A World of SCIENCE

Vol. 11, No. 2 ■ April–June 2013

Out of sight, out of mind?

'If more women owned mobile phones, there would be more development.'

Rebirth of a hunter

A little technology can go a long way

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Director of Publication:
Gretchen Kalonji;
Editor: Susan Schneegans;
Lay-out: Mirian Querol.

Register for a free
e-subscription:
s.schneegans@unesco.org,
fax: (331) 4568 5827

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Partnering in **groundwater** governance

Some 97% of the ready-to-use freshwater on Earth – that in liquid form – comes from underground aquifers. Groundwater is thus a public good for an obvious reason: it is a collective lifeline. In June 2010, the United Nations formally acknowledged the right to water, in a binding resolution adopted by 122 countries.

The question is: how do you ensure equitable access and prevent depletion and pollution when there are so many competing players? About 43% of the water used for irrigation worldwide comes from aquifers. In Europe and North America, however, the biggest user of freshwater is industry. It thus made sense to invite private corporations to the table last March when 22 countries of the UN Economic Commission for Europe met in Delft (Netherlands) to discuss ways of improving groundwater governance. The regional consultation was organized by UNESCO, the FAO, Global Environment Facility, World Bank and International Association of Hydrologists, within the Groundwater Governance Project described overleaf.

The roundtable explored avenues for involving the private sector more closely in groundwater governance. Instruments already exist but, whereas governments rely on regulations, laws and subsidies to govern groundwater use, the private sector tends to be more concerned with obtaining permits, compliance reporting and avoiding 'bad behaviour' that might damage its reputation with consumers.

Corporations which drill into the Earth in search of water, minerals, oil or gas gain vast knowledge of the subsurface. As this gives them a comparative advantage and comes at great cost, some corporations are reluctant to share their data with the public sector, particularly if this could expose them to future liability. Yet the public sector needs this knowledge and data. Now, more than ever, the public sector needs the financial might that corporations can wield; much of existing water infrastructure, for instance, has been provided or financed by the energy sector. How then can the public sector drive a sharing culture with the private sector? Some panellists had the answer: with big carrots and small sticks!

The panellists – from Schlumberger, Shell, Heineken, Vitens, Nestlé Waters, etc – expressed readiness to cooperate and share their data. They could see that consolidating ties with the water community, government and agriculture sector was in their best interests. After all, as Andrew Cameron from Shell observed, many decisions that appear to fall outside the domain of groundwater governance still have an impact on groundwater use, including energy and land-use policies, trade and agricultural subsidies. The problem is the lack of clear mechanisms for consolidating these ties. One wit described the groundwater scientist community as being 'like a ghetto.'

Then there is the 'cultural' barrier. Companies might need a decision 'by Monday,' for instance, but governments do not work to such time scales. Conversely, companies' long-term investment plans rarely match the short cycle of electoral mandates. Could the best way to engage people across sectors and scientific disciplines be to focus on a risk-based approach, a language understood by all stakeholders?

The mood of the meeting was summed up by Ronan LeFanic from Nestlé Waters. 'It is the first time that we can present our vision and expertise on this topic and discuss with a broad range of experts how to enhance groundwater governance,' he enthused. 'We are willing to participate in future meetings to follow up the conclusions of this roundtable.'

UNESCO's International Hydrological Programme is taking him at his word. In September, it is organizing a full-day seminar for the public and private sectors. Several panellists have agreed to help prepare the programme.

Gretchen Kalonji
Assistant Director-General for Natural Sciences

Out of **sight**, out of **mind**?

Women recover water from a well in Niger, within an FAO project to boost agro-pastoral production.

Worldwide, 2.5 billion people depend solely on groundwater for their daily needs. Hundreds of millions of farmers irrigate their fields with groundwater to produce food for the masses. Yet experts consider that few, if any, of the world's aquifers are being managed sustainably or equitably. The truth is that groundwater science, law and management are still in their infancy. Incredible as it may seem, we know much more about the planet's oceans, lakes and rivers than we do about the lifeline beneath our feet. This hasn't prevented us from pumping it with growing voracity.

The Groundwater Governance Project aims to raise awareness of the paramount importance of managing the planet's aquifers sustainably, in order to influence political decision-making and thereby avert the impending water crisis. The last of five regional consultations, that for 22 countries of the UN Economic Commission for Europe (UNECE[1]), has just concluded in The Hague on 19–21 March.

The Groundwater Governance Project was initiated in September 2011 by FAO, UNESCO, the World Bank and the International Hydrological Association (IAH), which are contributing US$2.7 million to the project. The Global Environment Facility (GEF) is providing a further US$1.75 million. Via a vast consultation, the three-year project intends to develop a Global Framework for Action targeting policy-makers and stakeholders. Eleven thematic papers have been prepared for these consultations to highlight key issues.

The Global Framework for Action will consist of a set of governance tools that include policy options, legislation, regulations and customary practices. In a nutshell, good groundwater governance is the art of coordinating administrative procedures and decision-making at different jurisdictional levels, one of which may be global. It lays the foundations for management practices that ensure broad participation, transparency, data- and information-sharing and conjunctive use *(see box)*.

The lack of effective governance is one of the main causes of groundwater depletion, aquifer pollution and inequitable allocation. As needs and priorities tend to vary from one locality to another, UNESCO convened five regional consultations[2] between April 2012 and March 2013 with local groundwater experts, agencies, ministries and other stakeholders, in order to ensure that local concerns fed into the Global Groundwater Governance Diagnostic. This diagnostic will then serve as the basis for the Global Framework for Action.

Africa's blue gold

At the regional consultation in Nairobi (Kenya) in May last year, David Stower, Permanent Secretary of the Kenyan Ministry of Water and Irrigation, said that 'we need to stop looking at groundwater only in emergency situations and as a last resort. This is a narrow view that needs to be addressed and reversed,' he said, 'in order to fully apply the principles of integrated water resource management. The sub-Saharan region faces several challenges,' he added, 'including poor understanding of groundwater regimes and poor and inadequate data and information.' He concluded by saying, 'I hope that this very important regional meeting will outline practical solutions to address the unique groundwater challenges facing our region.'

Two years after the worst drought in 60 years, some 12 million people are at risk of starvation in northern Kenya and parts of Ethiopia and Somalia. Within UNESCO's Groundwater Resources Investigation for Drought Mitigation in Africa

Programme (GRIDMAP), experts have spent the past year mapping the location of groundwater using WATEX remote-sensing technology, in order to bring the weakened population a sustainable water supply. In parallel, Kenya has launched a Regional Groundwater Training and Research Centre in the past year, under the auspices of UNESCO, to improve the long-term management of East Africa's aquifers.

Although Kenya is considered a water-scarce country, with about 647 m^3 water per capita per year, the Ministry of Water and Irrigation cited studies which show that Kenya may have up to 60 billion m^3 of groundwater potential that simply needs locating. 'Groundwater's advantages are numerous.' said Kenya's Assistant Minister, Fednand Waititu, in Nairobi. 'Its occurrence in many places, the speed with which it can be developed, the relatively low capital cost of development, its drought resilience and ability to meet water needs on demand all make it a critical component of the rural water supply and for small towns, as well as for domestic water, irrigation, industrial and commercial uses.' In Kenya's 2009 census, 43% of rural and 24% of urban households identified a spring, well or borehole as being their main source of water.

Signs of poor governance: overmining and pollution

Groundwater is the source of nearly half of all drinking water in the world and represents about 43% of water used in irrigation. Over the past 50 years, groundwater abstraction has tripled, thanks to the widespread availability of energized pumping. Agriculture is the dominant user but pumping in and around urban areas can be even more intensive.

The decision whether or not to turn on a groundwater pump seems difficult to regulate. This is because access to groundwater is perceived as an essentially private concern, even though most jurisdictions define all water as being a 'public' good. The users are an identifiable group, however: those with access to a pump. If you add to this group those who spread chemical fertilizers and pesticides, extract oil, gas or minerals, dispose of untreated or dangerous (nuclear, chemical, etc) waste, or build underground (tunnels, transport systems, sewerage systems, etc), almost everybody bears some responsibility for the quality of groundwater.

Kakuma Refugee Camp in Turkana (Kenya), which now has access to a sustainable water supply, thanks to a UNESCO project which identified where to drill boreholes. These are now being drilled across the drought-stricken region.

This arguably makes protecting aquifers from surface pollution a more difficult governance issue than groundwater pumping. Studies conducted by UNESCO in Abidjan (Côte d'Ivoire) found concentrations of nitrates, ammonium and aluminium in groundwater in excess of WHO standards for drinking water. This chemical pollution had been caused by the use of pesticides and fertilizers in industrial plantations of pineapple, rubber and palm oil. In 2002, UNESCO's Nairobi office initiated a joint project[3] with UNEP to assess the impact of pollution on aquifers in Abidjan and eight other major African cities. The project developed methodologies for assessing groundwater vulnerability and identifying pollution hotspots and major threats. It also set up an early warning system involving a network of African scientists and alerted decision-makers in the public and private sectors to the dangers of indiscriminate waste disposal.

It is always easier to solve a problem of pollution when there are good lines of communication. In the Indian State of Tamil Nadu, the aquifer was being contaminated by chromium waste from a local chemical company. Thanks to a dialogue between researchers and decision-makers, the company has since reformed its practices. In the city of Hyderabad, water was being polluted by the immersion of large Ganesh idols during a religious festival. A respectful dialogue with the local

Promoting conjunctive use in Kenya

Kenya has spent five years developing an Integrated Water Resources Management and Water Efficiency Plan. The plan integrates a number of recommended governance practices, including a broad stakeholder consultation process, decentralized management and conjunctive use.

Conjunctive use refers to managing groundwater and surface water as a single entity, rather than as two separate sectors. Conjunctive use does not necessarily mean that both waters are used simultaneously, as groundwater can compensate during dry periods for the seasonal nature of rivers. Nairobi, Nakuru, and Machakos already operate conjunctive use schemes but that these sometimes bear a closer resemblance to a coping strategy than a planned approach to meeting water demand.

The lack of rational land use planning has meant that attempts to restrict abstraction from the Nairobi aquifer system have come up against indifference, commercial interests and a building boom. Moreover, the poor level of compliance by water users with respect to water permits and the payment of water-use charges makes water allocation an uncertain exercise at best.

The construction of the Kiserian Dam to supplement existing groundwater supplies to several Kenyan towns and cities is a conjunctive use scheme. The private commercial irrigation sector also often uses surface water and groundwater conjunctively, as for example in the Naivasha and North West Mt Kenya areas.

Source: A. Mumma et al. (2011) Kenya Groundwater Governance Case Study. *World Bank*

community resulted in the extended immersion of idols being replaced by a quick dip!

Deep-seated challenges

Deep-seated aquifers (beyond 500 m) can act as a buffer against climate change, as they are isolated from the active hydrological cycle and thus from climatic variation. They are also ideal in an emergency like an earthquake, if water from shallower aquifers has become contaminated or depleted. This 'fossil' water is not replenished, however, so once it is gone, it is gone forever. Yet the Nigerian city of Lagos relies permanently on deep boreholes (800 m+) to compensate for its chronic water supply problems.

There are few specific regulations governing water in deep-seated aquifers, as van der Gun *et al.* (2012) recall in one of the thematic papers written for the Groundwater Governance Project. In some countries, mining laws even supersede water law beyond a certain depth.

Even deep-seated aquifers can be affected by pollution or depleted. In the 1930s, abandoned oil and gas wells in Kansas (USA) were found to be responsible for the salinization of aquifers. Deep-seated aquifers may also be contaminated by drilling fluids, the infiltration of surface disposal or reinjected fluids.

'Oil and gas wells are the second most wide-scale intrusion into the underground space after water wells,' observe van der Gun *et al.* 'By the second half of the 20th century, major oil companies had built up a very questionable legacy of bad practices in many oil and gas provinces. These companies are adept at evading any subsequent penalties arising from cavalier practices, as seen in the Niger Delta, where the environmental damage places it in the world's "top ten" of worst contamination events.'

Drilling rig

The authors recommend that countries with weaker legislation or enforcement capabilities review their oil and gas licensing agreements to make sure these include ample internationally recognized indemnities to cover all potential resource and environmental degradation. As the oil and gas companies will resist such a move, the authors suggest that either the WTO or another relevant UN agency could design and implement this insurance cover on behalf of oil and gas exporting countries.

New frontiers, new risks

Several new frontiers in electricity generation involve drilling to reach unconventional sources of energy. These include oil (or tar) sands, an industry pioneered by the Canadian State of Alberta, and shale oil and gas. All three resources are extracted using techniques that consume a lot of water and … energy.

