaria from mosquitoes that have been able to range higher in elevation due to warmer temperatures. Today, there are no native birds below 1500 m. In the 1960s, mosquitoes were restricted to elevations below 762 m.

The mosquito vector of malaria can survive as long as temperatures do not regularly fall below 16°C; in recent years, human cases have been reported in southern Europe, the Korean peninsula and the former Soviet Union.

Another worrying trend is that vectors of disease are becoming more virulent. The *Aedes* mosquito, which transmits the Dengue virus, is biting at a faster rate because of the warmer temperatures and therefore infecting more humans. In the first two months of this year, Brazil reported 85 000 cases of dengue fever, nearly 30% more than for the same period in 2006; half of these cases concerned a state bordering on Bolivia and Paraguay. In March, Uruguay confirmed the country's first domestic case of dengue fever in 90 years.

So 'tropical' diseases will migrate to higher latitudes, as these become warmer and more humid?

I think it likely that vector-transmitted pathogens will move into higher latitudes. The classic example of this is the ongoing epidemic of Bluetongue virus in European sheep. Until very recently, Bluetongue was restricted to Africa; it then moved across the Mediterranean at multiple locations and by colonizing new vector species (within the same genera of midges) was able to spread into southern Europe and as far north as the Netherlands.

The worrying thing here is that the range change was predictable by climate models; the ability to switch vectors was not predicted, however, and it was this that allowed the pathogen to spread much further north than predicted by climate models.

The key message here is, we should be more worried than we are about what we can predict using climate models and *very* worried about the unexpected!

Andrew Dobson with a baby tapir in the Peruvian Amazon



photo: Peter Hudson



What can we do to combat the spread of infectious diseases?

Culex pipiens
mosquito

High biodiversity manages to buffer some of the negative effects of infectious diseases at present but, as we convert habitats for agriculture, or with urbanization, even as we improve human access to food and infrastructure, we may be reducing the ability of natural systems to buffer disease.

As infectious diseases move from tropical zones into temperate ones, the latter may find themselves harder hit than the tropics.

Why would the temperate zones be harder hit?

There is a greater biodiversity of species in tropical zones and thus a good chance that a mosquito will bite a species in which the disease doesn't develop. In temperate zones though, biodiversity is lower, so vectors have fewer options about what to bite. This means that any pathogen which manages to spread from the tropics to the temperate zone in a warmer world is likely to have a bigger impact, as it can focus on a few common and abundant susceptible species...particularly humans and domestic livestock which are increasingly the most common species!

The West Nile Virus is causing concern in the USA. It is carried by *Culex pipiens*, a mosquito which thrives in hot, dry climates in Africa, the Middle East, India and Europe. In 1999, the virus turned up in the USA for the first time, where it infected 62 people in New York, killing 7. During the next hot, dry summer in 2002, it infected 9000 people in 44 states and cases were even reported in Canada.

Generally speaking, will things get worse?

I suspect that things will get worse for two reasons. Firstly, climate change will have its most significant impact along the margins of habitats – the edges of deserts, the edges of cultivation on mountains. Climate change will allow some vector-transmitted pathogens to establish in these regions where they will increase the disease burden in populations of humans and domestic livestock with only low levels of immunity to these pathogens due to restricted prior exposure.

Secondly, other species may buffer this impact, as infected insect vectors that bite a non-viable host for the pathogen are essentially lost from the epidemic. So, as we lose biodiversity, we lose alternative hosts for insect vectors to bite and the epidemic becomes concentrated in humans and domestic livestock.

What are the consequences for human health of allowing a natural predator to die out, like the bobcat in North America which preys on white-footed mice infected with ticks, a vector of Lyme disease which can infect humans?

I suspect that the recent outbreaks of prion diseases (chronic wasting disease in deer in the USA and perhaps Scrapie in the UK) are connected to the loss of predators

whose main ecosystem service is to eat recently dead carcasses rather than leave them to rot in the landscape.

In regions with very poor soils, antelope and deer tend to be very calcium-deficient. They compensate by chewing on old carcasses at the end of winter when they're really hungry and nutritionally stressed. This is a great way to transmit a prion. However, if you have a healthy and abundant predator and scavenger community, these carcasses are removed by the wolves, coyotes and bobcats before they can transmit their pathogens.

Predators like wolves also disproportionately remove sick animals from herds of elk and deer; this again reduces rates of pathogen transmission within the herd and on to the hunters who may consume meat from animals they have successfully hunted.

Could climate change help animal diseases cross the species barrier to humans?

Climate change is likely to change the diversity of pathogens to which humans are exposed. We simply don't know enough to say whether it changes susceptibility. Nor do we have enough people, or funds, to work on this. In the USA, more bright medical graduates tend to go into sports medicine than into climate-related health problems. So it will be a while until we find out.

This of course increases our worries about the unknown effects of climate change on disease. Lots of things are unknown because we spend a disproportionate amount of money on either self-inflicted human dietary ailments or 'faith-based' vaccine development. There is an enormous reluctance among the medical community to recognize that, if our real goal was reducing the human burden of infectious disease, then money spent on vaccine development would be better spent on relatively simple methods of disease prevention: bed-nets for malaria would be the classic example here but there are many others, particularly among the diseases that are prevalent in the tropics but likely to spread into the temperate zone as climate change progresses.

You are working on the ecology of cholera⁵ and climate. What are your initial findings?

Work with Mercedes Pascual and her colleagues at the University of Michigan in Ann Arbor, Michigan (USA), and with colleagues at the International Center for Diarrhoeal Disease in Bangladesh has shown that the dynamics of cholera is very dependent upon climate, particularly rainfall and hence river depth and flow. Some of this work is published in the journals *Nature*⁶, *Science* and *EcoHealth*; more work is appearing over the next year.

The key thing to note here is that the recently published complete genomes for *Vibrio cholerae* and for humans tell us essentially nothing about this interaction! Instead, our understanding of infection dynamics and seasonal outbreaks has to come from the ecological and mathematical analysis of long-term cholera cases and climate data.

There is a perception in the medical community that genomics will supply all the answers. As we look more and more at the long-term dynamics of cholera and malaria, I think this is unlikely to be the case. Genomics tells us almost nothing about interactions between host and pathogen at the population level and nothing about the influence of climate. This is an epiphenomenon of the same mentality that focuses on vaccine development, when developing a deeper understanding of disease dynamics, and how to break cycles of infection, would be a more effective way to reduce the impact of the pathogen on people who bear the burden of infection.

Too much of the research in medical schools is for the benefit of the egos and career of the researcher and makes negligible contributions to developing effective ways to control infectious diseases. Even the Bill and Melinda Gates Foundation has been woefully misled in funding research for vaccines for which we shall never reach levels of coverage sufficient to have an impact on transmission.

