



United Nations Educational,
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When learning
science becomes
child's play p. 2

A World of **SCIENCE**

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Roadblocks can be lifted

If we miss the boat for achieving environmental sustainability by 2015, we can wave good-bye not only to this Millennium Goal but also to many others, warns a major study published on 30 March. 'Any progress achieved in addressing the goals of extreme poverty and hunger eradication, improved health and environmental protection is unlikely to be sustained if most of the ecosystem services on which humanity relies continue to be degraded', says the study, which describes the ongoing degradation of ecosystem services serves as a 'roadblock' to achieving the Millennium Development Goals agreed upon by world leaders at the United Nations in 2000. According to the study, 60% of the ecosystem services supporting life on Earth are being degraded or used unsustainably.

The fruit of a four-year global assessment by a team of UN agencies – including UNESCO – international scientific bodies and development agencies, the *Millennium Ecosystem Assessment Synthesis Report* claims there is now enough evidence for experts to warn that the ongoing degradation of 15 of the 24 ecosystem services examined – including freshwater, capture fisheries, air and water regulation, and the regulation of regional climate, natural hazards and pests – increases the likelihood of potentially abrupt changes that will seriously affect human well-being. This includes the emergence of new diseases, sudden changes in water quality, creation of 'dead zones' along the coasts, the collapse of fisheries and shifts in regional climate.

The study confirms what many have long suspected: that it is the world's poorest who bear the brunt of ecosystem changes. The regions facing significant problems of ecosystem degradation – sub-Saharan Africa, Central Asia, some regions of Latin America and parts of south and Southeast Asia – are also those finding it hardest to reach the Millennium Goals. In sub-Saharan Africa, for example, the number of poor is forecast to rise from 315 million in 1999 to 404 million by 2015. Southern Africa is unlikely to be spared, as we shall see from one of the sub-regional reports for the Millennium Assessment, reproduced in this issue.

As this issue goes to press, the G8 countries have just agreed to write off the debt of 18 of the world's poorest countries: Benin, Bolivia, Burkina Faso, Ethiopia, Ghana, Guyana, Honduras, Madagascar, Mali, Mauritania, Mozambique, Nicaragua, Niger, Rwanda, Senegal, Tanzania, Uganda and Zambia. A further nine may soon join them. Freed from the stranglehold of debt, this first group of countries will now dispose of \$1.5 billion in annual savings from debt repayments to invest in such areas as education, health and the environment. It could make all the difference to their chances of meeting the Millennium Goals.

W. Erdelen
Assistant Director-General for Natural Sciences

When learning science becomes **child's play**

The recent development of inquiry-based science teaching in primary schools owes much to the efforts of the scientific community. It was Leon Lederman, Nobel Laureate for Physics 1988, for instance, who introduced the movement into poor neighbourhood schools of Chicago in the USA. Three French physicists would later visit these schools, only to discover children fired with enthusiasm for science. Upon their return to France, the three physicists – Georges Charpak, Nobel Laureate for Physics in 1992, Pierre Léna and Yves Quéré – would decide to launch their own version of inquiry-based science teaching, *La main à la pâte* (or Learning by doing).

Over the past five years, the movement has spread to schools in Afghanistan, Argentina, Brazil, Cambodia, Chile, China, Colombia, Egypt, Malaysia, Mexico, Morocco, Senegal, Slovakia, Togo and elsewhere. Together with David Jasmin, responsible for the programme's international activities, Yves Quéré explains here how *La main à la pâte* has caught on around the world.

It all began in France in 1996 when we learned from the Ministry of Education that science was being taught in just 3% of classes in kindergartens and primary schools. This startling figure reflects, above all, just how much teachers dread having to teach a subject they believe has become too difficult. Science has undoubtedly made dizzying progress but what teachers don't seem to realize is that the basic concepts they should be showing children have not changed.

Having visited schools in the suburbs of Chicago, we suggested to the Minister a modest experiment which had the unanimous backing of the French Academy of Sciences. The experiment would involve 350 teachers keen on revitalizing science teaching for children, who would teach the inquiry-based method developed by *La main à la pâte* (see box). There was nothing really new about this 'teaching recipe', except for a few novel ingredients. A set of ten

principles summing up the general idea behind *La main à la pâte* was drafted and presented to the teachers.

There are two extremes in teaching, if we set aside the 'hybrid' methods inbetween. One is the top-down, or vertical, method: the teacher deposits knowledge, by gravity as it were, into the brain of the pupil, who is then required to store and hopefully retain this knowledge. Through this tried and true method, the child memorizes a remarkable store of knowledge. Its weak point is that this method of rote learning often attaches little importance to whether the child actually understands the concepts and ideas she or he is learning by heart.