According to Alberta Energy,[4] 80% of the state's known oil sand reserves lie more than 75 m beneath the surface, too deep for open-pit mining. Various techniques are used to extract these deep-seated resources, which represented 49% of total oil sand extraction in 2011. There is concern that aquifers may be contaminated both by drilling and by surface pollution, which can percolate through geological layers. Open-pit mining requires

Preserving the Pacific's fragile underground lifelines

For the low-lying atoll nations of the Pacific, securing safe and sufficient freshwater is a constant challenge. Unreliable rainfall patterns and the absence of lakes or rivers mean that many atoll communities rely almost exclusively on small and fragile lenses of freshwater that 'float' on the underlying seawater.

Both the quality and quantity of this groundwater are now threatened by population growth, urbanization and climate change. Groundwater is already suffering from saltwater intrusion as a corollary of rising sea levels. Rainfall is also becoming increasingly erratic, raising the spectre of periodic drought.

On the main island of Kiribati, a woman recovers water from a well polluted by the toilet nearby.

In the small island state of Kiribati, population densities are among the highest in the world, yet the population is growing at a rapid rate of 3.87% per annum. This is having a profound effect on groundwater.

Kiribati is a collection of 32 low-lying atolls spread across 3.5 million km^2 of ocean. Nearly half of the small island state's 103 000 citizens live on the main island of South Tarawa. Here, widespread contamination of groundwater by nitrates and bacteria, compounded by saltwater intrusion, has left residents dependent on a piped water supply that is available for only two hours three times a week. The government is now contemplating expensive alternatives to groundwater like desalination technologies.

Necessity being the mother of invention, this dire predicament has spawned a number of innovative approaches. The recent success of ecosanitation, or composting toilets, in Tuvalu is being shared with 11 other Pacific countries. Pisi Seleganiu, Project Manager of Tuvalu's Integrated Water Resources Management Demonstration Project, is actively assisting the Marshall Islands, for instance, in building and testing composting toilets on Majuro Atoll. This project is funded by GEF and coordinated by the Secretariat of the Pacific Community's Applied Geoscience and Technology Division (SOPAC).

SOPAC is also coordinating national training workshops in ecosanitation in Kiribati and elsewhere which bring together all the relevant ministries – those for agriculture, land development, public works, environment, water, health, etc – with relevant NGOs.

Source: Dave Hebblethwaite, SOPAC

8–10 barrels of water for every barrel of oil produced. Even though much of this water is recycled, it still ends up mixed with sand and chemicals as slurry in artificial lakes known as tailing ponds.

Likewise, the technique used to extract shale oil and gas, hydraulic fracturing of the rock using pressurized fluids, 'has become a contentious environmental and health issue,' state van der Gun *et al.*, 'with France banning the practice and a moratorium in place in the State of New South Wales (Australia), Quebec (Canada) and some states of the USA. Concerns […] include the contamination of groundwater, risks to air quality, the migration of gases and hydraulic fracturing chemicals to the surface and the potential mishandling of waste.'

Another new frontier is 'supercritical water', a form of geothermal energy currently being experimented in Iceland, where three wells have been drilled to a depth of 4–5 km. Above 374°C and 221 bar pressure, the distinction between liquid and vapour disappears as water enters a supercritical phase. This water is brought to the surface as superheated steam. Although supercritical water is renewable – the water is reinjected into the aquifer – its extraction is energy-intensive and costly.

Geologists are also exploring carbon capture and storage. It is planned to store carbon dioxide (CO_2) in unused gas and oil reservoirs and other underground repositories to reduce carbon emissions to the atmosphere. As CO_2 tends to become liquid or supercritical beneath 800 m, it will most likely be stored beyond this depth. One concern is that this liquid CO_2 could then leak into aquifers.

Few urban experiments in collective governance

Most experiments in groundwater governance are taking place in rural settings, where agricultural use dominates. In India, for example, one village council faced with overpumping took things into its own hands, with pleasing results (*see box*).

There is little evidence of collective approaches to aquifer management among urban users, even though groundwater dependency can be higher in peri-urban and urban areas than in rural areas. This is all the more problematic in that the urban population is slated to nearly double to 6.3 billion by 2050, up from 3.4 billion in 2009. High population growth in many of the world's cities is already creating a shortage of freshwater that can be an acute source of tension. For instance, high tariffs or an inefficient water distribution system can incite urban dwellers to bore private wells.

This is what happened in Aurangabad City. Located in the elevated, drought-prone interior of Maharashtra State (India), the city has very limited groundwater. In the past 20 years, its population has grown rapidly to 1.1 million. Many inhabitants have bored private wells to ensure a reliable water supply. Since 2004, the Aurangabad Municipal Corporation has been considering increasing the quantity of water it imports from a reservoir situated 45 km distant. The scheme would necessitate an initial investment of US$80 million and generate high recurrent costs. The municipality has been trying to introduce volumetric charging (household meters), in order to ensure cost recovery and manage demand, but the proposal has met with public resistance. One solution might be for the municipality and relevant state government departments and agencies to form a standing committee, in order to devise a policy that would regulate the exponential rise in the number of private bore wells.

In Fortaleza in northeastern Brazil, one of Latin America's fastest-growing cities, the supply of surface water by the Companhia de Agua e Esgoto do Ceará tends to be unreliable during periods of peak demand and drought. This has prompted 40–60% of the population to supplement its water supply with private wells. In 2003, there were almost 10 000 documented wells in Fortaleza, a six-fold increase over 1980. Over 70% of these wells are polluted with raw sewage or seawater.

A village council takes charge

Overpumping of groundwater is a familiar problem to both rural and urban India, with aquifers being depleted in the hard rock terrain of peninsular India, the coastal regions and in the sedimentary aquifers of the Ganges valley.

The village of Hivre Bazar lies in the elevated, drought-prone Deccan Traps area of Maharashtra State. The 1 200 villagers grow staple crops primarily for home consumption. In good years, almost 60% of the land can be irrigated but, in times of drought, wheat and summer crops have to be radically reduced. In the early 1990s, farmers struggled to feed their families and cattle without leaving the village periodically in search for paid work.

Under the leadership of an informed and charismatic chief, the Village Council adopted a comprehensive five-year plan in 1994 to improve groundwater management, as part of the Maharashtra Ideal Village Social Development Scheme.

Most importantly, village-level crop-water budgeting was introduced in 2002. In dry years, villagers are asked to reduce their proposed irrigated area and to give preference to low-water demand crops, with mutual surveillance usually being enough to achieve compliance. Sugarcane cultivation has been banned, owing to its high water consumption.

The Village Council also prohibited the use of borewells for agricultural irrigation. This incited farmers to maximize benefits from groundwater rather than competing with one another to dig deeper into the aquifer. Livestock grazing was also banned from some areas to favour reforestation.

This proactive approach to groundwater management has resulted in a marked contrast between Hivre Bazar and most of the surrounding villages.

Source : Héctor Garduño et al. (2011) India Groundwater Governance Case Study. *World Bank*

One consequence of overmining an aquifer is subsidence (*see box*). Confronted with severe subsidence of 7.5 m in the city centre which played havoc with infrastructure, building foundations and sewerage systems, Mexico City decided to relocate its wells to the suburbs. Subsidence in the city centre subsequently dropped to about 3 cm per year … but the suburbs were then found to be sinking by 45–60 cm a year![5]

Tensions at the periphery

Peri-urban areas and the urban–rural interface are becoming the theatre of a new form of simmering conflict. Among urban, domestic and agricultural users, an unhealthy competition is developing for the same resource.

Howard (2011) explores this theme in a thematic paper written for the Groundwater Governance Project. He explains that most

The day Bangkok began sinking

Greater Bangkok is underlain by a very productive aquifer system. Widespread exploitation of this groundwater commenced in the 1950s, leading to land subsidence of over 60 cm in the central city by the mid-1980s. The subsidence caused substantial damage to urban infrastructure and exposed the coastal city to a high risk of flooding during tidal surges. To compound matters, seawater intrusion threatened the quality of groundwater.

The public water authority progressively closed its pumping wells from 1985 onwards. However, the rising cost of tariffs for those connected to the mains water supply induced domestic, commercial and industrial users to drill private wells.

Confronted with a deteriorating environment, the government redoubled its efforts to control pumping by defining 'critical areas' where water well drilling was banned, adopted the power to seal water wells in areas connected to the mains and licensed and charged for groundwater according to metered (or estimated) abstraction rates. Initially, pricing provided little incentive to reduce pumping but at least it established an administrative framework and useful database. Subsequently, charges were raised and structured to ensure that the greatest financial burden was borne by industrial and commercial users in critical areas. Public awareness campaigns were introduced as the well-sealing programme was aggressively pursued.

Slowly, the situation was brought under control. By 2008, there were just over 4 000 licensed water wells in Greater Bangkok providing about 15% of the total water supply. Licenses are required for all wells more than 15 m deep. About 58% of the current licensed production is for industrial use. Many of the largest industrial water-users have been driven out of Greater Bangkok by the steep water charges.

Conflicts arose in some districts when an extension of the mains pushed up the cost of water. The dispute was resolved by allowing people to continue using their wells conjunctively for the duration of their current license and to retain their wells as a back-up supply for 15 years, provided they were adequately metered and open to inspection.

One groundwater management aspect which remains outstanding concerns groundwater pollution control in the recharge area to the north of Bangkok. Whereas the local regulatory agency has responsibility for identifying areas of higher vulnerability that lie within the capture zones of municipal wells, it has no jurisdiction over activities that are potentially polluting, such as the storage and handling of industrial chemicals, effluent discharge to the ground and agricultural practices. This urban–rural 'co-management' issue clearly needs resolving.

Source: Ken W.F. Howard (2011) Urban–Rural Tensions and Opportunities for Co-Management. *Thematic Paper 3. IAH Urban Groundwater Network.*

Food market in central Bangkok. Overpumping of groundwater caused subsidence in the 1980s which the authorities managed to bring under control by closing a number of wells.

groundwater-dependent cities are ultimately reliant on external aquifers over which they may have little, if any, jurisdiction or influence. The cities worry that farmers in peri-urban and rural areas will overmine the aquifer or pollute it with chemical fertilizers, pesticides, herbicides or wastewater. Attempts by cities to protect their drinking water at the periphery are often impeded by the fragmented nature of the administration, with regulations governing land use being disconnected from pollution control or from water use.

Howard observes that rural communities likewise feel at a disadvantage but for different reasons. Either they cannot compete financially with their urban neighbours or they are unable to influence water allocation owing to being less represented in positions of power, such as political parties and lobby groups. Farmers also worry about their groundwater being contaminated by urban runoff.

They agree with their urban neighbours on one point, though; it is very difficult to regulate when there are so many actors involved. NGOs, foreign government assistance programmes and private companies often act independently and work with different government ministries when implementing their respective agendas. The lack of coordination prevents responsible resource management (*see box*).

Adding another layer of complexity

From the foregoing, it is obvious that governance of the world's groundwater resources is still in its infancy. This is true at the local and national levels and even more so when it comes to transboundary aquifers, given the complexity of sharing groundwater across two or more borders.

To manage any aquifer efficiently, you need reliable data and information. Unfortunately, a decade ago, there was still very little knowledge of transboundary aquifers and certainly no regional or global estimations.

© FAO/Noah Seelam

Farmers on the Deccan plateau measure rainfall at one of 190 rain gauge stations, within an FAO project which is teaching them how to manage their limited freshwater resources in a sustainable manner.

To remedy the problem, UNESCO's International Hydrological Programme (IHP) launched the International Shared Water Resources Management (ISARM) programme in 2001. ISARM was the first attempt to inventory all transboundary aquifers and establish criteria for the sustainable management of these systems. As its name suggests, ISARM brings together specialists not only in hydrogeology but also from the legal profession, economics, international relations and ecological sciences.

ISARM's accomplishments include the compilation of regional inventories and the publication of the first *Atlas of Transboundary Aquifers* in 2009; the most recent update of the global map of transboundary aquifers, prepared in 2004, was released in 2012 (*pictured overleaf*). The ISARM inventory revealed that

Growing pains in Zhengzhou

Zhengzhou is a rapidly growing city of 8.6 million. It is located in the lower reaches of the Yellow River in water-scarce northern China. Some 39% of the population lives within the city limits and 61% in the surrounding rural area.

Groundwater represents about 70% of Zhengzhou's water supply, with just over half being used for agriculture. Industry is the next biggest user, at 31%.

Between 1990 and 2000, the number of tube wells increased from 37 164 to 42 763, lowering the water table and causing a shift from shallow to deep tube wells. Most of the new deep tube wells were funded by the government or village collectives.