In Central America, the impact of climate change on biodiversity is already visible. This Panamanian golden frog is one of more than 100 species of Harlequin frogs disappearing from the cloud forests and rainforests of Central America. Over the past 20 years, 110 endemic frog species (about 67%) have become extinct, including the Monteverde Harlequin frog and the golden toad. Recent research has shown the critical role of the chytrid fungus coupled with climate change in the extinction of Harlequin frogs: higher air temperatures create optimum conditions for the fungus, while greater daytime cloudiness prevents the frogs from finding thermal refuges from the pathogen. Source: Case Studies on Climate Change and World Heritage (see also pages 20 and 24)



©Forrest Brien

Will climate change be the main cause of species loss in coming decades?

Although climate change is a huge worry at the moment, particularly for people living in the Arctic and temperate zones, I actually lose more sleep worrying about habitat loss and rainforest destruction, particularly in the tropics. This not only makes a major contribution to the rate of climate change but it also reduces a major buffer to future rates of environmental change.

Only this month [June], Walter Jetz, David Wilcove and I published an article in *PLOS Biology* on the Projected impacts of Climate and Land-use Change on the Global Diversity of Birds. We used the Millennium Ecosystem Assessment Scenarios to evaluate the exposure of all 8750 land bird species to the projected transformation of land cover due to changes in climate and land use. Even under environmentally benign scenarios, we found that around 400 species will suffer >50% range reductions by 2050, a figure that rises to 900 species by 2100. Species most at risk are predominantly narrow-ranged

and endemic to the tropics. The vast majority of these species (>90%) are impacted by land-use change; only the minority suffer significant loss from climate change. In either case, most are currently not recognized as imperiled.

This tells us that, although climate change will have a significant impact this century, habitat loss, particularly in the tropics, will be an even bigger threat to land bird species. This ties in with the Red List⁷, which cites habitat loss as the dominant cause of species loss in around 70% of the species listed as threatened or endangered, ahead of habitat fragmentation, overexploitation of populations for food and other economic uses, the introduction of invasive species and diseases, climate change and pollution.

Interview by Susan Schneegans

5. Cholera is transmitted from person to person via fecal or oral matter but also via indirect transmission through the environment, such as contaminated food and water. This is why outbreaks are closely tied to poverty and poor public hygiene. The main reservoir for cholera are freshwater invertebrates. This means that, even if we had an effective cholera vaccine, we'd have to vaccinate everyone living close to potential sources and we'd have to repeat this every two to three years. We have never achieved this level of coverage for any of the handful of diseases for which we have lifelong vaccines
6. In an article published in *Nature* in August 2005, the team explained how it had analysed 40 years of medical records for cholera in the town of Matlab near Dhaka (Bangladesh). The scientists developed a computer model which took into account two key factors influencing cholera transmission in the area: immunity to the cholera bacterium in local people, thought to last up to three years after an outbreak, and climatic factors like trends in rainfall. Their findings indicated that floods caused by heavy monsoons could contaminate drinking water with the cholera bacterium and that drought also favoured the bacterium, as it developed more easily in small pockets of stagnating water. The authors explained that the team would be turning its attention to designing new computer models based on its findings to provide short-term forecasts of future epidemics and elaborate scenarios for how cholera would be affected by climate change: www.scidev.net/pdf/nature/nature03820.pdf
7. www.redlist.org

A blue goldmine in need of protection

Beneath our feet run aquifers which can span thousands of kilometres. Like rivers, aquifers cross national borders and can be shared by two or more countries. Unlike rivers, little is known about transboundary aquifers. Nor are there many specific international rules and conventions governing the shared management of these aquifers.

In 2002, UNESCO set out to map the world's aquifers, within a project for Internationally Shared Aquifer Resources Management (ISARM). Together with the International Association of Hydrologists (IAH), FAO, regional partners and national experts, UNESCO's International Hydrological Programme (IHP) has spent the past five years overseeing an inventory of transboundary aquifers around the world.

The African survey was the first to get under way. It uncovered 38 transboundary aquifers, five of which had never been identified before. Progress towards completing the survey in West Africa was assessed at a UNESCO workshop in Cotonou (Benin) on 30 May – 1 June this year. The meeting recommended preparing an atlas of the sub-region's internationally shared aquifers by 2009.

Organized by UNESCO's Accra office and the IAH, in cooperation with the International Groundwater Resources Assessment Centre in the Netherlands, the June workshop analysed the information amassed thus far and prepared the final collection of data for the sub-regional inventory. Once completed, this inventory will form part of a GIS database of transboundary aquifers in the sub-region.

Hydrogeologists from Benin, Burkina Faso, Côte d'Ivoire, Ghana, Mali, Mauritania, Niger, Nigeria, Togo and Senegal then gave a status report on the data and information available on shared aquifers in their home countries. The case of Côte d'Ivoire is typical, in that it illustrates the kind of problems countries in the sub-region will need to tackle if they are to protect their precious resource.

The case of Côte d'Ivoire

The Gulf of Guinea has two shared aquifer systems composed of two large sedimentary basins, the Tano and Keta Basins. The Tano Basin extends from the coastal town of Fresco in Côte d'Ivoire to the town of Axim in Ghana. The aquifer covers 2.5% of Côte d'Ivoire's territory.

There are three types of aquifer in the Tano Basin. The Quaternary aquifers (younger than 1.8 million years [Ma]) are very vulnerable to pollution because the surface of the aquifer is close to ground level. The second type is the



Street scene in Cotonou, Benin's largest city. In 2002, hydrogeologists from Benin learned that the aquifer providing water for Cotonou extended across the border into Togo. Both countries have expressed interest in developing a framework to manage this aquifer jointly. The aquifer will become increasingly important as rainfall in the region declines with climate change

Mio-Pliocene (5–8 Ma) or Continental Terminal aquifer. This is the one which provides Abidjan and the surrounding region with drinking water. The third type of aquifer dates from the Late Cretaceous (94 Ma). This holds the reservoir of mineral water in Côte d'Ivoire that is exploited by the Société africaine d'exploitation d'eau minérale. It is the most enigmatic of the aquifers, as neither its geometry, volume, level, nor lateral extent are known.

Most of Côte d'Ivoire's major cities lie on the coast. These include Abidjan, Bonoua and Aboisso. The region also sports numerous industrial plantations producing pineapple, rubber and palm oil, as well as the Afema goldmine in Aboisso, all of which consume large quantities of water.

Studies of groundwater in the Abidjan area have revealed a concentration of nitrates (NO_3^-), ammonium (NH_4^+) and aluminium (Al^{3+}) in excess of WHO standards for drinking water on the plateau, in Adjamé and in the western zone. This chemical pollution is caused by the use of pesticides and fertilizers in the plantations. Fishermen are also polluting the lagoons in the region with pesticides. Other lagoons are contaminated by gold mining, including the Afema Lagoon and Aby Lagoon in neighbouring Ghana. The pollution of surface waters with chemicals and domestic waste threatens both human health and aquatic biodiversity.