Keeping to our geometric metaphor, we shall call the other extreme the horizontal method. Here, the teacher takes the pupil by the hand and leads him or her on a voyage of discovery, stimulating the child's observation skills,



What happens to food after we swallow it? A class in Nankin, China. The *La Main à la pâte* programme here is run by the Chinese Ministry of Education and the University of Nankin



© Éléves de l'école de l'APET à Kpalimé



For the launch of *La Main à la Pâte* in Togo, the theme of water is chosen. In this school at Kpalimé, the programme for classes at all levels involves school outings, using a scientific album and talks by water specialists. (Left) A visit to a vegetable garden. (Centre) Upon their return, the children study the water needs of a plant. (Right) After reading an album, pupils from the Kpodzi Kindergarten in Kpalimé are conducting experiments on the theme of 'Does it sink or float?' This programme is being run in parallel with a multidisciplinary project called @llo ! A l'eau involving Ms Liska-Baptiste's class of 8–9-year olds in France

imagination, curiosity and reasoning capacity. Given the time it takes pupils to make discoveries of their own, to reflect on what they see and express themselves orally or in writing, the amount of knowledge acquired is obviously less than with the top-down method. However, the horizontal method gives children a desire to understand and a mental elasticity which will help them to adapt better to our highly mobile social and professional world.

There is nothing new in this. It would not be farfetched for a Frenchman to imagine his Magdalenian¹ forebears using both of these methods: teaching his child of an evening, in the cave they call home, the names of fish or the best shape for hooks, before taking him next morning to the river for a practical fishing lesson. More recently in France, the laureate of the Nobel Prize for Physics (1903) and Chemistry (1911), Marie Sklodowska Curie, dextrously juggled the top-down approach with her students at the *Université de la Sorbonne* and the horizontal method with 7–8-year old children, whom she helped to discover physics by making them do it themselves using their own hands and brains.

1. *The Magdalenian period (between 17 000 and 10 000 years ago) represented the height of prehistoric cave art in France*



© Pamela Lucero/La main à la pâte



In this Colombian primary school in Bogotá, the 11-year old pupils are still at the stage of making forecasts. They are discussing ideas before beginning a series of experiments on mixtures. In the insert are the jars containing the different mixtures the children will later create. Pequeños Científicos programme (University of Las Andes/French Lycée of Bogotá/ Maloka Centre)

We knew that both of these approaches had their place but also that each was appropriate at a particular stage of the curriculum. For our purposes, we opted for the second approach, knowing full well that, as pupils progressed beyond the primary level, the top-down approach would have to be used more and more.

The ten principles of *La main à la pâte*

The teaching approach

1. Children observe an object or a phenomenon in the real, perceptible world around them and experiment with it.
2. During their investigations, pupils argue and reason, pooling and discussing their ideas and results, and building on their knowledge, since manual activity alone is insufficient.
3. The activities suggested by the teacher are organized in sequence for learning in stages. The activities are covered by the programme and leave much to pupil self-reliance.
4. A minimum schedule of two hours per week is devoted to the same theme for several weeks. Continuity of activities and teaching methods is ensured throughout the entire period of schooling.
5. Each child keeps an experiment logbook, in which the children make notes in their own words.
6. The prime objective is the gradual acquisition by pupils of scientific concepts and operating techniques, with consolidation through written and oral expression.

Partnership

7. The family and community are solicited for work done in class.
8. At the local level, scientific partners (universities, etc.) support classwork by making their skills and knowledge available.
9. Teaching colleges in the vicinity give teachers the benefit of their experience.
10. Teachers are able to obtain teaching modules, ideas for activities and replies to queries via the Internet. They can also take part in a dialogue with colleagues, training officers and scientists.

For more details: www.inrp.fr/lamap



© Laura Pacheco

(Top) These kindergarten pupils at the French Lycée in Buenos Aires, Argentina, are trying to light a bulb using a battery. This experiment favours a personal discovery of the concept of a closed circuit. (Lower photo) A lesson on recycling paper at the same school

Lighter than air

Joseph (1740–1810) and Etienne (1745–1799) Montgolfier were respectively the twelfth and fifteenth of the sixteen children of Pierre Montgolfier, a paper manufacturer in Vidalon-les-Annonay in France.

In November 1782, Joseph travelled to the town of Avignon to sell paper to the printers in the region. In his room, a fire in the grate heated his shirt. As Joseph was mulling over the siege of Gibraltar by the French navy (Gibraltar is a rocky outcrop of 5 km² at the mouth of the Mediterranean, belonging to the United Kingdom), he approached the mantelpiece and saw his shirt billow. His mind made a correlation between the two observations: surely it would be easier to enter Gibraltar using airborne craft inflated with hot air than by sea. Joseph cut out and sewed a square of cloth, which he then held over the fire. When he let it go, the cloth began to rise. This idea might work, he realized.