In the city, sources of pollution include wastewater from industry and domestic sewage, whereas, in rural areas, the problem stems from fertilizers, pesticides and wastewater from livestock. According to the Water Resources Bureau of Zhengzhou, 1.5 million farmers (38% of all farmers) lack access to safe drinking water from ground or surface sources.

In theory, many of these problems could be resolved by requiring that all water-resources management, including groundwater, fall under the Ministry of Water Resources and its provincial and local arms. The reality is that, like in most of the world, management is scattered among a multitude of agencies, many with overlapping responsibilities. Insufficient communication and, in some cases, competing interests have resulted in groundwater regulations and policies being ineffectively implemented, or even conflicting one another. For example, one agency in Zhengzhou was working to close urban tube wells while others were opening new ones!

A reasonable goal would be to build institutional frameworks under which ministries and agencies with differing mandates and goals could share information on the state of groundwater resources and the impact of use. This would generate at least partial coordination of policies for groundwater management. It has been suggested that the Water Resources Bureau of Zhengzhou could take the lead and serve as a focal point for communication and coordination within Zhengzhou.

Source: Ken W.F. Howard (2011) Urban–Rural Tensions and Opportunities for Co-Management. *Thematic Paper 3. IAH Urban Groundwater Network.*

transboundary aquifer systems could extend over thousands of square kilometres and that the great majority were not directly connected to any international river basin.

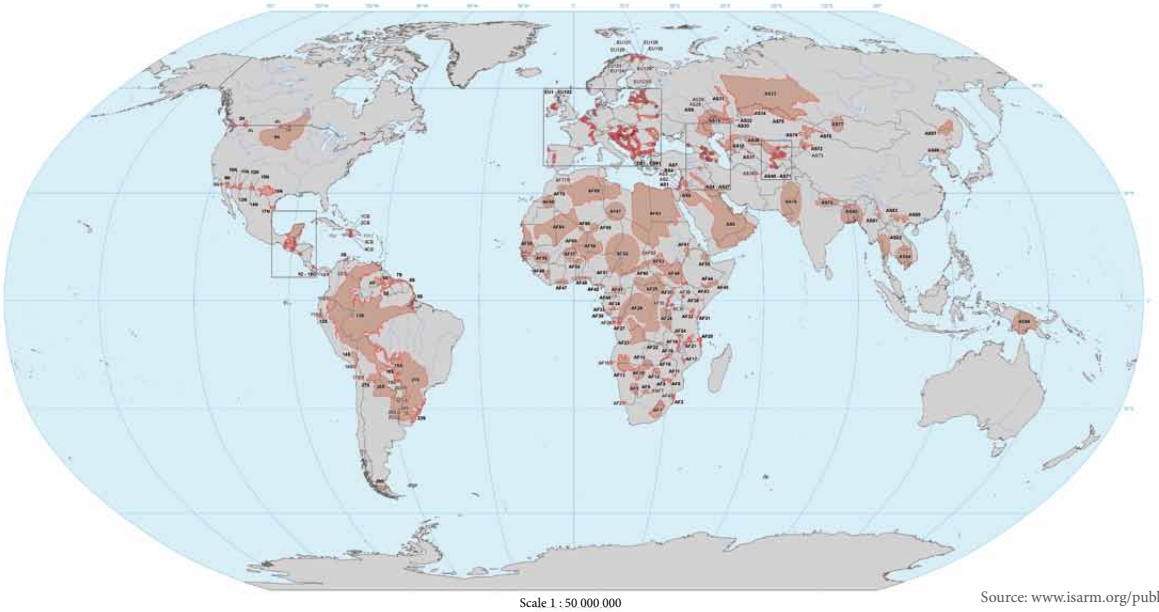
In just over a decade, ISARM has mapped more than 400 transboundary aquifers. The first continent to be targeted was Africa, in 2002. This was followed by the Americas in 2003, Asia in 2005 and the Balkans in Southeast Europe in 2009. Each inventory took several years to complete and helped to strengthen the knowledge base in other regions. The experience gained in Africa of karst aquifer systems, for instance, proved extremely useful in designing the DIKTAS project for Southeast Europe (*see box*).

Coming soon: a law on transboundary aquifers

Although groundwater represents 97% of available freshwater – the remainder being found in rivers and lakes – international law paid little attention to it until recently.

There are currently two global conventions on the use of transboundary water resources. The first is the Convention on the Protection and Use of Transboundary Watercourses and International Lakes (1992), which includes transboundary groundwaters. It concerned only the countries of UNECE until

Transboundary Aquifers of the World (2012)



Scale 1 : 50 000 000

Source: www.isarm.org/publications/419

Having a common purpose can favour reconciliation

The Dinaric Karst Aquifer System (DIKTAS) in Southeast Europe is one of the largest in the world. Like many karst areas, permeable rocks make up much of the landscape and there is only a thin layer of soil, if any at all. Rainwater seeps through the rock, resulting in an almost total lack of rivers and lakes and making groundwater the primary source of freshwater.

Prior to the 1991–1995 war which split Yugoslavia into several autonomous states, tourism was the main economic activity on the coast, compared to agriculture and hydropower inland. Today, the region's economic growth has been spurred, at least for some countries, by the opening of negotiations for accession to the European Union. Countries have enthusiastically embraced the European Framework Directive, which provides a framework for sustainable water management.

In 2009, UNESCO began carrying out a transboundary diagnostic analysis of the aquifer system to identify gaps in knowledge. This was part of the preparatory phase for the DIKTAS project, which assists Albania, Bosnia and Herzegovina, Croatia and Montenegro in particular in managing this precious resource. The project is funded by GEF, implemented by UNDP and executed by UNESCO.

In November 2010, the practical component of the four-year project got under way. Data were collected and a regional database complied during this first phase. The project is now putting mechanisms in place for the regular exchange of this information and data, while fostering greater cooperation among the participating countries.

Experts are currently conducting an in-depth analysis of the characteristics of the Dinaric Karst Aquifer System and its boundaries. Solutions are also being explored to the problem of competing demands for groundwater, coupled with pollution in some areas.

There is no multicountry policy at present to regulate land use and development planning, even though the aquifer is highly vulnerable to contamination and the upstream dams have an impact on downstream users. Even at the national level, there is often insufficient coordination among ministries, such as those for water, the environment, tourism, agriculture, spatial planning, forestry and energy.

The project is advancing so well that it looks as if the creation of a subregional cooperative mechanism will go ahead as planned.

Source: UNESCO

February this year when it was opened to all UN Member States. The second is the UN Convention on the Law of Non-navigational Uses of International Watercourses (1997), which considers groundwater only when related to a surface water body; it has not yet entered into force.

ISARM lifted a key obstacle to the development of an international law on transboundary aquifers specifically by establishing the first global inventory. In 2008, the UN General Assembly adopted Resolution 63/124, which includes, in annex, a set of draft articles prepared by the UN International Law Commission with the scientific and technical support of the UNESCO-IHP.

These draft articles include the core principles of international water law: 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 transboundary aquifers into the regular exchange of data. The draft articles then codify specific principles for the management of transboundary aquifers, such as their monitoring and protection, as well as for direct cooperation with developing states, or indirect cooperation through a competent international body like UNESCO.

The latest draft of the law is due to be discussed at the UN General Assembly in New York (USA) later this year. Whether or not the law is adopted in October, ISARM will continue encouraging governments to set up their own plans and commissions to manage shared aquifers jointly with their neighbours.

This is already the case in the Sahara *(see box)* and Latin America *(see box overleaf)*, for instance, where countries collaborate in managing three of the largest deep-seated aquifers in the world. The Guarani Aquifer Agreement (2010) is even the first to 'tak[e] into account also Resolution 63/124 of the UN General Assembly on the Law of Transboundary Aquifers.'

Agreements can also be brokered at the local level. In the arid border regions of Chihuahua (Mexico) and Texas (USA), concerted efforts across the border to foster conservation, quality wastewater treatment and artificial recharge of the Hueco–Bolson aquifer have paid off. The aquifer is the sole source of water for Ciudad Juarez (Mexico) and accounts for 30% of the domestic water supply for the city of El Paso (USA). Pumping of the aquifer by El Paso peaked at a high of 98 700 km^3 in 1989 but had been halved by 2002.

Managing fossil water in the Sahara

Some 10 000 years ago, the barren Sahara was a lush savannah. When the rains that fed the region disappeared about 3 000 years ago, they left behind a precious legacy: 373 000 km^3 of 'fossil water' in the twin reservoirs of the Nubian Sandstone Aquifer System, which spans Chad, Egypt, Libya and Sudan.

A Joint Authority for the Study and Development of the Nubian Sandstone Aquifer System was established between Egypt and Libya in 1989 to manage the aquifer system in a collegial fashion; it was formally launched in 1991, through the agreement on the Constitution of the Joint Authority for the Study and Development of the Nubian Sandstone Aquifer Waters. Sudan joined in 1996 and Chad in 1999.

In 1991, Libya began piping the aquifer's water across the country through the Great Man-Made River Project, the world's largest civil engineering scheme. As this fossil water cannot be replenished, this move sparked controversy.

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. Run by the Centre for Environmental Development of the Arab Region and Europe, the programme helped the countries to work together while giving the Joint Authority an active role.

In 2006, the IAEA launched a three-year study of the transboundary aquifer within the Nubian Project, together with UNDP, UNESCO and GEF. Specialists first prepared a Shared Aquifer Diagnostic Analysis of the priority issues and threats to the aquifer system. They then used sophisticated technology to fill the data gaps that were hindering strategic planning. A Strategic Action Programme followed, outlining the necessary legal, policy and institutional reforms needed to address the priority threats identified earlier by the project and their root causes.

The second-biggest aquifer system in the Sahara covers an area of about 1 million km^2 and is shared by Algeria (69%), Libya (23%) and Tunisia (8%). These three countries established a Consultative Mechanism for the Northwestern Sahara Aquifer System in 2002.

In the case of both aquifer systems, cooperation does not seem to have been perturbed by the regime change in Egypt, Libya and Tunisia during the Arab Spring of 2011.

Source: UNESCO/ IAEA

A nursery worker inspects rows of cypress and Senegalese mahogany trees in Ismailiya Governorate, within a National Tree Planting and Development of Peri-Urban Forestry project being executed by the Egyptian Ministry of Agriculture.

A challenge we cannot afford to ignore

As Alice Aureli, Senior Programme Specialist with the UNESCO-IHP, said at the Nairobi consultation last May, formulating good governance strategies for groundwater is a challenge we cannot afford to ignore. In the face of the unprecedented challenges that lie ahead, not least of which involves nearly doubling food and energy production in the next 40 years while coping with climate change and embracing sustainable development, humanity's very survival will depend upon how well we treat the lifeline beneath our feet.

Compiled by Susan Schneegans

Much of the information in this article can be found at the website of the Groundwater Governance Project: www.groundwatergovernance.org

1 *See: www.unece.org/oes/member_countries/member_countries.html*
2 *Latin America and the Caribbean* (Montevideo, Uruguay, 18–20 April 2012), sub-Saharan Africa (Nairobi, Kenya, 29–31 May 2012) , *Arab States* (Amman, Jordan, 8–10 October 2012), *East and South Asia and the Pacific* (Shijiazhuang, China,-3–5 December 2012), *Europe, Western and Central Asia and North America* (The Hague, Netherlands, 19–21 March 2013)
3 *See* A World of Science, July 2007: *http://unesdoc.unesco.org/images/0015/001516/151633e.pdf*
4 *See: www.energy.alberta.ca/OilSands/791.asp*
5 *See* A World of Science, *July 2005: http://unesdoc.unesco.org/images/0013/001399/139966e.pdf*

An aquifer of plenty

The Guarani Aquifer extends over 1.2 million km² and is thought to be the largest in Latin America. It is shared by Brazil (71%), Argentina (19.1%), Paraguay (6.1%) and Uruguay (3.8%).

People tend to associate Brazil with luxuriant vegetation and fast-flowing rivers but parts of the country are semi-arid, like the northeast. In these areas, nearly one-third of the total water supply comes from aquifers. Moreover, in the populous southern State of São Paulo, as much as 60% of urban centres are served by groundwater.

At the time it was launched in 2003, the Guarani Aquifer System Project was the first in Latin America to focus on transboundary aquifers and one of the first multicountry initiatives in groundwater to be undertaken worldwide. The project involved all four riparian countries and was funded by GEF. The World Bank implemented the project, whereas the Organisation of American States served as executing agency.