With annual growth of about 2% per year, Côte d'Ivoire's population of 18 million is expected to climb to 24 million by 2025. Just under half the population now lives in urban areas.

Abidjan itself has a rapidly growing population estimated at 3.2 million in 1999. The city's aquifer is coming under stress from a variety of factors tied to its rapid urbanization: the construction of buildings and



Clémentine Soropoul/UNESCO

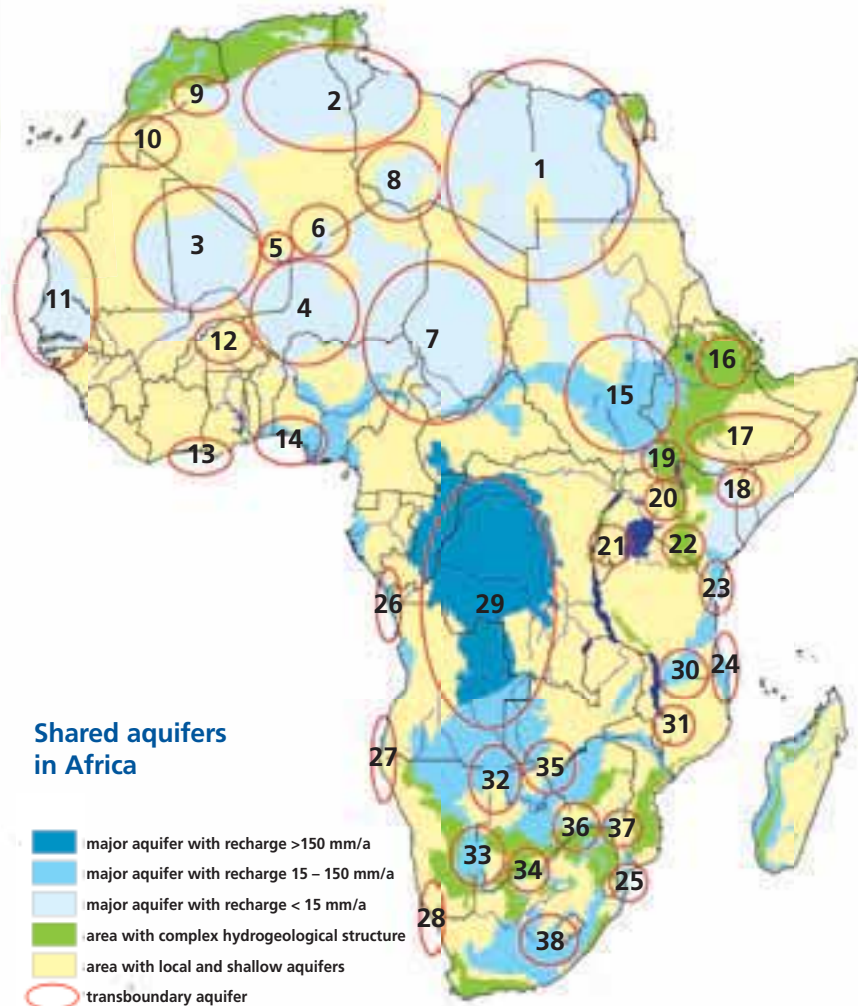
Downtown Accra, the capital of Ghana, in 2004. The ISARM survey uncovered a major aquifer shared by Ghana and Côte d'Ivoire. Hydrologists from Côte d'Ivoire had already begun studying the aquifer, which provides 80% of the local population's water needs, but experts from Ghana learned during the survey that the aquifer crossed into their territory. There are plans to manage the shared resource jointly

infrastructure on land previously covered with vegetation is rendering the ground impermeable to rainwater; this, combined with the anarchic occupation of land by slum dwellings, is making it difficult to access the water wells to monitor groundwater in the aquifer and is contributing to the drop in recharge of the aquifer.

The absence of systems for water treatment or the disposal of household waste means that waste water is emptied directly into rivers and other surface waters. The aquifer is also being polluted by agriculture on the outskirts of the city.

The strong demand for water in Abidjan means that the city's groundwater supply will soon be over-extended. It is envisaged to begin using the groundwater which serves the nearby town of Bonoua but, here again, this could rapidly lead to over-use. The amount of water drawn from the Bonoua source has already more than doubled, from 767 767 m³ in 1990 to 1 836 699 m³ in 2000.

Another serious problem concerns saltwater intrusion, which is probably responsible for the strong presence of chlorine in the coastal aquifer.



No.	Name of aquifer system	Countries underlain by aquifer system
1	Nubian Sandstone Aquifer System	Chad, Egypt, Libya, Sudan
2	Northwest Sahara Aquifer System	Algeria, Libya, Tunisia
3	Taoudéni Basin	Algeria, Mali, Mauritania
4	Iullemeden Aquifer System	Mali, Niger, Nigeria
5	l'Air Cristalline Aquifer	Algeria, Mali, Niger
6	Tin-Séririne Basin	Algeria, Niger
7	Chad Basin	Central African Republic, Chad, Cameroon, Niger, Nigeria
8	Mourzouk-Djado Basin	Chad, Libya, Niger
9	Errachidia Basin	Algeria, Morocco
10	Tindouf Aquifer	Algeria, Morocco
11	Senegalo-Mauritanian Basin	Gambia, Guinea-Bissau, Mauritania, Senegal
12	Liptako-Gourma Aquifer	Burkina Faso, Niger
13	Coastal Sedimentary Aquifer	Ghana, Côte d'Ivoire
14	Coastal Sedimentary Aquifer	Benin, Nigeria, Togo
15	Upper Nile Basin	Ethiopia, Sudan
16	Awash Valley Aquifer	Djibouti, Ethiopia
17	Ogaden-Juba Aquifer	Ethiopia, Kenya, Somalia
18	Merti Aquifer	Kenya, Somalia
19	Rift Aquifers	Kenya, Tanzania, Uganda

No.	Name of aquifer system	Countries underlain by aquifer system
20	Mount Elgon Aquifer	Kenya, Uganda
21	Kagera Aquifer	Tanzania, Uganda
22	Kilimanjaro Aquifer	Kenya, Tanzania
23	Coastal Sedimentary Basin	Kenya, Tanzania
24	Coastal Sedimentary Basin	Mozambique, Tanzania
25	Limpopo Basin	Mozambique, Swaziland
26	Coastal Sedimentary Basin	DR of Congo, Angola
27	Coastal Sedimentary Basin	Angola, Namibia
28	Coastal Sedimentary Basin	Namibia, South Africa
29	Congo Intra-cratonic Basin	DR of Congo, Angola
30	Karoo Sandstone Aquifer	Mozambique, Tanzania
31	Shire Valley Alluvial Aquifer	Malawi, Mozambique
32	Northern Kalahari/Karoo Basin	Angola, Botswana, Namibia, Zambia
33	SE Kalahari/Karoo Basin	Botswana, Namibia, South Africa
34	Ramotswa Dolomite Basin	Botswana, South Africa
35	Nata Karoo Sub-basin	Botswana, Namibia, Zimbabwe
36	Tuli Karoo Sub-basin	Botswana, South Africa, Zimbabwe
37	Medium Zambezi Aquifer	Botswana, Mozambique, South Africa, Zimbabwe
38	Karoo Sedimentary Aquifer	Lesotho, South Africa