Back home in Annonay, Joseph pursued his experiments with Etienne. The brothers had already thought of blocking hydrogen in little silk or paper envelopes but had been unable to prevent the gas from escaping. They succeeded, however, in getting little round balls filled with hot air to rise.

On 4 June 1783, Joseph and Etienne Montgolfier demonstrated their balloon for the first time to an admiring crowd in Annonay (see sketch). The balloon rose to almost 1000 m and covered a distance of 2 km in 10 minutes. At the behest of the king, they repeated the exploit at the Palace of Versailles five months later. The passengers on this second flight were a rooster, a duck and a sheep. Not until its third flight, on 21 November 1783, did the hot-air balloon transport human passengers.



It is not hard to imagine how this exercise develops a child's imagination and observation skills. The child rubs shoulders with the concept of truth, learns to question preconceived ideas expressed by others or rooted in the child's own prejudices. He or she acquires a new awareness of the universality of laws, the absurdity of racism, and the global nature of the world we live in. His or her mastery of language improves – science has no time for imprecise words or unfounded assertions. The child discovers the virtues of teamwork and acquires the manual skills needed to prepare and carry out an experiment.

By way of example, we could cite the class curious to understand what was meant by 'rhythm'. The children made rudimentary pendulums out of weights attached to a piece of string. Swinging the pendulums back and forth, they then measured the periodic regularity of the motion (or the oscillation) and tried to work out why the pendulums moved at different speeds. Each child was convinced – and could not hide a certain complacency – that their idea was the 'right' one. It took some time and a lot of patient reflection on the separation of the different parameters before the truth was revealed: the time it took for the pendulum to swing back and forth in a full cycle did not depend on the weight, nor on the thickness of the string, nor on the initial impetus nor on how the knot was tied (all hypotheses suggested by the children) but solely on the length of the pendulum. This was a superb lesson in that it taught the children much more than a simple physics formula: the teacher's clever commentary helped the children to realize that any real phenomenon – not only physical but also climatic, sociological or epidemic – cannot be interpreted, let alone understood, until all

The teaching technique

Teachers usually set the ball rolling by quizzing the children about inert objects (such as rocks, water and the sky), living beings (insects, the human body, plants and so on) and natural phenomena (winds, tides and climate). Rather than giving an answer, the teacher turns the question back to the children. 'What do you think?', thus inviting them to advance their own hypotheses. Even the most naïve of these hypotheses is accepted on face value. The next step is to stage an experiment. This usually involves four or five children working in a small group. The children decide which is the best hypothesis and, ideally, answer the question. To round off the lesson, the children are encouraged to express themselves by noting the practical and intellectual adventure they have just experienced in their 'experiment logbook'.

Archimedes' Law of Buoyancy

As legend has it, the law of buoyancy came to Archimedes (Sicily, ca 287–212 BC) while he was taking a bath. On seeing the bathwater overflow, he realized that the density of an object (in this case his own body) could be measured by determining how much water the object displaced. Archimedes was reportedly so excited by his discovery that he ran naked through the streets shouting 'Eureka! 'Eureka! ('I have found it! 'I have found it!').

The action exerted by water on an object plunged into its midst is today known as Archimedes' Law of Buoyancy. According to this principle, when an object placed in water is weighed and its weight in the water is compared to its weight out of the water, the object loses an amount of weight that is equal to the weight of the water it displaces. It is easier to carry an object in water than out of it, as anyone who has ever carried a person in a lake, or dragged a net full of fish out of the water, will know.

The principle of Archimedes holds not only for water but also for gases like air. Gases are not very dense, so the force they exert is weak; they are sufficiently dense however for a balloon of 1400 m³ at Versailles to carry three passengers on 19 September 1783: a rooster, a sheep and a duck (see above *Lighter than air*).

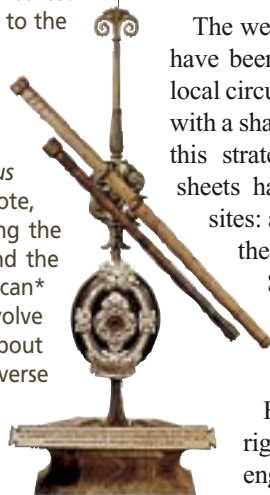
Galileo's telescope

Galileo Galilei (1564–1642) was teaching astronomy at the University of Padua (Italy) when he learnt in 1609 of the invention of the telescope in Holland (The Netherlands). Relying on the barest of descriptions, Galileo built himself a model far superior to the original. With this, he was able to study the heavens and position the four satellites of Jupiter, which he named Medicean stars in tribute to his benefactor, Lorenzo di Medici.