The quality of water in the Guarani Aquifer was found to be good, although some hot spots of pollution were detected in the recharge and extraction areas. It is still not known precisely what amount of water is drawn from the aquifer each year but scientists estimate that it could supply 300 litres of water per day to 720 million people.

The project first devised then implemented a common institutional framework for managing and preserving the aquifer. One achievement was the trust that developed among the four riparian countries, including through the sharing of information and data on the aquifer's characteristics.

The Ministry of Foreign Affairs in each country proved to be a critical actor in negotiations over the aquifer's management. The project also stimulated debate in the media and university sector. It clearly contributed to the success of the ISARM Americas Programme and has been hailed as a model for other countries to follow.

The project culminated in the adoption of the Guarani Aquifer Agreement on 2 August 2010. This umbrella agreement outlines general principles for cooperation among the four riparian countries and details plans for an institutional mechanism which would manage the aquifer within the Commission on the Río de la Plata.

Source: UNESCO

Rush hour at an underground station in São Paulo, one of the world's biggest megacities. Across the state, 60% of urban centres are served by groundwater.

Photo: Wikipedia

Geoscientists to map **toxicity of abandoned African mines**

A team of 50 geoscientists will be devoting the next 12 months to mapping the impact of mining on human and environmental health in sub-Saharan Africa, within the International Geoscience Programme (IGCP). The project is being coordinated by geologist Sadrack Felix Toteu from UNESCO's Nairobi office (Kenya), with US$237,000 in funding from the Swedish International Development Cooperation Agency.

Over the next 12 months, the team will compile a database and use geographical information systems to elaborate precise maps of the location of all abandoned mines in Sub-Saharan Africa. At selected sites, they will study and document the rate at which specific toxic trace elements are absorbed by the soils, plants, fungi, surface and ground water, as well as by animals and humans via the food chain. Samples collected from the site of major derelict mines will be analysed by the laboratories of participating institutions. Different technologies will also be tested to ascertain which give the best results for rehabilitating sites contaminated by trace metals.

On the basis of their findings, the team will then advise governments and local authorities on the best available remediation technologies and on land-use planning. It is also planned to prepare a policy brief and other materials for decision-makers. The geoscientists also intend to give interviews to local media on the project, in order to alert the general public to potential hazards and keep people informed of progress.

Mining operations contribute more than 20% of GDP in sub-Saharan Africa. Just under half of the world's diamonds come from Africa and one-fifth of the world's gold. Africa also produces about 5% of copper, coal and aluminium, 9% of bauxite and 16% of uranium.

'Like agriculture, mining is crucial for the region's economy,' observes Toteu. 'The two industries are not only complementary but also inextricably linked, with pollution from mining impinging on the development of agriculture and *vice versa*. Decades of mining metals has polluted surface and ground water, soil and food crops,' he adds. 'Moreover, in many counties, the danger is compounded by the lack of a precise inventory of abandoned and derelict mines. The surveys and impact assessments we shall be conducting over the next year will reveal the true extent of metal pollutants across the continent and their impact on human and animal health, the environment and ecosystems. This groundwork should pave the way to the adoption and enforcement of legislation.'

In developed countries, mining companies are legally bound to rehabilitate operational mine sites and ensure that they are environmentally safe once the mine has been closed down. However, in Africa, this is rarely the case.The highly publicised case of the dumping of chemical waste in Côte d'Ivoire in August 2006, after a Dutch multinational company shipped its toxic cargo to Abidjan on the *Probo Koala*, illustrates the legal loopholes in environmental protection on much of the African continent. Rather than pay the €500,000 demanded in the Netherlands to depollute the cargo, the multinational preferred to pay a fraction of the cost to a local Abidjan company which then dumped the waste in and around the city, according to Amnesty International and other reports. More than 100 000 people were treated for intoxication and at least 15 died.

The impact on public and environmental health of derelict mines has become so critical in South Africa that the government faces liability of more than US$4.2 billion to rehabilitate about 6 150 abandoned mines around the country. In most sub-Saharan countries, little information has been gathered of the concentration and behaviour of numerous hazardous compounds, including heavy metals such as lead or cadmium, radioactive elements such as caesium or strontium, or even fine particles such as soot or asbestos fibres. Many of these accumulate in the ecosystem over time; for example, fish in polluted rivers stock the contaminants in their bodies, where they accumulate until the fish is ingested by a bigger fish or human.

The past few years have seen a surge in cooperation between geoscientists from Europe and Africa via two other IGCP projects which operated on a more modest scale; these studied the environmental impact of mining in Ghana, Namibia, Nigeria and South Africa in particular.

Given the magnitude of the problem on the continent, the new project involves a much larger network of geoscientific institutions and more consequential funding. The team leaders remain the same, however: Theo Davies from Mangosuthou University of Technology in Durban (South Africa) and Bohdan Kribek from the Czech Geological Survey.

Via their host institutions, the African geoscientists collaborating on the new project belong to the African Network of Earth Science Institutions. This network was launched by UNESCO on 13 January, with the endorsement of the Conference of Vice Chancellors and Deans of Science, Engineering and Technology.

For details: sf.toteu@unesco.org; theo.clavellpr3@gmail.com; Bohdan.Kribek@geology.cz

© Ben Mapani, Namibia

The Karavatu Mine in Namibia extracted copper and zinc until it was abandoned in the 1970s.

Solar energy comes to Altaisky Biosphere Reserve

On 1 March, a 100 kW hybrid diesel–solar power station began supplying the remote village of Yailu in Altaisky Biosphere Reserve with round-the-clock electricity. The new power station is the only one in Russia to use solar energy.

Previously, the village had used an old diesel generator which only supplied electricity during the daytime.

The power station was financed out of the federal budget, with cofinancing from Hevel in Moscow, a joint venture between the Russian Corporation for Nanotechnology (Rosnano) and the Renova Group of Companies. Other organizations were involved mainly in installing equipment: the A.F. Loffe Physics Technical Institute (St Petersburg), Russian Academy of Science, LLC Avelar Solar Technology (Moscow) and Solar Energy (Altai Republic).

The autonomous hybrid power station, which combines solar modules with a diesel generator, functions automatically. It is expected to reduce annual consumption of diesel fuel by 50%.

The power plant will be demonstrated to students and visitors to Teletskoe Lake and the wider biosphere reserve, in order to educate them about renewable energy.

Scientists believe that the installation of this hybrid power station could mark the beginning of large-scale development and deployment of solar energy in Russia, beginning with remote regions.

Altaisky Biosphere Reserve was designated in 2009. It is located in the Altaï mountains and covers 3.5 million hectares, for a population of just 15 000.

For details: mab@unesco.org; www.unesco.org/mab

An Action Plan for **Mali's monuments and manuscripts**

An Action Plan for the Rehabilitation of Cultural Heritage and the Safeguarding of Ancient Manuscripts in Mali was adopted by an international experts' meeting organized by UNESCO and France in Paris on 18 February. The plan will cost an estimated US$11 million.

The Action Plan has three priorities: to rehabilitate cultural heritage damaged during the conflict, with the active participation of local communities; to protect the ancient manuscripts kept in the region, including via digitization; and to provide local experts with training in state-of-the-art preservation techniques for cultural monuments and manuscripts. Digitization of the manuscripts will continue the work initiated by an earlier project funded by Luxemburg.

Measures foreseen under the plan for monuments concern both world heritage sites and cultural properties protected under national legislation. Specific actions are foreseen for Timbuktu, the Tomb of Askia in Gao, the Old Town of Djenne and the Cliff of Bandiagara (land of Dogon), as well as for museums.

Timbuktu's three major mosques, Djingareyber, Sankore and Sidi Yahi, along with 16 mausoleums, were first inscribed on the World Heritage List in 1988. The Askia Tomb in Gao followed in 2004. In July 2012, following the destruction of 11 mausoleums and the doors of Sidi Yahi, both properties were inscribed on the List of World Heritage in Danger. UNESCO provided topographic maps and coordinates to the armed forces of Mali, France and Chad in January this year to help prevent shelling of these sites.

In April 2012, extremists occupied the Ahmed Baba Institute of Higher Learning and Islamic Research in Timbuktu, the largest repository of ancient manuscripts in West Africa. UNESCO had helped Mali establish the institute in 1974, which had moved to new premises built with the support of South Africa in 2008. Much of the institute's hardware, including digitization equipment, was destroyed. Even worse, before fleeing the premises in mid-January at the approach of French and Malian troops, the extremists had burned some manuscripts on mainly religious themes that were still stored at the institute.

Fortunately, 90–95% of the 45 000 manuscripts collected by the institute had been discreetly exfiltrated in recent months by courageous inhabitants to safeguard them from harm. In fact, most of Timbuktu's ancient manuscripts are kept in 30 private libraries maintained by the same families for generations. An estimated 300 000 manuscripts are kept in private and public collections in Timbuktu and the wider region.

The ancient manuscripts explore theology, mathematics, medicine, astronomy, music, literature, poetry and architecture. They also contain invaluable information about the pre-colonial history of Muslim Africa. Many of them date from the 13th to 16th centuries and were produced by great scholars from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the city and elsewhere, or came from the ancient markets of North Africa, Al-Andalus and the eastern-most Arab countries. Situated at the juncture of the Saharan desert and River Niger, Timbuktu was a hub for trade and an intellectual centre. In the 16th century, its university counted 25 000 students, one-quarter of the population.

On 18 February, UNESCO Director-General Irina Bokova said in her opening speech that 'when a world heritage site is destroyed because of stupidity and violence, the whole of humanity feels it has been deprived of part of itself'.

'The destroyed mausoleums and attempted destruction of manuscripts are a new manifestation of fanaticism, the old enemy of reason,' said French Culture Minister Aurélie Filippetti. 'This particular fanaticism views every trace of the past as a testimony to cultural diversity that must be destroyed.' The

Minister pledged France's support for the reconstruction and enhancement of cultural heritage in northern Mali, at the request of the Malian authorities and UNESCO.

Malian Culture Minister Bruno Maïga welcomed the rallying of international support for his country's cultural heritage. 'This crisis revealed the vulnerability of cultural heritage and the insufficient preparedness of heritage management structures to handle emergency situations,' he said. He also spoke of the illicit trade in Dogon fetishes or statues.

Since the start of the conflict in April 2012, UNESCO has enlisted the support of Mali's neighbours to prevent trafficking of Mali's cultural goods, including statues and ancient manuscripts.

On 2 February, the Director-General visited Timbuktu's world heritage sites and the Ahmed Baba Institute before travelling on to Bamako with French President François Hollande and the President of Mali, Dioncounda Traoré.

For details (manuscripts): j.springer@unesco.org; (monuments): l.eloundou-assomo@unesco.org

UNESCO assesses **cyclone damage in Samoa**

UNESCO's Apia office contributed to the post-disaster needs assessment carried out from 7 to 21 January, after Cyclone Evan caused widespread damage in Samoa on 13 December.

The combination of strong winds, heavy rainfall and flash floods resulted in at least five deaths and the displacement of 4 763 Samoans out of a total population of 182 000, many after the Vaisigano River flooded its banks. Cyclone Evan destroyed a power plant and relays, cutting power nationwide and disrupting communication services. Water facilities and distribution systems were also badly damaged.

After an inspection of affected areas by the National Disaster Council, the Samoan government declared a 30-day state of emergency and appealed for international assistance for the evacuees.

UNESCO's Apia office led the component of the post-disaster needs assessment devoted to disaster risk management. UNESCO worked with experts from the Samoan government, World Bank, UN International Strategy for Disaster Reduction and the Secretariat of the Pacific Community's Applied Geoscience and Technology Division (SOPAC) to assess Samoa's forecasting and warning systems for floods and tropical cyclones.

The study noted that the warning had been issued tardily to the general population, with some inaccuracies, but also that the country's response and coordination had improved since the previous emergency in 2009.

To improve forecasting, the experts recommended training local staff in the latest hydro-meteorological techniques, greater real-time monitoring of rainfall and stream flow, a robust communication system and greater response planning for local communities, including evacuation drills. The experts acknowledged that much was already being done to educate schoolchildren and build awareness of risks among the population.

With rainfall projected to increase globally by about 20% within a 100 km radius of the eye of a cyclone and with population growth centred mainly in and around Apia, Samoa's National Building Code (1992) will need updating to revise land zoning, especially as concerns construction in floodplains. The absence of any provision in the Disaster Emergency Act for penalties for negligence also needs rectifying; at least one school which collapsed had not respected any building codes or standards but no government body could be held accountable.