Towards a map of the world's transboundary aquifers

In the five years since ISARM was launched, regional surveys have been completed for the Americas, Western Europe and the Euro-Mediterranean region. Each regional survey marks an important step towards a global inventory and database which will offer assessments of the water quantity and quality of every transboundary aquifer in the world. The inventory will also provide detailed case studies of innovative techniques for managing these resources from a technical, socio-economic and legal perspective.

The African inventory was the first to get under way, at a workshop in June 2002 which launched a regional network of more than 200 experts from 25 African countries. This workshop was organized in Tripoli by UNESCO and the General Water Authority of the Libyan Arab Jamahiriya. The first sub-regional workshop to monitor progress took place in January this year and involved the countries of the Southern African Development Community.

Later this year, UNESCO and the Organisation of American States will be publishing a preliminary assessment of their three-year joint project on transboundary aquifer systems in the Americas (see *A World of Science*, July 2005).

The Balkans project is run by UNESCO Chairholder Prof. Jacques Ganoulis at the Aristotle University of Thessaloniki in Greece and the International Network of Water-Environment Centres for the Balkans, with UNESCO-IHP support. In 2003, Prof. Ganoulis presented the results of the first phase during a workshop at which experts from the UNESCO-IHP, UN Economic Commission for Europe and national experts from Southeastern Europe began work on an atlas of transboundary aquifers in the region. Progress towards this goal was monitored at a second workshop in April this year.

A preliminary assessment of transboundary aquifers in Asia was presented last October, with a special focus on China. The assessment was made public during a session on Transboundary Aquifers in Asia organized by UNESCO at an IAH Congress in Beijing.

This has forced the population to abandon certain wells. Hydrologists have detected this phenomenon in Jacquerville, the Abidjan plain and farther to the east in the region of Adiaké.

The central problem is the inadequacy of the national legislation framework. Laws covering the environment, the water and mining sectors have been adopted but have not yet entered into force. Côte d'Ivoire has ratified a number of international legal instruments related to water but these tend to cover seawater and surface waters.

Why cleaning up a polluted aquifer is so hard to do

The groundwater contained in the world's aquifers represents 30% of the world's supply of freshwater, compared to just 0.3% for lakes and rivers. Yet groundwater studies in general have been sorely lacking, despite groundwater's obvious value and the fact that many countries rely upon it for 80% of their needs, like Mauritania. Even in more humid regions, people are becoming increasingly dependent upon groundwater because of severe pollution of rivers or surface water.

Although aquifers offer extremely safe and reliable resources, they are fragile. It is extremely difficult, if not impossible, to clean up an aquifer once it has been polluted by sewage and chemicals that seep down from communities, factories and farms. Moreover, the sources of urban pollution are becoming more diverse; these now include organic pesticides, nitrates, heavy metals and waterborne pathogens.

'It is economically impractical and may sometimes even be technically impossible to clean up urban aquifers once they have become polluted,' explains UNESCO programme specialist Emmanuel Naah, who works from UNESCO's Regional Bureau for Science in Nairobi (Kenya). 'Consequently, in the long term, polluted urban groundwater will either be abandoned, leading to acute water shortages, or require complex and expensive treatment systems to avoid placing public health in jeopardy.'

Africa's urban population has nearly tripled since 1970, with 35 cities now accommodating more than a million inhabitants. This rural exodus has been exacerbated by severe climatic conditions, desertification and poverty.



© Moussa, ENDA Dakar

An early warning system for polluted city aquifers

In 2002, UNESCO's Nairobi office and UNEP initiated a project to assess the impact of pollution on aquifers in Abidjan and eight other major African cities: Dakar (Senegal), Ouagadougou (Burkina Faso), Bamako (Mali), Cotonou (Benin), Keta (Ghana), Mombasa (Kenya), Addis Ababa (Ethiopia) and Lusaka (Zambia).

The project has developed methodologies for assessing groundwater vulnerability, identifying pollution hotspots and major threats. It has also set up an early warning system made up of a network of African scientists and is building awareness among decision-makers in the public and private sectors of the dangers of such practices as indiscriminate waste disposal.

'The idea was to provide a robust system of monitoring,' recalls Naah, 'to give legislators and water managers early warning so that they could take timely action against pollution.' The project is being developed further, in line with the recommendations of an evaluation workshop in Cape Town (South Africa) in November 2005.

Filling a legal vacuum

If transboundary aquifers are difficult to map from a scientific perspective, political factors can further complicate the process. Governments are often reluctant to admit that other countries share the aquifers they rely upon for drinking water and irrigation. Despite a growing body of international rules and conventions concerning shared rivers, these do not apply fully to aquifers.

Until recently, international law had paid little attention to groundwater and transboundary aquifer systems. In the only global convention so far on the use of water resources, the UN Convention on the Law of Non-navigational Uses of International Watercourses adopted in May 1997, groundwater is considered only when related to a surface water body, as in most inter-state treaties and agreements on transboundary waters. However, things are changing.

In 2006, the United Nations' International Law Commission adopted at first reading a full set of draft articles on the law of transboundary aquifers⁸, prepared with the scientific and technical support of the IHP. As part of this effort, UNESCO and FAO co-published a compilation of binding and non-binding international agreements involving groundwater the same year (*see box for examples*).

The draft articles include the core principles of international water law: the equitable and reasonable utilization and the no-harm rule. They also include the general principle of international law: the obligation to cooperate, translated in a practical manner in the case of

Facing page: left: women drawing water from a well outside the village of Sarkin Yamma Gabi Maradi in Niger; centre: a young herdsman with donkeys and cattle around a water trough near the same well; right: a water tower built in the Nigeran village of Tibiri Maradi after the village wells were contaminated by fluoride of primarily geological origin

The case of North Africa

Government representatives have recognized the need to develop a legal agreement covering the Nubian Sandstone Aquifer System, which spans Libya, Egypt, Chad and Sudan. This can be divided into two major reservoirs: the oldest and most extended reservoir, the Nubian Aquifer System, and the Post-Nubian Aquifer System.