Galileo reported his discoveries in *Sidereus Nuncius* (*Starry Messenger*, 1610). On the Medicean stars, he wrote, 'Here, we have a fine and elegant argument for quieting the doubts of those who, while accepting with tranquil mind the revolutions of the planets about the sun in the Copernican* system, are mightily disturbed to have the moon alone revolve about the Earth and accompany it in an annual rotation about the sun. Some have believed that this structure of the universe should be rejected as impossible. But now we have not just one planet rotating about another while both run through a greater orbit around the sun; our own eyes show us four stars which wander around Jupiter as does the moon around the Earth, while all together trace out a grand revolution about the sun in the space of twelve years'. (Translation made available by Bard College, USA)

From his observations of celestial bodies rotating around a body other than the Earth, Galileo constructed his heliocentric theory placing the sun at the centre of our solar system. In so doing, he refuted Ptolemy's theory (Egypt, ca. 90–168), according to which the bodies of the solar system circled the Earth (geocentric theory).

* Galileo was able to confirm the truth of the sun-centred theory expounded by Polish physicist Nicolaus Copernicus (1473–1543), according to which it was the planets that revolved around the sun and not the reverse.



level scientists have agreed to answer questions on elementary science gratuitously within 48 hours. The questions and answers are naturally made public and by the end of 2004 represented a repertoire of over 1000 entries.

The website has engendered others. A dozen regional sites have been set up in France proposing activities adapted to local circumstances and resources. All the sites are networked with a shared search engine and common charter. Since 2000, this strategy has been extended beyond France: activity sheets have been translated and posted online at partner sites: a mirror site in China², sites in Brazil and so on. By the end of 2005, sites will be online in Portuguese and Spanish (Universidad de las Andes), Serbian (Vinča Institute of Nuclear Sciences, Serbian Physical Society) and Arabic (Bibliotheca Alexandrina).

Furthermore, a quadrilingual site³ enabling copyright-free resources to be shared among ten countries engaged in reforming science education has been created. To complement this, *La main à la pâte* has opened a bilingual portal on science teaching in primary schools to showcase the teaching activities of members of the International Council for Science (ICSU) and InterAcademy Panel (IAP)⁴. It also features a brief description of science education systems in different countries, the proceedings of symposia on science teaching in primary and secondary schools, and synopses of publications on the subject.

the different elements have been separated and documented. The children learnt that neglecting that rule opens the door to falsifications and to all the political and sectarian manipulations to which children might be exposed.

Some new ingredients

Neither our ancestors nor Marie Sklodowska Curie ever knew the Internet, of course. This modern tool has proved extremely effective in expanding the outreach of *La main à la pâte*. It is very popular with teachers, 200 000 of whom visited our site every month in 2004. Our website has three missions: to make resources available to primary school teachers in the form of multiple experimental sheets, scientific data and teaching tips; to provide a vast "chat forum" enabling teachers to talk to each other, compare teaching methods, share their successes, describe problems and propose sequences they have devised themselves to colleagues. It is remarkable that the forum has quite naturally opened up to subjects other than science, such as grammar and history; and lastly, to create a whole new relationship between the world of teachers and that of researchers. Some 100 high-

2. University of Nanjing: www.lamap.handsbrain.com

3. This experimental site covers: Belgium, Brazil, Canada, (Québec), Chile, Colombia, Egypt, France, Morocco, Serbia & Montenegro and Spain: www.mapmonde.org.

4. Yves Quéré is co-president of the IAP, an international network of academies of science



This class of sixth-year primary pupils from Phnom Penh, Cambodia, is working on levers, a project adapted from an activity developed in France. The children have been asked to devise a system for lifting a 50 kg bag of rice. In collaboration with the programme of the Agence universitaire de la francophonie and the Cambodian Ministry of Education

Measuring the Earth is child's play!

Since September 2000, 8–14-year olds have been measuring the circumference of the Earth using a method devised by Eratosthenes, Director of the Bibliotheca Alexandrina, 22 centuries ago. The children place a stick vertically to the sun and measure the length of the shadow when the sun is at its peak. They then deduce the angle of the sun's rays in relation to the vertical line of the stick. The children exchange their results with another class living at a different latitude. A few geometric strokes and a rule of three (the method of finding the 4th term of a proportion when the other three are given) enable the children to evaluate the length of the Earth's meridian (a circle of constant longitude passing through a given spot on the Earth's surface) at their latitude.

As of 2005, some 52 classes, mainly from France but also from Belgium, Brazil*, Cameroon, Canada, Egypt, Latvia, Malta, Poland, Serbia & Montenegro and the United Kingdom were participating in the project.

More measurements are needed to complete the experiment. Your class can join in by going to: www.inrp.fr/lamap/eratos. The French Ministry of Education has created pages in English: www.educnet.education.fr/phy/interpc/eratos.htm



source: <http://educar.sc.usp.br/bfl/>

(Left) In front of the Bibliotheca Alexandrina, this Egyptian class is measuring the Earth's circumference on the day of the summer solstice, 21 June, at the very place where Eratosthenes took his measurements all those years ago.