The experts found that Samoa remained too response-oriented and needed to focus more on prevention and preparedness. They recommended adopting a multihazard approach to early warning systems and mainstreaming disaster risk reduction and climate change adaptation in the country's environmental and development policies, as well as in urban and coastal zone management and in community resilience programmes. Consequently, UNESCO's Intergovernmental Oceanographic Commission (UNESCO-IOC) funded a national review of the Samoan national warning systems for tropical cyclones and tsunamis from 27 February to 5 March this year, to which both the UNESCO-IOC and SOPAC contributed.

UNESCO's Apia office contributed to two other components of the assessment on damage, loss and the social impact. UNESCO and UNICEF backstopped the Ministry of Education, Sports and Culture in assessing the substantial damage to schools. In addition to building repairs, the team recommended providing waterproof containers to ensure the safety and security of school equipment and resources in future. It also urged the Planning and Urban Management Agency of the Ministry of Natural Resources and Environment to review the building codes for schools and sanitation blocks. The team also suggested that schools could use this experience to explore ways of making their school more resilient to disaster in future, as part of climate change education.

With the technical support of Japanese experts from the International Council on Monuments and Sites (ICOMOS), UNESCO assessed ten cultural sites and facilities impacted by the cyclone. The damage sustained was fortunately moderate, with the exception of the historic Robert Louis Stevenson Museum and Old Courthouse. The Trust for the Apia Courthouse has since applied to the World Monument Watch for funding to repair the building's roof.

On 15 January, specialists from UNESCO's Apia office and ICOMOS visited the Fagaloa–Uofato protected area, which is home to a large rainforest and several villages. The area features on Samoa's Tentative List for future nomination for the World Heritage List as a mixed cultural and natural site. The cyclone had blown away some of the metal roofs of modern homes in the protected area but the few remaining traditional Samoan *fales* managed to withstand the strong winds (*see photo*).

This was the first time that cultural heritage had been included in a post-disaster needs assessment in Samoa. UNESCO has since prepared a project proposal for community-based safeguarding of cultural properties in villages which is now being examined by potential partners.

UNESCO's Apia office is currently working with the Samoan government to prepare a long-term recovery and reconstruction strategy.

Samoa is also vulnerable to subterranean earthquakes and tsunamis. In 2009, an earthquake measuring 8.1 on the Richter Scale occurred close to the Samoan islands, in the Kermadec–Tonga Subduction Zone where tectonic plates converge. The subterranean earthquake generated a tsunami wave 14 m high that killed nearly 200 people in Samoa and Tonga, most of them children.

Samoa is one of 30 Pacific Rim countries which participate in tsunami warning exercises every two years or so, under the aegis of the UNESCO-IOC. The last exercise in the Pacific dates from November 2011; the next one is planned for April 2013. In July last year, the Samoan capital hosted a regional training workshop run by the UNESCO-IOC on the tsunami early warning and mitigation system for the Southwest Pacific, followed by the third meeting of the system's regional working group.

© Kanefusa Masuda/ICOMOS

The Fagaloa–Uofato protected area shortly after the passage of Cyclone Evan. This traditional Samoan fale*, with its thatched roof and open walls, withstood the strong winds.*

The UNESCO-IOC organizes short training courses for government officials in the Pacific. Last August, 15 participants from the Pacific and Caribbean regions participated in a 10-day course in Hawaii (USA), run within the International Tsunami Information Centre's Training Programme. A one-week training course for national authorities was also run by the UNESCO-IOC and the Hawaiian centre in Port Moresby (Papua New Guinea) in September. A similar course was dispensed in Fiji and Tonga in 2010 and in Vanuatu in 2011.

For the second year running, the UNESCO-IOC organized a session on Early Warning Systems during the annual Pacific Disaster Reduction Platform meeting from 17 to 21 September last year, in Noumea, New Caledonia. Water and sanitation experts and managers from the region also met to discuss cross-cutting issues between disasters, water management and climate change risk. Other sessions looked at community-based disaster reduction management, governance, training and capacity-building and the development of an integrated strategy combining disaster risk management and climate change.

In September last year, UNESCO's Apia office and the Samoan National Disaster Management Organization distributed a documentary film to local media and other partners on the lessons learned from the 2009 tsunami. Copies of the DVD, which was produced for UNESCO by Stephen Percival, may be requested from UNESCO's Apia office.

On 6 February this year, a subterranean earthquake of magnitude 8.0 off the island of Santa Cruz in the Solomon Islands generated two tsunami waves more than 1 m high, killing five people.

For details: s.vize@unesco.org; (UNESCO-IOC) r.prasad@unesco.org; (science) d.chang-seng@unesco.org; (culture) a.takahashi@unesco.org; www.unesco.org/new/en/apia

UNESCO fêtes the 'crown jewels of the ocean'

The 46 marine sites inscribed on the World Heritage List constitute more than one-quarter of all marine protected areas on Earth. On 7 February, the World Heritage Centre paid tribute to the Tides of Time partnership and the Government of Flanders for their role in protecting what it calls the 'crown jewels of the ocean.'

Co-hosted by UNESCO and the Government of Flanders at UNESCO's Paris headquarters, the event brought governments up to speed with the achievements of the Tides of Time partnership established in 2008 between UNESCO's World Heritage Centre, leading Swiss fine watchmaking manufacturer Jaeger-LeCoultre and the *International Herald Tribune* newspaper, owned by the New York Times Company. The partnership began as an international communication campaign, with articles on 33 world heritage marine sites appearing in the online and print editions of the *International Herald Tribune* and the online global edition of the *New York Times* since 2008.

Additionally, the partnership provides core funding for the World Heritage Marine Programme. Together with the Government of Flanders, the Tides of Time partnership has provided more than US$3 million to date to help states and site managers tackle the growing challenge of pollution caused by coastal development and shipping.

Each year since 2008, Jaeger-LeCoultre has organized an online auction of one or more of its watches, the proceeds of which have gone to a specific world heritage marine site. Last year, the proceeds of about US$14,600 enabled the Puerto-Princesa Subterranean River National Park (Philippines) to purchase a zodiac-type inflatable boat, GPS and hand-held sonar equipment, as well as diving gear and lessons for two staff members who will be monitoring the park. The previous beneficiaries were the Malpelo Fauna and Flora Sanctuary (Colombia, 2011), Sundarbans National Park (India, 2010) and Tubbataha Reefs Marine Park (Philippines, 2009).

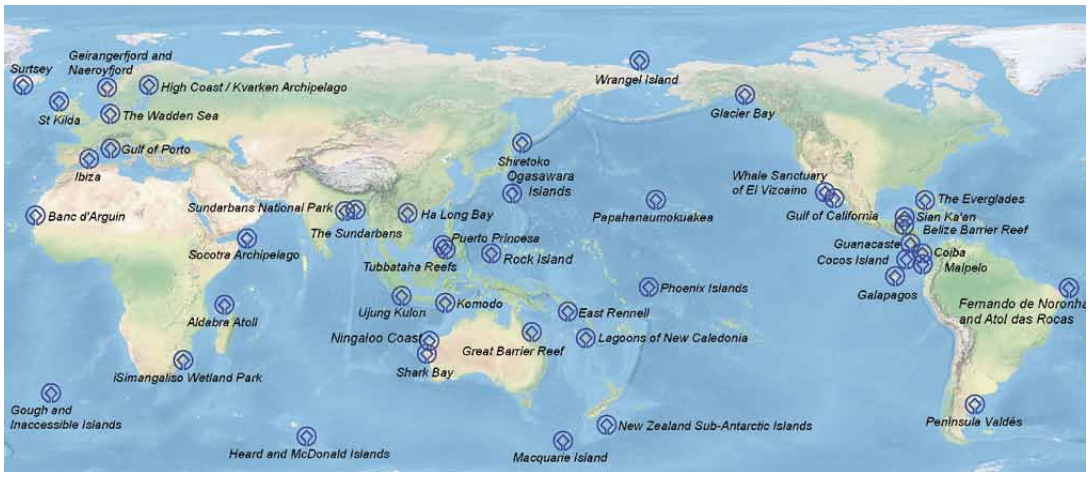
At the February event, a short film on *Marine World Heritage: the Crown Jewels of the Ocean* was screened. It was narrated by French filmmaker and actor Jacques Perrin, who also took the floor. Other speakers included Jérôme Lambert, CEO Jaeger-LeCoultre; Stephen Dunbar-Johnson, Publisher of the *International Herald Tribune*; Nic Vandermarliere, Representative of Flanders to UNESCO; and British stage and screen star Clive Owen.

The second part of the event took place at the Jaeger-LeCoultre Boutique on the Place Vendôme in Paris to mobilize support from private-sector players in France.

The Tides of Time partnership was one of a dozen sponsors of the first-ever meeting of world heritage marine site managers in Honolulu (USA) on 1–3 December 2010. Managers vowed at

the meeting to speak with one voice at regional and international fora to make themselves heard. They also undertook to consolidate 'sister site' arrangements like that between the Papahānaumokuākea (USA) and Phoenix Islands Protected Areas (Kiribati) world heritage sites. The exemplary cooperation on migratory birds between the sites of the Wadden Sea (Denmark, Germany, Netherlands) and Banc d'Arguin National Park (Mauritania) was cited as another act to follow.

All world heritage marine site managers are coming together for the second time in October this year in Scandola (France) for the third International Marine Protected Area Congress.



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The 46 world heritage marine sites

For details: http://whc.unesco.org/en/marine-programme; f.douvere@unesco.org;

article archive: http://whc.unesco.org/en/news/694

UN-Water endorses **World Water Scenarios project**

In Washington DC (USA) on 19–21 February, the 30 bodies that make up UN-Water endorsed the World Water Scenarios project as an affiliated scheme. The project was initiated in 2009 by the World Water Assessment Programme (WWAP), which is hosted and led by UNESCO.

UN-Water designated a working group to act as an interface with the project. The group will include existing members of the project, the UN-Water Management Team and any other interested parties. WWAP will coordinate the working group.

The World Water Scenarios project explores alternative futures for the world's freshwater resources and their use to 2050, in order to inform sound decision-making in all related sectors: agriculture, water management, industry, energy production, etc. The project's initial findings were published in the last edition of the *World Water Development Report* (see *A World of Science*, April 2012).

In 2012, UN-Water decided to publish the *World Water Development Report* annually in future, rather than every three years. The themes for the next two reports will be Water and Energy (2014) and Water and Sustainable Development (2015). The report's themes will be harmonized with those of World Water Day (23 March).

UN-Water also decided that WWAP would lead the preparation of an official report on the UN Decade on Water for Life, which ends in 2015.

A set of sustainable development goals is currently being drafted by the United Nations to take over from the Millennium Development Goals in 2016. In Washington, UN-Water agreed to develop a sustainable development goal on water. Each thematic area (water supply, sanitation, wastewater, etc) will be represented in a working group led by UNDP which will draft a common position for UN-Water.

UN-Water is supported by a Technical Secretariat in Geneva (Switzerland) and Secretary (Vice-Chair) based at the United Nations in New York. The current Chair is Michel Jarraud (WMO) and the Vice-Chair is Bert Diphoorn (UN-Habitat). The incumbent of these posts rotates every two years in an election organized among UN-Water members.

UN-Water meets twice a year, its second meeting always coinciding with the Stockholm World Water Week. Decisions are made by consensus.

For details: e. koncagul@unesco.org; www.unesco.org/water/wwap/wwdr

Five scientists pierce some of **nature's mysteries**

On 28 March, the annual L'Oréal–UNESCO Awards for Women in Science took place for the 15th time.

Each prize worth US$100,000 rewards a laureate in the physical and life sciences in alternate years. The 15 international fellowships awarded at the same time always target young life scientists; in addition, one past fellow is singled out in mid-career for a special fellowship *(see map overleaf)*. In a first, this year's ceremony took place at the Université de la Sorbonne in Paris (France) rather than at UNESCO headquarters.

Francisca Nneka Okeke (Nigeria) is the Laureate for Africa and the Arab States. Professor of Physics at the University of Nigeria in Nsukka, Francisca Okeke studies a world situated between 50 km and 1 000 km above the Earth's surface, the ionsphere, which is a very thick layer of charged particles. When these ions move about in the Earth's magnetic field, current is induced as dynamo, which

produces changes in the magnetic field on the Earth's surface.

Prof. Okeke's research has resulted in new discoveries about the part of the ionosphere located above the equator, including the equatorial electrojet phenomenon. Energized by the sun, the electrojet is a river of electrical current that traverses the globe eastward around the dip equator and causes the magnetic field at the dip equator to vary almost five times more than anywhere else on the planet. The dip equator differs from the equator by a few degrees, as the Earth's magnetic north pole – that on compasses – deviates from what we generally think of as the north pole. Prof. Okeke's research on how such solar activity in the ionosphere affects the Earth's magnetic field could lead to a better understanding of climate change and help pinpoint sources of phenomena such as tsunamis and earthquakes.