The two reservoirs combined contain approximately 373 000 km³ of fossil water which is thousands, perhaps even millions, of years old. This is the liquid legacy of a bygone era, when the barren Sahara was a lush savannah about 10 000 years ago. The rains that fed the region disappeared some 3000 years ago, leaving phenomenal but finite water supplies known as fossil water, which the Libyan government began mining in 1991 through the world's largest civil engineering project, the Great Man-Made River Project. Once used however, fossil water is gone forever, which is why controversy surrounds the mining of it.

In 2000, Chad, Egypt, Libya and Sudan joined the Programme for the Development of a Regional Strategy for the Utilization of the Nubian Sandstone Aquifer System. The programme was run by the Centre for Environmental Development of the Arab Region and Europe, based in Cairo. A second agreement binding Algeria, Libya and Tunisia established a Consultative Mechanism for the Northwestern Sahara Aquifer System in 2002. Details of these and other agreements may be found in *Groundwater in International Law*, published jointly by UNESCO and FAO last year.

Request a copy from:

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Known as 'the pearl of the desert', the city of Ghadamès stands in an oasis. It is one of the oldest pre-Saharan cities. Libya's Great Man-Made River project delivers about 500 000 m³ of water a day to Libya's coastal cities, home to most of the population, through a network of concrete pipes 4 m in diameter. This artificial 'river' lies under the desert and covers a total length of 3500 km



transboundary aquifers through the regular exchange of data. The draft articles then codify specific principles for the management of transboundary aquifers such as monitoring, the protection and preservation of transboundary aquifers, and direct cooperation with developing States or through a competent international body like UNESCO. The draft articles have been circulated to the Member States of the United Nations for comment by 1 January 2008.

ISARM is encouraging governments to set up plans and, in some cases, commissions to manage shared resources jointly with their neighbours and to protect the environment. There are also plans to broker legal agreements to protect the aquifers further.

Raya Stephan⁹, Abou Amani¹⁰ and Amy Otchet

8. www.un.org/law/ilc – under Report, then Shared Natural Resources

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The heat is on for Australia's forests

Australia is currently in the throes of its worst drought in living memory, with all but the far northwest affected. Between 1910 and 1999, the country saw an average increase in temperature of 0.7°C, most of which occurred after 1950. Projections by the Australian Commonwealth Scientific and Industrial Research Organization (CSIRO) based on climate models indicate an increase in average annual temperatures ranging from 0.4°C to 2.0°C by 2030 and as much as 1.0°C to 6.0°C by 2070. Evaluating future trends in rainfall remains more difficult. This change in climate regime raises a special concern for forests, where the impact of higher temperatures could heighten the risk of more frequent, intense and destructive wildfires, and decimate biodiversity.



© Jim Tarsell/UCN Photo Library

The Greater Blue Mountains Area owes its blue haze to the highly flammable eucalyptus oil released into the atmosphere in response to heat. More than 100 eucalypt taxa have been recorded here

The Greater Blue Mountains and The Wet Tropics of Queensland are two of the sites profiled in *Case Studies on Climate Change and World Heritage*, published by UNESCO's World Heritage Centre in April. Separated by over 2700 km, these two Australian sites are poles apart in many ways: the former ecosystem is made up of temperate eucalypt forests, the latter of tropical rainforests and mangroves. Yet both will be highly vulnerable to Australia's warmer and drier climate in the 21st century.

In 2003, Lesley Hughes from Sydney's Macquarie University argued that it was difficult to plot the impact of climate change in Australia on the broad range of species, due to the lack of sufficient baseline data from which to work. Studies carried out since however on vulnerable alpine and forest ecosystems point to a significant reduction in the numbers of many species and the probable extinction of some.

Perhaps the most vulnerable vertebrate species is the Mountain Pygmy Possum (*Burrhamys parvus*), whose life cycle requires sustained alpine snow cover. It is estimated

that a 1°C rise in temperature would eliminate its bioclimate and a 2°C increase would eliminate the bioclimate of five other alpine species. Given that migration to an environment that has more snow cover is not an option, it is likely that such species will be driven to extinction.

In drier woodland ecosystems of Western Australia, a 0.5°C increase in temperature would reduce the habitat of all frogs and mammals by 28% and a 1°C increase would see the shrub species *Dryandra* become extinct or shrink to small pockets. Again, with only a 1°C increase in temperature, Hilbert *et al*¹¹ estimate that highland

rainforest will decrease by around 50%. This is critical, given the importance of these ecosystems for many of the country's endemic vertebrates.

Moreover, the fragmentation of habitat associated with small protected areas like World Heritage sites often provides limited opportunities for migration to more compatible environments.



© Mel Williams



© Sean McLean

The Greater Blue Mountains World Heritage Area is home to the endangered Brush-tailed rock wallaby (left) and Tiger Quoll (right). Their habitats and life-support systems could be profoundly impacted upon by climate change and the increased frequency and intensity of forest fires

One of the world's most fire-dependent forests

The eucalypt forests of Australia, including those of the Greater Blue Mountains in the southeastern state of New South Wales (*see map overleaf*), are among the most fire-dependent forest ecosystems in the world.

The Greater Blue Mountains World Heritage Area consists of over 1 million ha of sandstone plateaux, escarpments and gorges covered largely by temperate eucalypt forests. Comprised of eight protected areas, the site was inscribed on the World Heritage List in 2000 for its representation of the evolutionary adaptation and diversification of eucalypts in post-Gondwana isolation on the Australian continent (*see box overleaf*).

Another justification for the site's inscription on the World Heritage List is that it hosts 120 rare or threatened species, including 114 endemic taxa and evolutionary relict species like the Wollemi pine, which have persisted in highly restricted microsites.

Eucalyptus oil highly flammable

The blue haze of the Greater Blue Mountain Area, from which it derives its name, is caused by the highly flammable eucalyptus oil being released into the atmosphere in response to heat. Many species of eucalypt, banksias and other native flora have become so adapted to fire that they only release their seeds after burning has taken place, the ash compensating for the often nutrient-poor soils.

There is usually a high rate of regrowth of eucalypts and banksias within the first three years following a major fire. However, a second hot fire, during that stage in the regeneration process, can lead to severe stress and a loss of species diversity by killing plants before they have matured sufficiently to produce seeds.

Consequently, if the interval of intense bush fires moves from long cycles of 10–20 years to below 6 years, there will be a significant decline in the diversity of the major eucalypt species and other flora of the region, a change that would have serious consequences for the ecosystem integrity of the area.

Studying fire behaviour

Several strategies are being developed to protect the Greater Blue Mountains from the adverse impact of wildfires in the context of a changing climate. The first is to implement more informed policies through greater research into fire behaviour and its ecological impact, especially following the terribly destructive fires of 2002 that led to the establishment of a Bushfire Cooperative Research Centre in December 2003.