(Right) On the same day, this Latvian girl is measuring the Earth's circumference in Dzerbene. The vertical angle from the sun measures $33^{\circ}10''$

*Visit the Brazilian site: <http://educar.sc.usp.br/bfl/>

A science coach for teachers

A scientific coaching programme for teachers has been launched in France. This brings teachers into direct contact with scientists to complement the initial and on-going training provided by teacher training colleges. The coaching programme instigates a more personal relationship with the scientists and engineers who agree to go into schools (not to teach but to help teachers introduce the inquiry-based method), or with the students who fulfil the same role, more and more often as part of their university course.

The scientific coaching programme has been so successful that a *Coaching Charter* was even drafted in 2004 and endorsed by the French Ministry of Education. The *Charter*

outlines both the best practices and those to avoid. It underscores, for instance, that the scientist is in the classroom to assist the teacher and not to teach the class.

It works both ways

We have evoked experiments launched in the USA and actively encouraged by the US National Academy of Sciences but science education for children has been thoroughly overhauled in many countries in recent years. By way of example, we could cite the remarkable initiatives by Wei Yu in China, Maurizio Duke in Colombia and Jorge Allende in Chile, not to mention the growing number of international conferences on the subject.

Many countries have made bilateral contacts and signed agreements, often between science academies, leading to active co-operation. This is particularly the case for Afghanistan, Argentina, Brazil, Cambodia, Chile, China, Colombia, Egypt, Malaysia, Mexico, Morocco, Senegal, Slovakia, Switzerland and the USA. Courses for teachers and trainers have been organized with two-way translation of documents and exchanges of teaching material. The virtue of these exchanges is that they are of mutual benefit. For instance, some of our books and documents have been translated into Chinese; in exchange, Chinese texts for kindergarten teaching have been translated into French.

Moreover, a number of scientific activities have been launched which simultaneously bring into play schools from different countries. European Discoveries, for example, introduces European children to discoveries from their continent. These discoveries are placed in their historical context. There is the hot-air balloon invented by the Montgolfier brothers in 1783 (a beautiful illustration of Archimedes' Law



© Elisabeth Pé. IUFM de Kemis

These girls at Dourani High School in Kabul are about to discover the temperature at which water boils. Although they are fifth-year pupils (high schools in Afghanistan cover all levels of schooling), the girls are aged about 14 (Ed. owing to the three years of schooling they lost under the Taliban, who banned schooling for girls until the fall of the regime in 2002)



© Edith Sahlstedt, *La main à la pâte*

This class of 8-year olds in Cairo, Egypt, is working on the five senses. The pupils have been asked to identify the object inside the mysterious container without opening it. The children are being encouraged to compare, describe and draw parallels between the sounds coming from the different objects in the container

of Buoyancy), the Galilean telescope or Volta's battery... (see boxes) and so on. All are perfectly suited to scientific experimentation in the classroom.

Likewise, since 2000, children aged 8–14 years have been measuring the circumference of the Earth using a method developed 22 centuries ago by Eratosthenes, Director of the Bibliotheca Alexandrina. Participating classes from more than a dozen countries are contributing to the project by exchanging and comparing their measurements taken at different latitudes (see box on p. 6).

Children take up the challenge

The international science challenges were inaugurated by *La main à la pâte* in June 2004 and so far involve ten classes in different countries. Thanks to new computer platforms making it possible to view videos transmitted from different locations in real time and in parallel via Internet, each of the competing classes can be filmed simultaneously by a webcam(era) as it tackles a given scientific or technical challenge, the same for every class.



© D&F

In small groups, these children at a school in Port-au-Prince, Haiti, are dissecting a rabbit and observing its different organs. They are in the process of inflating the rabbit's lungs using a straw introduced into the animal's throat. Programme implemented by the NGO Défi, with support from the Mérieux Foundation



© José Braz, Nana

The challenge of the straw tower. At the same time on the same day, 20 pupils from each of the participating countries (Brazil, Canada, Colombia, Egypt, France, Morocco) – here one of the Brazilian teams – had to build the highest tower possible using

100 straws and 100 paper clips. Once the tower was completed, they had to test its strength by attaching weights of 10 g to the summit. Their efforts were transmitted live via Internet (www.mapmonde.org). The concepts targeted were: how the materials used and the shape of the tower related to the strength and resilience of the structure

One of these science challenges saw 8–11-year olds build a vehicle capable of protecting an egg dropped from a height of 2 m. The 'egg-tronaut' had to survive the landing without cracking its shell.

Another challenge involved classes from six countries. Each group of 9–10-year olds was asked to build a structure using 100 straws and paper clips, in an exercise from the construction module. The jury presided by Georges Charpak awarded prizes in four categories: for the highest tower, the most original tower, the most beautiful tower and the strongest tower (see above one of the Brazilian teams in action).