Reiko Kuroda (Japan) is the Laureate for Asia–Pacific. At the Research Institute for Science and Technology at the Tokyo University of Science, Prof. Kuroda has managed to determine whether molecules are left- or right-handed and the effects of such handedness (known as chirality) on a variety of physical and biological systems.

All living things are either right- or left-handed.

Prof. Kuroda invented a device for measuring chirality in solid matter at a time when existing instruments could only measure liquids. Today, she is using her invention to study how certain proteins, including those implicated in Alzheimer's disease, adopt a particular structure. Her basic research into chirality at the molecular level has important implications for manufacturing drugs and agricultural chemicals, as well as for the study of gene-determining animal body asymmetry.' People have been looking for the gene for snail coiling for over 100 years,' she smiles. 'I want to be the one! When, why and how the handedness of the biological world occurred is one of the essential keys to investigating the origin of life on this planet.'

Pratibha L. Gai (UK) is the Laureate for Europe. Chair of Electron Microscopy and Director of the York JEOL Nanocentre at the University of York, Prof. Gai, who was born in India, is one of a select group of scientists throughout history who have invented a way of seeing previously invisible natural processes. Thanks to her truly ingenious modifications to electron microscopes, it is now possible to see chemical processes at the atomic level that were once completely mysterious. She is currently working with firms that will transform her findings into technology and products that range from ecofriendly paints to more efficient agriculture and new medicines, materials and energy sources.

Marcia Barbosa (Brazil) is the Laureate for Latin America. Director of the Physics Institute at the Federal University of Rio Grande do Sul in Porto Alegre, Prof. Barbosa is recompensed for discovering a peculiarity of water which may improve our understanding of how earthquakes occur and proteins fold. At the microscopic level, water can behave in unusual and unexpected ways under different pressures and temperatures — what scientists call anomalous behaviour.

Proteins are the building blocks of all living things. It is the water which surrounds proteins that shapes them. Learning more about how this protein-shaping process works will be essential to knowing how to manipulate proteins in the quest for a cure to a disease, for example. Among other potential applications, the work being done by Prof. Barbosa's group could also help solve what she considers the world's most pressing problem: energy. The study of water anomalies could lead to advances in the production of biofuels from crops, in particular.

Deborah S. Jin (USA) is the Laureate for North America. Prof. Jin studies what happens when molecules are cooled to near-absolute zero, the lowest possible temperature. First, however, she and her team at the University of Colorado had to invent a method for performing this difficult task. The point of cooling molecules to such low temperatures is that the colder they are, the slower they move. They must slow down enough for researchers to see what actually goes on during chemical reactions. 'The study of ultra-cold molecules could lead to new precision-measurement tools,' she says, 'and new methods for quantum computing; they could also help us better understand materials that are essential to technology.'

For details:
http://tinyurl.com/unesco-womeninscience;
s.bahri@unesco.org

The 15 fellows and special fellow

Barbara Birungi

'If **more women** owned mobile phones, there would be **more development**'

© Barbara Birungi

In 2010, Barbara Birungi founded Women in Technology Uganda. This NGO provides networking, training, mentoring and partnering to increase the number of women in technological fields. Ms Birungi is also Executive Director of Hive Colab, a business incubator in Kampala for East African start-ups in technological fields which also dates from 2010.

On 26 February, she was one of several speakers invited by UNESCO to describe how e-science was being used in their country to strengthen the interface between science, policy and society. One of the session's recommendations was for UNESCO to design a demand-driven web-based platform which would reflect the dynamics of the science–policy interface at all levels, from national to global. This session was one of more than 70 hosted by UNESCO at its Paris headquarters over three packed days, within a ten-year review of progress since the World Summit on the Information Society in 2003 which included recommendations for the post-2015 development agenda.

How many Ugandans have access to Internet and mobile phones?

Uganda has a population of 34 million. According to the Uganda Communications Commission, 14% of the population had access to Internet in 2011, whereas 39% owned a mobile phone. Mobile phone use is growing fast and Internet use is spreading but access to both technologies has been limited by high costs, especially those imposed by telecom companies for accessing Internet, as well as poor infrastructure in rural areas.

There is also a lack of electricity in most rural areas and frequent power cuts elsewhere. Illiteracy is another factor. It is projected that 85% of men and 71% of women will be literate in Uganda by 2015, according to the UNESCO Institute for Statistics. People also lack information on the benefits of both the mobile phone and Internet.

What is the profile of mobile phone users?

The majority of users are concentrated in urban areas. Most rural households own a mobile phone that is used by the whole family. The majority of these mobile phones are feature phones with a basic call and text function.

Most mobile phone owners are men. This has contributed to widening gender inequality in the country. The problem can be attributed to socio-cultural norms in rural areas, where men think it gives them superiority if they are the ones who own the mobile phone in the home.

Some men think that, if their wives own phones, it will create a way for them to cheat on them or disrespect them. I think that, if more women owned mobile phones, there would be more learning and development in communities but cultural norms make this difficult. Women would be more open than men to letting their children use their phones at an early age, thus introducing them precociously to technology.

Why are mobile phones so important for development in Uganda?

The most widely used technology for development in Uganda is the mobile phone because it can be purchased for US$10–20, an amount most families can afford. These mobile phones mainly use the short message service (SMS) and USSD[6] to send information within communities. Applications (Apps) may include prepaid roaming or mobile chatting and have the advantage of not needing to be installed on the phone. Most of these applications are built by NGOs and non-profit organizations like Hive Colab, Texttochange, UNICEF and the Grameen Foundation, as well as by government departments like the Ugandan Ministry of Health, Agriculture and Youth.

Most applications target the rural population. As the majority of people are farmers and there are not enough medical centres, the emphasis is placed on health and agriculture. A recent application called WinSenga blends old and new technology. A highly sensitive microphone is placed inside the traditional Pinard Horn with which midwives listen to the heartbeat of the foetus. Using an algorithm that converts the frequency (Hertz) to heartbeats per minute, the application can pick up the foetal heartbeat and transit it to the smart phone, which then runs an analysis. WinSenga can measure the position of the foetus in the uterus and calculate its age; it can also help detect an ectopic pregnancy or abnormal foetal heartbeat. The application is the brainchild of three Ugandan software developers, Joshua Okello, Aaron Tushabe and Josiah Kuvuma, who say the idea came to them after a visit to a maternity ward in Kampala.

What other applications target women specifically?

I am part of a group affiliated with Women in Technology Uganda which has created Mama-App, a mobile phone application which uses SMS to send information to women on pregnancy care and

monitoring. The message for the first trimester of pregnancy, for example, advises the woman to drink lots of water, avoid alcohol and eat green leafy vegetables. Other messages advise on infant care in the first few days of life or on the prevention, early detection or cure of infection. Messages may also provide information on nearby health centres and reminders about immunization and contraceptive use.

I got the idea for this application after visiting Mulago Hospital when a relative was in labour. While I was waiting to see her, I heard teenage girls and poor women who had just given birth talking casually about their prenatal care. Their conversation shocked me. Some had not attended more than two check-ups because they could not afford transportation or had been discouraged by the long queues at the hospital. When they went into labour, there were only a handful of nurses for more than 80 women. The women had no plans to have their babies' progress monitored in the weeks following the birth and some did not even understand the importance of immunizing them. Most of these women were discharged that very day; I couldn't help wondering how many of those babies would survive.

Mama-App also provides secondary school girls with information on the dangers of early pregnancy and preventive measures they can take, via a version designed for schools, Desktop App. Girls can access information at any time on their mobile phone using Desktop App, which dispenses with the need for an Internet connection.

I believe technology will reduce the number of unwanted teenage pregnancies in Uganda because most parents find it embarrassing and improper to talk to their children about sex, especially in rural Uganda. As for teachers, they have too much on their plate to make it a number one priority. Desktop App puts information at the girls' fingertips.

In addition, the government sends out health alerts to the masses by SMS whenever there are outbreaks of disease. It is also making it easier for women to report domestic violence by providing toll-free phone numbers, among other areas of concern.

What other groups are being targeted?

The basic feature phone is being used by private companies to send information to farmers on market prices and fake chemical products available on the market. Farmers also receive information on how to prevent, diagnose and cure plant and livestock diseases and combat pests. Farmers can also use their mobile phone to buy and sell produce without physical contact.

UNICEF has given youth a voice with U-Report. To become a volunteer U-reporter, a person simply sends a text message with the word 'join' to a toll-free number. Topics discussed so far have included female genital mutilation, outbreaks of disease, safe water, early marriage, education, health and inflation. Less than a year after the launch, there are 90 000 U-reporters, with up to 500 joining the network daily.

How are young Ugandans using ICTs to improve governance?

Initiatives target the education sector in particular. One example is Not In My Country, a website which allows university students to monitor their teachers and report cases of absenteeism and other forms of abuse, such as extortion or sexual harassment. Teachers monitor what is being written about them on the website and adjust their behaviour accordingly. Students sign up using an assumed name, so that no-one can trace a comment or report back to them. The university administration and other teachers monitor these reports and sanction their employees when necessary. The website was founded by an international group of concerned citizens from different walks of life. It focuses on universities because they produce Uganda's future leaders. 'If students learn at university that they must buy their grades with cash and bypass bureaucracy by selling their bodies,' the website states, 'their resulting cynicism will persist into their future careers.'

Last year, a group of private and public organizations in Uganda came together to encourage developers to create applications that will promote good governance. The movement is led by the NGO Development Research and Training and the technology hub I head, Hive Colab, which is hosting a governance application development challenge this year.

What more could be done to mainstream ICTs?

The government should set up community media centres to enable poor rural communities to access information. It should also make ICTs affordable for the masses and improve related infrastructure.

In addition, the government should work hand in hand with community-based organizations to develop and enforce policies that support the spread of ICTs, including education policies. With government funding, local organizations can help to disseminate information and learning on a massive scale and give citizens a voice.

The government should also support existing technology incubation hubs and introduce training schemes and competitions to encourage youth to create applications in all economic sectors. There is currently little or no local investment in the youth technology sector and little training or mentorship. Young inventors and entrepreneurs do not learn any business skills or have access to legal advice. Innovation centres within universities and technology hubs like Hive Colab have only sprung up in the past two or three years in Uganda. These alone cannot support the whole creative technology sector. They themselves need government support, in order to help youth create viable applications.

What role could youth play in the proposed web-based platform at the science–policy interface?

Youth can create mobile phone applications and web software to increase citizen participation in policy formation and implementation. They can also use mobile phones to collect and disseminate information, especially to the elderly who may not otherwise have access. Young people can also identify issues that the platform needs to address, translate the platform's information and otherwise help make the platform user-friendly. They can also play an advocacy role by encouraging people to adapt to new policies. Via social media, they can also engage government agencies and provide these with feedback from citizens.

Interview by Susan Schneegans and Nicole Webley

For details: http://tinyurl.com/unesco-e-science; www.unicef.org/infobycountry/uganda_62001.html; https://www.notinmycountry.org; http://hivecolab.org

6 *Unstructured Supplementary Service Data is a global system for mobile communication technology that is used to send text between a mobile phone and an application in the network.*

Rebirth of a hunter

This is a story about a hunter who is haunted by the killing of Cat Ba langurs, one of the rarest primates in the world. Mr Vu Huu Tinh, a former logger cum hunter in Cat Ba Biosphere Reserve in Hai Phong (Viet Nam), has been reborn as a 'people's forest ranger.'

Mr Tinh (far left) and his patrol team

As always, Mr Vu Huu Tinh gets up very early in the morning, puts on his damp clothes and worn-out shoes and goes into the forest to begin his patrol. He lives in Gia Luan, a village on the edge of Cat Ba National Park in the heart of the biosphere reserve where he was born and raised. It has been a long time since there were any langur groups anywhere near Gia Luan.

Most of the remaining endemic Cat Ba langurs live in the isolated limestone mountains which dominate Cat Ba National Park. Despite challenging terrain and patrolling forest rangers, local hunters still infiltrate the area. Being a former logger-cum-hunter himself, Mr Tinh knows all the tricks. This makes him all the more worried for the naïve langurs, which can easily become exposed to the guns of skillful hunters. If, in the past, Mr Tinh was cheered by his fellow huntsmen as an old 'sly hunter,' he is now known as the 'people's forest ranger.'

From sly hunter to forest ranger

Mr Tinh's change in attitude towards nature has surprised many people and intrigued other forest hunters. Once 'the king hunter and forest destroyer,' he now excels in saving animals and foiling attempts to fell trees. Irrespective of these achievements, the most important thing he has done is to help convert other forest destroyers and hunters by setting an example.