Significant loss of biodiversity is projected to occur by 2020 in some ecologically rich sites, including the Great Barrier Reef and Queensland Wet Tropics. Other sites at risk include the Kakadu wetlands, southwest Australia, sub-Antarctic islands and the alpine areas.

IPCC (2007)¹²

The second strategy concerns the use of controlled or mosaic burning to limit the risk of intense and ecologically destructive fires, appropriately designed to take into account the specific ecosystems involved. As the Greater Blue Mountains border the rapidly expanding suburban boundaries of Sydney – Australia's largest city with a population of 4.3 million – there is a real risk of conflicting policy priorities between the protection of urban property and biodiversity conservation.

The gradual emergence of fire-adapted species

In Australian ecosystems, like others that have evolved in relation to 'Mediterranean type' climatic conditions, fire has been the selective mechanism over a very long time-frame. However, in Australia, fire became a more important factor around 100 000 years ago, with the drying of the environment at the end of a major ice age.

This resulted in the decline of the country's megafauna (large animal species) and the emergence of more fire-adapted species. Fire was to become an even more significant feature of the landscape with the arrival of the first Aboriginal inhabitants around 60 000 years ago, who used fire to manage the landscape.

These two factors meant that the fire-sensitive species, such as beeches, pines, tree ferns and sheoaks, along with wet rainforest species, gave way to the more fire-dependent eucalypts and banksias. This was also associated with the emergence of sclerophyll forests¹³ and greater erosion of topsoil leading to the silting of coastal regions and the emergence of mangroves. For the Aboriginal population, the use of 'fire stick farming' to manage and clear the landscape was both a means of preventing extremely destructive fires and controlling the movement of game. Such cultural practices as mosaic burning over many thousands of years were to shape profoundly the Australian landscape.

As a result of reduced precipitation and increased evaporation, water-security problems are projected to intensify by 2030 in southern and eastern Australia.

IPCC (2007)

Rising temperatures could force species up the mountain

Rising temperatures may threaten flora and fauna in the very limited parts of the Greater Blue Mountains that are wetter



Two red-barked snow gums (Eucalyptus pauciflora). Unique to Australia's southeastern alpine regions, snow gums are especially threatened by climate change

The Wet Tropics: a biodiversity hotspot

A second case study in Australia concerns The Wet Tropics of Queensland World Heritage Area, which stretches along the northeastern coast of Australia for some 450 km (see map). It is made up of tropical lowland and upland rainforests and thickets, vegetation complexes, mangroves and sclerophyll forests and woodlands. These ecosystems host a particularly extensive and diverse array of plant and animal species, including a high proportion considered as endemic, evolutionarily significant, rare or threatened (see box). It was these features which justified its inscription on the World Heritage List in 1988.

This remarkable ecosystem is threatened by rapid changes in temperature and rainfall, as many species in this area are unable to keep pace with rapid climate change.

For about half of the species modelled, a warming of 3.5 °C – corresponding to the average projected scenario – may lead to the total loss of their core environment; for the remaining species, range sizes are likely to be reduced on average to 11% of the current area. Even a 1°C increase in mean air temperature will lead to a significant decline in range size for almost every endemic vertebrate in the Wet Tropics of Queensland.

A relict species of the Gondwanan unique to Australia and Papua New Guinea, the Southern cassowary (*Casuarius casuarius johnsonii*) is endangered by habitat loss. It is the third-largest bird in the world after the ostrich and emu – adults grow up to 1.8 m tall and weigh about 60 kg. Cassowaries feed on the fruits of over 150 rainforest tree species in the Wet Tropics, passing viable seeds in large dense scats (faeces). By dispersing seeds over more than 1 km, they make a key contribution to the rainforest's rich biodiversity



© Paull Isenboom

Vertebrates living in these isolated tropical mountain rainforests may become trapped with nowhere to go, in response to the projected changes in climate. Many species could be lost in the Wet Tropics of Queensland within the next 50–100 years, including a number of frogs, mammals, birds and skinks. The extent of biodiversity loss will depend on the rate and timing of climate change.

Australia's Marine and Tropical Scientific Research Facility is conducting research to formulate feasible, proactive management initiatives on a regional scale in response to projected climate change. This research programme, which benefits from substantial funding from the Australian government, will refine present climate change models and scenarios to verify which species and ecological communities are most at risk, the long-term effects of these threats and their geographical distribution, how climate change might interact with other threats such as clearing, fragmentation, fire, weeds and feral animals; and whether, or where, some areas may provide continued habitat, or new areas of habitat, in the future.

Concerning the Wet Tropics World Heritage Area specifically, the James Cook University in Townsville, Queensland, has established a Centre for Tropical Biodiversity and Climate Change Research that will focus its efforts on the impact of climate change on the biota of the Wet Tropics of Queensland.

and at a higher altitude, by forcing species to move up the mountains and reducing the availability of water. Yet one of the attributes of the site relevant to its listing under natural criteria is the variability of vegetation in response to decreasing temperature across an altitude range of 100 m to 1400 m.

For example, the upland swamps of the Greater Blue Mountains contain some unique species that are adapted to seasonally waterlogged soils. These species are at risk of being displaced by species tolerant of drier soils. Upland swamps also provide habitat for the endangered skink *Elamprus leuraensis* and the Giant Dragonfly. Their ability to retain and slowly release water also contributes to the survival of threatened plants, such as *Microstrobos fitzgeraldii* and *Epacris hamiltonii*, which have adapted to permanently moist habitats. Swamps currently at the lower end of the suitable rainfall spectrum would be most vulnerable to contraction due to changes in rainfall and/or evaporation associated with climate change.

Evidence of climate change still anecdotal

Much of the evidence of the impact of climate change on the ecosystems of the Greater Blue Mountains is anecdotal for the moment and has not been supported by adequate, systematic research. It is reported for example that at least one eucalypt species, *Eucalyptus corpulens*, related to the Snow Gums of the alpine regions, no longer grows in the Blue Mountains region. Some horticulturists and botanists attribute this to climate change.

Production from agriculture and forestry by 2030 is projected to decline over much of southern and eastern Australia ... due to increased drought and fire.

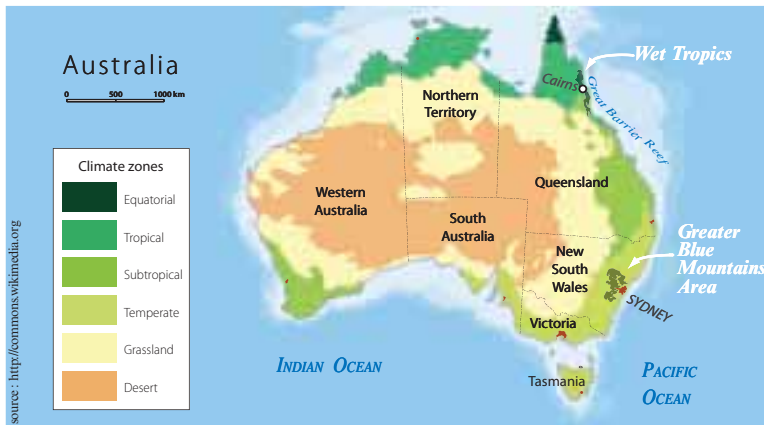
IPCC (2007)

There is also evidence of a lasting impact of the intense bush fires of 2002–2003, where normal regrowth of eucalypts has not occurred in the upper Greater Blue Mountains region.