Making education child's play

The current disaffection for scientific disciplines at university, coupled with the need to open the minds of children to observation, deductive reasoning, teamwork, free thinking and universal truths (which do not conflict with local cultures), leaves us no choice but to rethink the way we teach science to children, if we want them to enjoy learning and to think both imaginatively and rationally.



© Maria da Luz

Within the European Discoveries project, children from Figueira da Foz in Portugal are putting together a herbarium of medicinal plants. They are reproducing the work

of Garcia de Orta (ca. 1499–1568). This Portuguese naturalist and doctor taught his students the importance of observation and of using the senses to study the natural world. In collaboration with *Ciência Viva*, an agency of the Portuguese Ministry of Science and Technology

La main à la pâte is playing its part because it would like to see inquiry-based teaching catch on around the world. UNESCO can lend its prestige to making this happen, by providing a framework and an impetus for reform.

As for the situation in France, we were relieved to learn recently that the number of classes being taught science in French kindergartens and primary schools had climbed from the initial 3% to 35% by 2004.

Yves Quéré et David Jasmin

The boxes in this article were inspired by various publications of La Main à la pâte.

The first battery

It was the Italian Alessandro Volta (1745–1827) who built the first electric battery (or pile, as it was originally known) after realizing that a liquid between two plates of dissimilar metals could produce an electric current.

Volta himself describes his apparatus, "... I provide a few dozens of small round plates or disks of copper, brass, or rather silver, an inch in diameter more or less (coins for example), and an equal number of plates of tin, or, what is better, of zinc, nearly of the same size and figure. I make use of the term nearly because great precision is not necessary, and the size in general, as well as the figure of the metallic pieces, is merely arbitrary: care must only be taken that they are capable of being conveniently arranged one above the other in the form of a column. I prepare also a pretty large number of circular pieces of pasteboard, leather, or any other spongy matter capable of imbibing and retaining a great deal of water or moisture, with which they must be well impregnated in order to ensure success to the experiments. These circular pieces of pasteboard, which I shall call moistened disks, I make a little smaller than the plates of metal, in order that, when interposed between them, as I shall hereafter describe, they may not project beyond them..."

Letter to Joseph Banks, Secretary of the English Royal Society, 20 March 1800



These children in Bologna, Italy, are building a Voltaic battery using coins, lemons and oranges. Citrus fruits have been chosen because the acidity of their juice makes them an excellent electrolyte (i.e. a very good conductor of electricity)

Experts warn ecosystem changes threaten development

A landmark study launched worldwide on 30 March reveals that approximately 60% of the ecosystem services supporting life on Earth are being degraded or used unsustainably. The *Millennium Ecosystem Assessment (MA) Synthesis Report*⁵, compiled by 1300 scientists in 95 countries, warns that the harmful consequences of this degradation could grow much worse in the next 50 years.

In Paris, the study was presented at UNESCO by Salvatore Arico of UNESCO's Division of Ecological and Earth Sciences, member of the Board in charge of the study, and by Thomas Rosswall, Executive Director of the International Council for Science.

The report highlights four main findings:

- Humans have changed ecosystems more rapidly and extensively in the last 50 years than at any other time. This has been done largely to meet rapidly growing demands for food, freshwater, timber, fibre and fuel. More land has been converted to agriculture since 1945 than in the 18th and 19th centuries combined. More than half of all the synthetic nitrogen fertilizers ever used on the planet – since they were first made in 1913 – have been used since 1985. This has resulted in a substantial and largely irreversible loss in diversity of life on Earth, with some 10–30% of the mammal, bird and amphibian species currently threatened with extinction.
- Ecosystem changes that have contributed substantial net gains in human well-being and economic development have been achieved at growing costs in the form of degradation of other services. Only four ecosystem services out of the 24 studied have been enhanced in the past 50 years, with rises in: crop, livestock and aquaculture production, and greater recourse to carbon sequestration for global climate regulation. Two services – capture fisheries and freshwater – are now well beyond levels that can sustain current demands, let alone future ones. Experts say that these problems will substantially diminish the benefits for future generations.
- The degradation of ecosystem services could become significantly worse during the first half of this century and is a barrier to achieving the UN Millennium Development Goals (see table). All four plausible futures explored by the scientists predict progress in eliminating hunger but at far slower rates than needed to halve the number of people suffering from hunger by 2015. Experts warn that changes in ecosystems like deforestation influence the abundance of human pathogens such as malaria and cholera, as well as the risk of emergence of new diseases. Malaria, for example, accounts for 11% of the disease burden in Africa; had it been eliminated 35 years ago, the continent's gross domestic product would have increased by \$100 billion.