It is not easy for an experienced and talented hunter who has been in the business for 40 years to change his ways. Having grown up in a forest-dependent family, Mr Tinh once considered hunting as his main livelihood. Later on in life, the scenes of baby langurs clinging to their trapped mothers and langur couples risking their lives to retrieve their dead offspring from hunters tormented him. The case that haunted him most was the death of several baby langurs after a series of shots were fired by a group of hunters, including himself. This heart-rending incident made him realize that hunting had become unviable and that the merciless killing of langurs was making them increasingly scarce. When the newly established Cat Ba Langur Conservation Project asked if he would like to head one of their community forest protection groups in 2000, he didn't hesitate *(see box overleaf)*.

Young Cat Ba langur

One of the world's rarest primates

The endemic Cat Ba, or golden-headed, langur *(Trachypithecus poliocephalus poliocephalus)* is one the rarest primates in the world. Poached for its meat and traditional medicines, it is listed as critically endangered, with fewer than 60 animals remaining.

The range of the Cat Ba langur is restricted to Cat Ba Island, mostly inside Cat Ba National Park, where the core zone of the biosphere reserve is situated. Cat Ba Island lies adjacent to an archipelago of 1600 islands and islets in Ha Long Bay, a world heritage site.

Cat Ba langurs live in small groups in forested or rocky areas on limestone cliffs. Each group tends to consist of one male, several females and their offspring. The females usually give birth every 2–3 years to a baby which reaches adulthood 4–6 years later. Langurs have an average life expectancy of 25 years. Their diet consists of leaves but also bark, fresh shoots, flowers and some fruits.

'Poaching has been almost entirely eradicated since 2002,' says Rick Passaro, project manager of the Cat Ba Langur Conservation Project, 'but remains a continual threat. In the past,' he adds, 'langurs were generally either shot or caught while sleeping inside one of their caves at night. They were only rarely caught in traps.' Today, the remaining populations have been fragmented by the construction of new roads and settlements, as well as the extension of agricultural plots. The growing volume of tourists in the bay provides an additional disturbance.

The Cat Ba Langur Conservation Project was launched in 2000 by Allwetterzoo Münster (Germany), in cooperation with the Zoological Society for the Conservation of Species and Populations, a German NGO. The project is being implemented in partnership with Cat Ba Biosphere Reserve, established in 2004, and other Vietnamese partners. A sanctuary has been created on one of the islands within the national park which is home to several important reproductive groups. Here, the steep limestone cliffs offer the langurs some natural protection. The Langur Guards and community forest protection groups employed by the project – like that of Mr Tinh – offer a second line of defence.

For details: rick.passaro@catbalangur.de

Islands in Cat Ba Biosphere Reserve

Mr Tinh holding a cage trap and a steel trap with metal jaws which spring shut on the unsuspecting animal

An active campaigner

Over the past 12 years, Mr Tinh has become an active campaigner for the protection of langurs and other wildlife in the forest. Mr Nguyen Tien Ty is one of his converts. In the past, Mr Ty was also a logger and hunter. Following Mr Tinh's example, Mr Ty has changed his ways and joined one of the community forest protection groups funded by the Cat Ba Langur Conservation Project.

Acts of deforestation and hunting are still prevalent in Cat Ba Biosphere Reserve and langurs are still very much at risk. This makes Mr Tinh all the more determined to keep patrolling the forests, come rain or shine.

Adapted from a story by Duc Thuong[7]

For details: http://mabvietnam.net/CatBaBR.htm

This story was commissioned by UNESCO's programme on education for sustainable development.

7 *Vietnamese science journalist*

Cat Ba kids get in the driver's seat

In 2011, Cat Ba Biosphere Reserve was the focus of a UNESCO programme which sets out to convince teachers, journalists and others living in biosphere reserves in Indonesia, Timor Leste, the Philippines and Viet Nam that they can be actors of sustainable development rather than simple bystanders. Through the Biosphere Reserves for Environmental and Economic Security programme, UNESCO's Ha Noi office introduced teachers from Cat Ba Biosphere Reserve to a multimedia kit developed by UNESCO on Teaching and Learning for a Sustainable Future. Translated and adapted to the Vietnamese context, the kit helped the teachers to design 15 lessons on issues related to sustainable development. In addition, community groups involved in tourism, forestry, agriculture and aquaculture participated in a session on how to devise community action plans to help them adapt to climate change and mitigate its effects.

Schoolgirls recycling plastic bottles into ornaments and other products, a winning entry in the competition.

As part of the programme, UNESCO organized a competition for 12–18 year-old pupils in five of the participating lower and upper secondary schools. One winning proposal consisted of planting 1 200 m^2 of coastal mangroves in the Phu Long commune to combat erosion, stabilize mudflats and reduce the harmful effects of typhoons and storms. A second group recycled plastic bottles and other waste into useful products such as shoes and ornaments *(see photo)*. A third group outlined its plans to learn about apiculture from local beekeepers so that the group could set up its own beehives to make honey. A fourth group wanted to produce artwork of the Cat Ba langur to raise awareness of its status as an endangered endemic species, while the fifth advocated planting trees in the school grounds. Each of these five proposals won a Biosphere Award and US$1,000 in prize-money to help the teenagers implement their projects. Of the 23 prize-winners, 20 were girls.

This year, the Vietnamese component of the programme is targeting the Red River Delta Biosphere Reserve. As with Cat Ba Biosphere Reserve, the project is being implemented by UNESCO's Ha Noi office in partnership with the Vietnamese Man and Biosphere Committee, with Japanese funding. This time, though, the programme is also receiving support from the Ministry of Education and Training and has been extended to include primary school pupils.

For details (in Ha Noi): w.langslet@unesco.org;
to access the online kit: www.unesco.org/education/tlsf

Using a web-based platform to learn about biodiversity

UNESCO has created an online collaborative platform to help schools exchange their experiences, materials and information on biodiversity with other schools around the world. The more than 9500 schools belonging to UNESCO's Associated Schools Network (ASPnet) are all invited to sign on. Here, they will find other stories on environmental education in biosphere reserves in Cambodia, Mexico, Slovenia, South Africa and elsewhere: **https://en.unesco.org/aspnet**

For details: aspnetinaction-en@unesco.org

A little **technology** can go a long way

The new showhome, sporting a sloping roof and large eaves to evacuate rainwater, as well as a chimney

As the concept of innovation is often associated with high technology, it tends to be regarded by many African communities as an esoteric cult beyond the reach of the poor. The research coming out of universities circulates in specialized journals and scientific conferences but rarely finds its way into the rural communities living just down the road. Without concrete examples demonstrating how science, technology and innovation can solve everyday problems, politicians with little background in the sciences have trouble picturing the benefit of research. As a result, life remains difficult for many African women and children, even though affordable solutions exist.

Over the past year, UNESCO's Dar es Salaam office has been working with the advocacy group Tanzanian Women in Science and the NGO Tanzanian Women Architects for Humanity to design a series of improvements to the dwellings of Maasai women in the rural village of Ololoskwan in the district of Loliondo. The project is funded by the UN Development Assistance Plan for 2011–2015,[8] within a wider drive to increase the role of women in applying science, technology and innovation to national development. The idea for healthier, more comfortable dwellings sprang from the Maasai women themselves. Now that they have finished building their new 'showhomes,' the women plan to start their own small construction business.

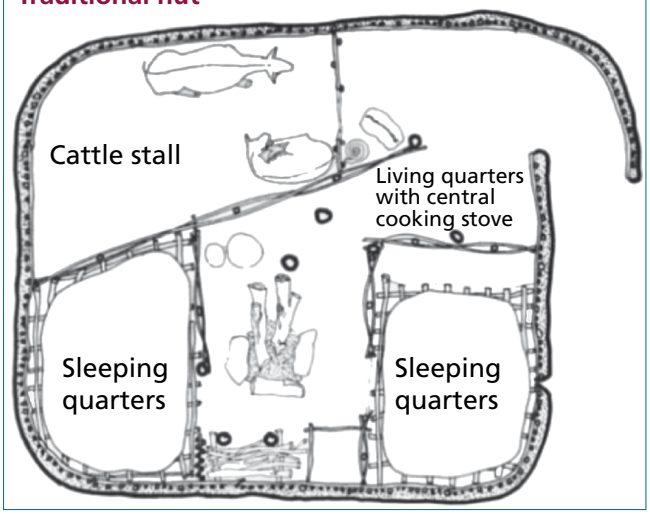
The district of Loliondo is home to a community of about 7000 Maasai, whose traditional homes are made of adobe. Adobe buildings are made of a mixture of sand, clay, cow dung and water that is sun-dried. They abound in Africa, Asia and Latin America, with some historic cities being almost entirely made of this natural building material, including Bam in Iran, Sana'a in Yemen and Timbuktu in Mali, all world heritage sites.

Dark, smoke-filled homes

Among the Maasai, it falls to the womenfolk to build the family's dwelling, or *boma*. As adobe materials can be found locally and the work is done by hand, the construction of the *boma* comes at little or no cost, produces no pollution or waste and barely consumes any energy. The Oiti tree poles used for the

The interior of traditional Maasai huts is dark and smoke-filled.

Traditional hut



Source: Kaj Blegvad Anderson (1977) *African Traditional Architecture*

skeleton are readily available in nearby forests and have the virtue of being durable and highly resistant to infiltration by termites or moisture. The mud keeps the homes cool and acts as insulation; it can also be recycled once a building is demolished.

But the *bomas* also have severe drawbacks. The mud absorbs a lot of water, causing the structure to swell when the rains come and to shrink in sunny weather. This causes cracks to appear which allow not only water but also insects to infiltrate the house, including termites. To prevent cracks appearing, the walls have to be replastered with cow dung every two years. In addition, the low ceilings force the occupants to stoop and the use of an open fire creates a smokey interior that is a health hazard. The tiny windows compound the problem by preventing adequate ventilation. Years of living in poorly lit, smoke-filled huts has taken its toll. 'Elderly women develop bloodshot eyes,' one woman explained. 'Women with red eyes were once considered witches and even killed at times,' she said. Fortunately, this superstition has died out but the women's smoke-polluted environment persists.

Staff at UNESCO's Dar es Salaam office decided to tackle the problem in October 2011, after visiting the new community multimedia centre set up by UNESCO in the village of Ololoskwan. During the visit, the UNESCO staff sat down with women and elders from the community. At first, the conversation focused on how the multimedia centre could help the women generate income and access health services and education. However, the Maasai women brought up another priority, that of obtaining better prices for the milk they sold through a cooperative.

This problem was solved by a training workshop. With the support of UNESCO and the Tanzanian National Commission for UNESCO, a well-known NGO in the Tanzanian milk industry, the Dutch Orkonorei Group, trained a total of 25 men and women in milk-handling and production from 24 to 27 June 2012. The villagers learned an easy method for eliminating pathogens from milk, for instance. The Dutch Orokonorei Group also showed them how to start and run their own microbusiness. Within days, the village men and women had mustered cows, goats and sheep worth 33,000,000 Shillings (US$20,625) to finance their own dairy enterprise. The community also set aside a portion of land for the construction of a minifactory to transform milk into yoghurts, cheese, cream and other dairy products.

A second critical issue for the women was to make their homes healthier places to live for their children and themselves. They urged UNESCO to support their idea of designing and building prototype *bomas* which they could then replicate in their own community and neighbouring villages for a fee.

The men pitch in

UNESCO duly organized a 20-day training course for 27 Maasai women from Ololosokwan, with UNDAP funding. Tanzanian Women Architects for Humanity agreed to run the course, which was programmed for July 2012. The participation of each Maasai woman was predicated on her being a member of a local association or cooperative, in order to guarantee her the necessary support. Eight young men from the village agreed to join the women on the course. This was quite an achievement, since the Maasai traditionally consider home-building as being women's work.

The Minister of Communication, Science and Technology, Hon. Makame Mbarawa, emerging from a traditional Maasai hut during his visit to the project site on 16 November 2012

The men went a step further in their show of 'gender solidarity.' In the Maasai culture, it is the men who take the cattle out to graze each morning and bring them back at night but the bulk of chores fall to women. When she wakes up in the morning, the first thing a woman does is to milk the cows, bathe the children and prepare them for school. She then takes the milk to the cooperative before returning to farm work. Later, she cooks the midday meal and awaits the children's return from school. In the evening, she milks the cows once more before serving the evening meal. This busy timetable would have left the women just four hours a day to work on the project. Thanks to the support of the men, who volunteered to pitch in by fetching building materials, mixing sand and clay with cow dung or fabricating clay bricks for the chimney, the women were able to devote twice as much time to building the model homes.