The spread of the soil pathogen *Phytophthora* is having a serious impact on a number of plant species in the mountains. Plant stress due to drought, erosion and the movement of soil due to extreme weather are believed to be some of the causes for its spread and impact on many vulnerable plant communities. There is evidence of greater long-term stress on hanging swamps¹⁴ and the invertebrate species that depend upon these swamps, due to hotter and drier conditions. However, it is difficult to substantiate the claim that climate change is the cause, due to the lack of adequate research.

A better understanding for better protection

Several research projects into the impact of climate change on the Greater Blue Mountains are being conducted under the auspices of the Australian Greenhouse Office, the New South Wales Department of Environment and Conservation and the Blue Mountains World Heritage Institute. The topics under study include the impact of climate change on biodiversity and ecosystem functions (terrestrial and aquatic), synergistic effects on other threats like invasive species and risks posed by bushfires to people and property.



The Strangler Fig (*Ficus virens*) is one of the largest trees in tropical north Queensland. It germinates atop another tree, its seeds often being dispersed by birds. As it grows, it drops its roots until it “strangles” its host. This adaptation gives the Strangler Fig a distinctive height advantage in the competition for sunlight, which can only be reached by growing above the dense tree canopy

With other partners, the Blue Mountains World Heritage Institute is undertaking a three-year research project between 2007 and 2010 to assess a range of threats to the region’s ecosystems, including climate change.

The Institute is also establishing collaborative research programmes with other research institutes in France and the USA to share research and techniques for addressing extreme weather conditions, more frequent drought, greater fire risk and other impacts of climate change.

*The Wet Tropics is home to Lumholtz’s Tree-kangaroo (*Dendrolagus lumholtzi*), which stands less than 60 cm tall. A nocturnal, solitary animal, it spends most of its time in the tree canopy feeding on leaves and fruits*



If the time-frames of the present climate change models are correct, we have very little time left to develop and test mitigation strategies for conserving both natural and cultural World Heritage sites. It is imperative that international agencies encourage developed countries with research capacity to engage in appropriate local and collaborative international research to support mitigation strategies as soon as possible. The window of opportunity may be smaller than we think.

Nothing is a substitute for tackling CO₂ emissions

While there are now better methods for fighting bushfires and managing some of their more damaging impacts, this is not going to be a substitute for addressing the underlying problem of CO₂ emissions. What is needed is much greater public awareness of the real costs to present and future generations of the loss of biodiversity and ecosystem services that are presently taken for granted.

John Merson¹⁵

Read: Case Studies on Climate Change and World Heritage: <http://whc.unesco.org/en/othermaterials/>

With thanks to Yacoub Raheem from the World Heritage Centre

A long evolution in isolation

The Wet Tropics region is home to about one-third of Australia’s 315 mammal species, including unique green possums, fierce marsupial cats, kangaroos that climb trees and rare bats. As well as relatively common Australian mammals like the platypus and wallaby, the Wet Tropics is home to 13 mammal species found nowhere else in the world. All but two – the endangered Tropical Bettong (*Bettongia tropica*), and the Mahogany Glider (*Petaurus gracilis*), a possum – are rainforest dwellers. These include two tree-kangaroos (see photo), a rat-kangaroo, four ringtail possums and a melomys (native rat).

Some of the Wet Tropics rainforest species have close relatives in New Guinea and Southeast Asia. When Australia became isolated after the break-up of the supercontinent of Gondwana [Ed: Australia separated from Antarctica about 67 million years ago], it drifted northward. About 15 million years ago, it bumped into the Asian continental plate. This collision allowed an exchange to take place between two sets of animals and plants which had evolved in isolation. Asian flora and fauna, including many placental rats, moved into Australia. At the same time, Australian species moved north. Many of them colonized New Guinea, a new high altitude land mass created by the ‘bow wave’ of Australia’s northerly drift. As a result, some of the unusual mammals of the Wet Tropics also live with Australia’s northern neighbours, including the Long-tailed Pygmy Possum in Papua New Guinea and the tiny Tube-nosed Insectivorous Bat (weighing just 8 g) in Southeast Asia.

11. Hilbert, D. et al. (2001) Sensitivity of tropical forests to climatic change in the humid tropics of north Queensland. *Australian Ecology* 26: 590–603
12. IPCC (2007) Impacts, Adaptation and vulnerability. *Executive Summary for Policy-makers. WGII Fourth Assessment report. April.* Lesley Hughes, cited in this article, was the lead author of the chapter on Australia and New Zealand and a contributing author to the chapter on ecosystems: www.ipcc.ch
13. The leaves on plants in sclerophyll forests contain a lot of woody tissue, making the build-up of top soil very slow
14. A shallow swamp with a wealth of plant life. Constant saturation creates anaerobic (oxygen-starved) conditions in the soil, inhibiting the decomposition of dead plant material, which accumulates as peat. Peat acts as a sponge, retaining rainwater for later slow release
15. Author of a case study on the Greater Blue Mountains World Heritage site, an abridged version of which was published in Case Studies on Climate Change and World Heritage, Blue Mountains World Heritage Institute: j.merson@bmwhi.org.au

Source: Wet Tropics Management Authority: www.wettropics.gov.au/pa/pa_mam_info.html

Diary

1-5 July

Quranic Botanic Garden

Intl Advisory Committee meeting. Shahaniyah (Qatar): b.boer@unesco.org

2-6 July

Convention on Biological Diversity

12th meeting of Subsidiary Body on Scientific, Technical and Technological Advice to the CBD. Hosted by UNESCO Paris: www.biodiv.org; s.arico@unesco.org

8-12 July

S&T education

World conf. organized by ICASE, sponsored by UNESCO. Perth (Australia): www.WorldSTE2007.asn.au

28 July - 3 August

Black Sea - Mediterranean Corridor

Special UNESCO-IGCP session at INQUA Congress: to coordinate research and correlate findings from East and West on paleo-environmental cataclysms over 30 000 years and their influence on human adaptive strategies. Cairns (Australia): www.inqua2007.net.au/index.htm; m.patzak@unesco.org

9-11 August

STI for a prosperous and securer Islamic world

Intl symposium organized by UNESCO, Ministry of STI, Academy of Science of Malaysia. Preceded by conf. for young scientists from Islamic countries 6-7 August. The new Consortium on STI for South (COSTIS) will prepare first COSTIS conf. Kuala Lumpur (Malaysia): m.el-tayeb@unesco.org; www.costis.g77.org