The Eight Millennium Development Goals to 2015

Eradicate extreme poverty and hunger	<ul style="list-style-type: none"> • Reduce by half the proportion of people living on less than a dollar a day • Reduce by half the proportion of people who suffer from hunger
Achieve universal primary education	<ul style="list-style-type: none"> • Ensure that all boys and girls complete a full course of primary schooling
Promote gender equality and empower women	<ul style="list-style-type: none"> • Eliminate gender disparity in primary and secondary education, preferably by 2005, and at all levels by 2015
Reduce child mortality	<ul style="list-style-type: none"> • Reduce by two-thirds the mortality rate among children under five
Improve maternal health	<ul style="list-style-type: none"> • Reduce by three-quarters the maternal mortality ratio
Combat HIV/AIDS, malaria and other diseases	<ul style="list-style-type: none"> • Halt and begin to reverse the spread of HIV/AIDS • Halt and begin to reverse the incidence of malaria and other major diseases
Ensure environmental sustainability	<ul style="list-style-type: none"> • Integrate the principles of sustainable development into country policies and programmes; reverse loss of environmental resources • Reduce by half the proportion of people without sustainable access to safe drinking water • Achieve significant improvement in lives of at least 100 million slum dwellers, by 2020
Develop a global partnership for development	<ul style="list-style-type: none"> • Develop further an open trading and financial system that is rule-based, predictable and non-discriminatory. Includes a commitment to good governance, development and poverty reduction, nationally and internationally • Address the least developed countries' special needs. This includes tariff- and quota-free access for their exports; enhanced debt relief for heavily indebted poor countries; cancellation of official bilateral debt; and more generous official development assistance for countries committed to poverty reduction • Address the special needs of landlocked and small island developing States • Deal comprehensively with developing countries' debt problems through national and international measures to make debt sustainable in the long term • In co-operation with the developing countries, develop decent and productive work for youth • In co-operation with pharmaceutical companies, provide access to affordable essential drugs in developing countries • In co-operation with the private sector, make available the benefits of new technologies, especially information and communications technologies

- The challenge of reversing the degradation of ecosystems while meeting increasing demands can be met under some scenarios involving significant policy and institutional changes. However, these changes are not currently under way. The report mentions existing options for conserving or enhancing ecosystem services that reduce negative trade-offs or that will positively impact other services. Protection of natural forests, for example, not only conserves wildlife but also supplies freshwater and reduces carbon emissions.

'The overriding conclusion of this assessment is that it lies within the power of human societies to ease the strains we are putting on the nature services of the planet, while continuing to use them to bring better living standards to all,' said the MA board of directors in a statement, *Living beyond Our Means: Natural Assets and Human Well-being*. 'Achieving this, however, will require radical changes in the way nature is treated at every level of decision-making and new ways of co-operation between government, business and civil society. The warning signs are there for all of us to see. The future now lies in our hands.'

For details: www.millenniumassessment.org;
s.arico@unesco.org;

See also the report on Southern Africa, p.16



Agriculture in the Pisac area of Peru, in 1999. Crop production is one of only four ecosystem services out of 24 studied that has been enhanced in the past 50 years

Tsunami early warning system moves into new phase

UNESCO's Intergovernmental Oceanographic Commission (IOC) is to formalize the management structure for developing and maintaining the tsunami early warning system for the Indian Ocean at its 23rd Assembly from 21 to 30 June at UNESCO Headquarters. The system is due to be fully operational by mid-2006.

This latest rendez-vous follows on from a first coordination meeting from 3 to 8 March at UNESCO Headquarters and a second in Mauritius from 14 to 16 April. At the former, it was decided to base the system on a co-ordinated network of national systems, with each Member State being responsible for issuing warnings within its own boundaries and each national system operating within a regional framework. The meeting recommended that an intergovernmental co-ordination group be set up, with the IOC providing the secretariat. The installation of six new sea-level gauges in India, Indonesia, Malaysia, Myanmar, Sri Lanka and Thailand

5. *The first in a series of seven summary reports and four technical volumes on the state of global ecosystems and their impact on human well-being. This first assessment was designed by a partnership of UN agencies, international scientific bodies and development agencies, with guidance from the private sector and civil society. Major funding is provided by the Global Environment Facility, United Nations Foundation, David and Lucile Packard Foundation and World Bank. The MA Secretariat is co-ordinated by UNEP. The MA is recognized by governments as a mechanism for meeting part of the assessment needs of the: UN Convention on Biological Diversity, Ramsar Convention on Wetlands, UN Convention to Combat Desertification and the Convention on Migratory Species*