A journalist from the Tanzania Broadcasting Corporation interviews the Minister as he emerges from the model home on 16 November 2012.

Building better

On the course, the women architects taught the Maasai a number of techniques to improve the comfort and durability of their homes. In order to raise the ceiling and strengthen the structure, the architects replaced the existing poles with sturdier, longer ones.

To prevent water leakage, they designed roofs with eaves and overhangs. A polythene sheet was spread across the roof to form a second layer of protection over the cow dung. Sloping aprons were also introduced at the foot of the walls to protect them from splashing rain. 'The new *bomas* don't leak when it rains,' enthused Kootu Tome, one of the Maasai women. 'With the old *bomas*, the roof leaked so much that it was like staying outside in the rain. I have already constructed my new *boma* and I am enjoying it.' One of the models proposes an additional feature: troughs made of ferro-cement that are fitted round the roof overhangs to catch rainwater and channel it into drums at the base of the structure.

To ensure the mud plaster would not erode over time, the Maasai women were shown how to add bitumen and kerosene oil to the adobe mixture of clay and sand. The adobe was then blended with cow dung to produce a hard cement. Once the walls had been plastered, they were polished with trowels to give a smooth finish. According to the architects, it should be another 5–10 years before the structures need any maintenance. This will also mean that wood has to be collected less frequently.

The interior was made more functional by installing a smoke-free cooking stove that burned less firewood. In traditional *bomas*, the stove tends to be placed in the centre of the room.

© A. Maduekwe/UNESCO

Solar water bulb made from a plastic bottle, which disperses about 55 Watts of light. The bottle is filled with water that has been treated with ammonia to eliminate fungal growth. It is then sealed. The top half of the bottle protrudes through the roof, catching sunlight which the water then scatters around the room.

In the new model, the stove was relocated in a corner and surrounded on two sides by a clay brick wall 70–80 cm high (*see sketch*), in order to help direct smoke upward. A hood or chimney to channel smoke outside completed the picture.

The windows were also enlarged to let in more light and improve ventilation. Lastly, a simple indoor lighting system based on solar water bulbs was installed (*see photo*). As the solar water bulbs work only during the day, solar panels will also be introduced to provide lighting at night for those who can afford them. One option is the Nokero N-200 solar bulb (short for No Kerosene), worth about US$20. It can be hung outside in the sun to charge and can provide up to six hours of lighting.

© A. Maduekwe/UNESCO

In August last year, Maasai men and women pose proudly in front of one of the newly completed showhomes.

A second option is the SunLite Solar Kit (US$50). This consists of a solar panel, control box with charger and battery, and a very bright LED light. The kit comes with a long cable and wiring that can be connected to most mobile phones. The advantage of this model is that owners can not only charge their own mobile phones but also earn extra income from providing a service to others.

UNESCO has estimated the average cost of building a single *boma* at US$770, excluding labour charges. Since the women are taking this on as a commercial venture, the cost of labour will need to be incorporated. Ten women were assigned to the task of building each *boma*, in return for payment of about US$7 per day for 20 days, bringing the total cost of each *boma* to US$2,170.

© Tanzanian Women Architects for Humanity

© A. Maduekwe/UNESCO

Maasai women learning how to build the chimney

Getting down to business

The two showhomes were completed in August last year. While they were being built, nearby villages sent emissaries to see what was going on. They were so impressed that many offered to pay the women to build model homes for them. Moreover, Airtel Tanzania, a mobile telephone company active in the region, has expressed interest in funding the replication of some of the model homes within the community. This would give the women the seed money they need to set up a small business.

It should not be difficult for the women to organize themselves, as they already produce handicrafts, raise chickens and sell milk within cooperatives. They can of course count on another valuable asset, the incredible solidarity within the community.

Anthony Maduekwe[9]

For details: a.maduekwe@unesco.org; v.jensen@unesco.org

8 *UNESCO's Dar es Salaam office has been leading the reform of STI in Tanzania within UNDAP (formerly the One UN Programme) since 2008. As part of this programme, UNESCO commissioned a survey (2011) of the participation of women in industries based on science, engineering and technology, as part of its support for the Tanzanian Women in Science group: http://tinyurl.com/acvse8c*

9 *Programme Specialist in UNESCO's Dar es Salaam office*

Diary

3–4 April
Education for sustainable development
Sub-regional open consultation to plan new programme framework for end of UN Decade on Education for Sustainable Development (post- 2014). Organized by UNESCO Santiago in Kingston (Jamaica), followed by one in Costa Rica (16–17 April): *http://tinyurl.com/esd-consult*

9–12 April
IOCARIBE
12th intergovernmental session. Panama City: *c.toro@unesco.org; http://iocaribe.ioc-unesco.org*

12–13 April
Green economy and biosphere reserves
UNESCO Cairo and Jordanian Royal Society for the Conservation of Nature. 8th ArabMAB meeting and regional workshop. Dana Biosphere Reserve (Jordan): *m.alaawah@unesco.org*

15 April
Ocean Compact Advisory Group
Deadline for nominations to UN panel supported by UNESCO-IOC, UNDP, UNEP: *http://tinyurl.com/oceans-compact*

18–21 April
Hydrometeorological hazards and climate change adaptation
Regional workshop to launch educational materials within project on related local and indigenous knowledge in Indonesia, Philippines, Timor Leste. UNESCO Jakarta, Asia–Pacific Network for Global Change Research, etc. For researchers, scientists, governments NGOs, local communities. Manila (Philippines): *l.hiwasaki@unesco.org*

25–29 April
High-energy physics and cosmology
Meeting of Southeastern European Network on Mathematics and Theoretical Physics, set up within Venice Process: 40 researchers plus EPS, CERN, SISSA, ICTP, UNESCO, etc. Vrnjačka Banja (Serbia): *www.seenet-mtp.info*

14–16 May
International Drought Initiative
2nd meeting of initiative launched by UNESCO-IHP and Iranian Ministry of Energy. Will finalize road map. Teheran (Iran): *sh.khorasani@rcuwm.org.ir; s.demuth@unesco.org*

27–30 May
Man and the Biosphere Programme
25th session of International Coordinating Council to review implementation of Madrid Action Plan (2008). New biosphere reserves and awards for young scientists and biosphere management to be announced: *m.bouamrane@unesco.org*

4–7 June
Traditional calendars for informing climate change policies
Intl experts meeting. UNESCO and New Zealand Nat. Comm. for UNESCO. Auckland (New Zealand): *h.thulstrup@unesco.org*

6 June
Water security challenges through scientific cooperation
Session during intl. conf. Koblenz (Germany): *a.mishra@unesco.org*

9–11 June
Contribution of indigenous and local knowledge systems to IPBES
Intl expert and stakeholder workshop on building synergies with science. UNESCO and UNU. Min of Environment. Tokyo (Japan): *d.nakashima@unesco.org*

10 June
From the double helix through the human genome to the human variome
Celebrates 60 years since discovery of DNA, targeting the non-specialist. UNESCO Paris: *c.vizzini@unesco.org*

17–19 June
Sustainable management of marginal drylands
11th and final project meeting. UNESCO-MAB. Ghent (Belgium): *t.schaaf@unesco.org*

New releases

Education for Sustainable Development in Biosphere Reserves and other Designated Areas
A Resource Book for Educators in Southeastern Europe and the Mediterranean
Produced by UNESCO Venice. English only, 258 pp.
UNESCO is launching a series of a series of e-learning courses based on this resource book, together with the Mediterranean Information Office for Environment, Culture and Sustainable Development. The first course will take place from 25 March to 21 April. For background, see *A World of Science*, January 2013; for details: p.pypaert@unesco.org; download: http://unesdoc.unesco.org/images/0021/002199/219946e.pdf

Climate Change Education for Sustainable Development
UNESCO Course for Secondary Teachers
This innovative online training kit uses Flash-based software. The Flipbook format provides an on-screen textbook along with web links to access other pages or complementary information, such as PowerPoint slides or fact sheets organized by region: Africa, Asia, Europe and North America and Small Island States. Provides information on international agreements and proposes maps, role playing ,etc. For teachers and teacher training institutions. Download: http://tinyurl.com/apcb57l

Climate Change Impacts and Adaptation Strategies in the Yellow River Basin
Popular Science Press, with UNESCO Beijing office. Yellow River Conservancy Commission and UNESCO-IHP. English only, 308 pp.
Under all six scenarii studied by this project, there will be water shortages along the Yellow River by 2050. The project received funding from the MDG Achievement Fund. Download: http://unesdoc.unesco.org/images/0021/002180/218026E.pdf; for details: r.jayakumar@unesco.org

Adaptation to Climate Change in Coastal Zones of West Africa
Brochure published by UNESCO-IOC. Exists in English, French and Portuguese, 8 pp.
Summarizes accomplishments at five pilot sites of the Adaptation to Climate Change in Coastal Zones Project (2008–2012) run by the UNESCO-IOC in Cape Verde, Gambia, Guinea-Bissau, Mauritania and Senegal. See also the guide from the same project, *A World of Science*, July 2012. For details: j.barbiere@unesco.org. Download: http://unesdoc.unesco.org/images/0021/002179/217953e.pdf

Securing the Future of Mangroves
By H. Van Lavieren , M. Spalding, D. Alongi, M. Kainuma, M. Clüsener-Godt (UNESCO) and Z. Adeel. Policy brief produced by International Tropical Timber Organization, International Society for Mangrove Ecosystems, FAO, UNEP, UNESCO, UNU-INWEH, Nature Conservancy. English only, 52 pp.
Based on 2nd edition of *World Atlas of Mangroves*. Provides managers and decision-makers with straightforward policy and management options. Describes which instruments and measures are readily available. Highlights lessons learned. Download: http://unesdoc.unesco.org/images/0021/002192/219248e.pdf

A Framework for Ocean Observing
E. Lindstrom, J. Gunn; A. Fischer (UNESCO), A McCurdy, L. K. Glover (eds). Published by UNESCO-IOC. IOC/INF-1284. English only, 28 pp.
Lays the basis of a governance model to optimize collaboration and integration across the many observing system elements and communities over the next 10 years. Download: http://unesdoc.unesco.org/images/0021/002112/211260e.pdf

How to Plan, Conduct and Evaluate UNESCO/IOC Tsunami Wave Exercises
Published by UNESCO-IOC. IOC Manuals and Guides, 58 rev. English and Spanish, 95 pp.
Guide prepared by Task Team 2 (Disaster Management and Preparedness) of UNESCO/IOC Working Group on Tsunamis and Other Hazards Related to Sea-Level Warning and Mitigation Systems. Download (replace 'e' with 's' for Spanish edition): http://unesdoc.unesco.org/images/0021/002189/218967e.pdf

Tsunami Glossary
Published by UNESCO-IOC. Technical Series No.85 rev. Arabic and English, 48 pp.
Reference document for scientific experts. Download (replace 'e' with 'a' for Arabic edition): http://unesdoc.unesco.org/images/0018/001882/188226e.pdf

Global Ecology and Oceanography of Harmful Algal Blooms (GEOHAB)
E. Berdalet, P. Tester, A. Zingone (eds). Produced by UNESCO-IOC and ICSU's Scientific Committee on Oceanic Research. GEOHAB Report No. 9. ISSN 1538 182X. English only, 64 pp.
Summarizes a GEOHAB core research project on harmful algal blooms in benthic systems. For details: h.enevoldsen@bio.ku.dk; download: http://unesdoc.unesco.org/images/0021/002187/218766e.pdf

Harmful Algal Blooms in Fjords and Coastal Embayments
S. Roy, V. Pospelova, M. Montresor, A.Cembella (eds). Published by UNESCO-IOC and SCOR. GEOHAB Report 10. ISSN: 1538 182X. English only, 53 pp.
Presents the major outcomes of the 2nd Open Science Meeting on Progress in Interpreting Life History and Growth Dynamics of Harmful Algal Blooms, which synthesized research efforts and planned future collaboration for after GEOHAB programme ends in December 2013. Download: http://unesdoc.unesco.org/images/0021/002198/219833e.pdf

Managing Natural World Heritage
Resource manual produced by World Heritage Centre with ICCROM, ICOMOS and IUCN. ISBN : 978-92-3-001075-1, English only, 100 pp.
Clarifies questions likely to be particular or unique to world heritage and either supplies relevant information directly or explains where this information can be found. Sister manual to follow on managing cultural world heritage. For details: v.vujicic@unesco.org; download: http://whc.unesco.org/uploads/activities/documents/activity-703-1.pdf