13-19 August

Karst hydrogeology and ecosystems

Joint intl conf. of 4 major intl karst research groups, including IGCP Project 513: Global Study of Karst Aquifers and Water Resources. Western Kentucky Univ. (USA): <http://hoffman.wku.edu/karst2007/k2007.html>; m.patzak@unesco.org

20-24 August

Indigenous knowledge and changing environments

Intl experts meeting of indigenous peoples and experts working on nature-society interface. Organized by

UNESCO LINKS with support from Christensen Fund. Hosted by James Cook Univ. and Australian Nat. Comm. for UNESCO. Cairns (Australia): www.unesco.org/links, d.nakashima@unesco.org

27-28 August

Renewable energy

4th regional forum co-organized by UNESCO. Montevideo (Uruguay): dgorfinkiel@unesco.org; geo@unesco.org

31 August

Groundwater and climate in Africa

Deadline for abstract submission to conference on 25-28 June 2008 for water and climate scientists from public and private sectors, intl agencies, donors. Sponsored by UNESCO-IHP, IAHS, IAH etc. Kampala (Uganda): www.gwclim.org/; a.aureli@unesco.org

1-5 September

East Asia MAB Network meeting

Ulan Bator (Mongolia): mab@unesco.org

2-7 September

Ecotourism, biosphere reserves, WH sites & geoparks

Training and seminar for Arabian Peninsula, Muscat & Salalah. Oman: b.boer@unesco.org

3-5 September

S&T Parks Development

Asia-Pacific training workshop for present and future managers, run by UNESCO, with Govt of Indonesia, KOICA, WTA. To select science park for UNESCO-WTA pilot project. Bogor (Indonesia): y.nur@unesco.org

3-6 September

Climate and water

3rd intl Conf organized by Finnish Environment Institute, Helsinki University of Tech., Academy of Finland. UNESCO, WMO and IAHS contributing via Scientific Committee. Helsinki, Finland: www.ymparisto.fi/; a.liipponen@unesco.org

6-13 September

Sustainable management of marginal drylands

6th intl workshop for SUMAMAD project. Xilinhot City (China): t.schaaf@unesco.org; c.lee@unesco.org

10-15 September

AfriMab Network meeting

Cape Town (South Africa): mab@unesco.org

10-11 September,

Group on Earth Observations capacity-building

1st global symposium. Sevilla (Spain): www.earthobservations.org; y.berenguer@unesco.org

12-14 September

New directions in urban water management

UNESCO-IHP Intl Symposium on results of IHP Urban Water Management Programme. UNESCO Paris: SymposiumUWM2007@unesco.org; www.unesco.org/water

14 September

UNESCO-L'OREAL fellowships

Deadline for applications for 15 fellowships of \$40 000 each for doctoral or post-doctoral research in life sciences. Open to women under 35 years from all Member States. Up to 4 candidates per country: www.unesco.org/fellowships; s.mougharbel@unesco.org; www.forwomeninscience.com

17-21 September

Groundwater and ecosystems

IAH Congress with UNESCO-IHP, UNEP et al. Lisbon (Portugal): a.aureli@unesco.org; s.demuth@unesco.org; www.iah-2007.com/

18-20 September

STI indicators - trends and challenges

Seminar/workshop run by UNESCO science policy programme, UNESCO Institute for Statistics and UNESCO Moscow for high-level staff from S&T policy bodies and universities of Armenia, Azerbaijan, Belarus, Moldova, Russia. Moscow: e.martinez@unesco.org, m.prchalova@unesco.org

19-21 September

MAB Bureau meeting

UNESCO Paris: mab@unesco.org

25-27 September

Vice-Chancellors, Deans of Science, Engineering and Technology in Africa 2nd regional conf.

Main organizer UNESCO Nairobi. In Pretoria (South Africa): j.massaquoi@unon.unesco.org

25-28 September

Renewable energy: realities and perspectives

Workshop on removing barriers to implementation of renewable energy technologies in Caribbean. Tobago: (in Kingston) m.kuzee@unesco.org

New Releases

Case Studies on Climate Change and World Heritage

Produced by UNESCO World Heritage Centre. English only, 80 pp.

Features 26 case studies of natural and cultural sites inscribed on UNESCO's World Heritage List which are threatened by climate change. (See p. 20).

Download: <http://whc.unesco.org/en/othermaterials>

Marine Habitat and Cover

Their Importance for Productive Coastal Fishery Resources

By John F. Caddy. Oceanographic Methodology series, UNESCO Publishing, ISBN: 978-92-3-104035-1, 26.00 €, English only, 256 pp.

Maintains that, when fishery resources are depleted, harvest controls alone are ineffective for their recovery and subsequent conservation; integrates ecological and management notions into a common framework; targets marine ecologists, engineers, coastal oceanographers, those involved in marine fisheries and aquaculture, and those protecting threatened or overexploited fishery resources.

Gender Indicators in Science, Engineering and Technology

An Information Toolkit

Sophia Huyer and Gunnar Westholm. Produced by UNESCO's Division of Basic Sciences and Engineering, S&T for Development series. UNESCO Publishing, ISBN 978-92-3-104038-2, 20.00€, English only, 142 pp.

Offers policy- and decision-makers, researchers and practitioners guidance in collecting gender-disaggregated data. Looks at international methods for

measuring R&D, personnel, qualifications and occupations, as well as how these can be properly disaggregated by gender, age and other variables. Discusses the reasons for differential rates of participation between women and men.

Open Training Platform

Portal of free training materials powered by UNESCO. English only.

Covers key areas for development, including science, engineering and natural resources management. Fed by United Nations and others: e.g., one biotechnology education module has been produced jointly by Punjab State Council for S&T and UNESCO's Section for S&T Education. New material added regularly to this user-rated platform. Most of the training platform's programmes have open licenses like Creative Commons, meaning they may be used by anyone for non-commercial purposes.

To access: www.opentrainingplatform.com. For details: a.arrou@unesco.org

Nanotechnologies, Ethics and Politics

Ethics Series, UNESCO Publishing, 22.00€, ISBN: 978-92-3-104051-1. In English and French (Arabic, Chinese, Russian, Spanish to come), 244 pp.

Written by 14 advisors to the World Commission on the Ethics of Scientific Knowledge and Technology (COMEST). For background, see *A World of Science*, April 2007.

Environmental Ethics and International Policy

Ethics Series, UNESCO Publishing, 22.00 €, ISBN: 92-3-104039-1, English only, 226 pp.

What is the moral value of the environment? What in nature is worth protecting, preserving or respecting? What do we mean by global sustainability? Eight advisors to COMEST develop approaches for determining how international policy can promote ethical reflection on the environment.