One of 20 camps of internally displaced persons on the island of Siberut, in early May. Three months after the December earthquake, an aftershock of 6.7-magnitude struck this island off Sumatra's west coast on 10 April, causing structural damage but no casualties. Many government officials fled to Padang after the earthquake, making it difficult to develop a rapid response and monitor conditions in the camps, which still housed one-fifth of the island's 40 000 population in May. UNESCO has more than 20 project staff working with governmental agencies and NGOs on Siberut to ease hardship in the camps: UNESCO has shown people how to build sanitation and waste management facilities, for example, and



helped to distribute 2770 mosquito nets provided by the NGO SurfAid International to reduce the risk of malaria outbreaks. With communication channels down, misinformation had been circulating on the island about earthquakes and the risk of future tsunamis, making many villagers fearful to return to their homes and livelihoods on the coast. UNESCO has since set up temporary information centres in three of the camps and, in response to a request from the local authorities, has begun teacher training on earthquake awareness and preparedness

was also decided in March, together with the upgrading of 15 others placed throughout the Indian Ocean basin. The installation of deep-sea ocean bottom pressure sensors is also in the planning.

In Mauritius a month later, countries re-affirmed their commitment to establishing the tsunami early warning system for the Indian Ocean in the short term and to working towards a global multi-hazards warning system in the longer term. Countries around the Indian Ocean were invited to assess their requirements for the tsunami early warning system as a first step towards national strategic plans.

Eighteen countries have since requested assistance from the IOC for these assessments. Consequently, joint expert teams from the IOC, WMO and UN International Strategy for Disaster Reduction will be touring the region between the end of May and August to provide assistance. The assessments will be used to finalize plans for both the national and regional systems and should facilitate the co-ordination of donors' assistance for the different components, from technical requirements and instrumentation to communication channels and public education programmes.

Donor nations attending the Mauritius meeting, including Belgium, Finland and Norway, pledged some \$5 million over and above earlier contributions for specific activities linked to the tsunami system. Several others, including Australia, France, Germany, Italy, Japan and the USA, along with the European Commission, also reiterated their willingness to provide more financial aid as the plans for the system became more clearly defined.

The 26 December earthquake killed about 217 000 people. Many detailed studies are being made to assess its size. Assessments vary from a magnitude of 9.0 to 9.3 and it may be months before consensus is reached. One problem stems from the fact that the December earthquake was measured using equipment – modern seismometers and the broadband data they produce – that did not exist 40 years ago.

On 31 March, scientists writing in *Nature*, for example, requalified the December earthquake to 9.3, making it second only to the 1960 Chilean earthquake in recorded magnitude. Sidao Ni from the Science and Technology University of China and Hiroo Kanamori and Don Helberger from the California Institute of Technology in the USA asserted in

Nature that the December earthquake had been so massive as to cause the entire rupture zone along a 1200 km-fault to slip, thereby releasing the strain accumulated from the subduction of the India plate beneath the Burma plate. They stated that 'there is no immediate danger of a similar tsunami being generated on this part of the plate boundary'.

Their analysis would seem to be borne out by the fact that the 28 March earthquake off the coast of Sumatra, which occurred along the same fault as in December, did not generate a tsunami, despite being of a magnitude of 8.7. The island of Nias bore the brunt of the aftershock, the biggest since December, with at least 300 casualties and as many houses destroyed. Extensive damage was also reported on the neighbouring island of Simeulue. The earthquake was felt in Indonesia, Malaysia, Singapore and Thailand.

For details: <http://ioc.unesco.org/indotsunami/>

A project office for IODE

On 25 April, the project office for the International Oceanographic Data and Information Exchange (IODIE) programme was inaugurated in Ostend, Belgium.

The IODE project office will serve as a training centre in oceanographic data and information management for students from all IOC Member States, providing 'starter' training for new data centre staff as well as advanced training within an ongoing career development programme. The office will develop and maintain existing training tools like the on-line OceanTeacher. All IODE web-based data and information servers will be based at the office.

In tandem, the office will serve as a 'think tank' where experts and students can meet up and work. To this end, Member States will be invited to second data and information managers to the office for varying lengths of time.

In her address, Fientje Moerman, Vice-Minister-President of the Flemish Government and Flemish Minister for Economy, Enterprise, Science, Innovation and Foreign Trade, recalled that the Flemish government had decided to host the IODE project office in 2003 'on the basis of the

solid collaboration with UNESCO's IOC and the results achieved by the Ocean Data and Information Network for Africa (ODINAFRICA)'.

'In the dramatic context of the tsunami disaster that struck so many countries in the Indian Ocean last 26 December [and] in response to the IOC's appeal', she added, 'I decided to bolster the expert training programme related to data and information management'. Consequently, 'special attention will be paid to training experts on early warning systems related to large-scale natural phenomena. Accordingly, the IODE project office will receive an additional annual contribution of 500,000 euros'.

In the 45 years since IODE was launched by UNESCO's IOC, Member States have established 65 oceanographic data centres in as many countries. Over the years, the network has made millions of ocean observations available to Member States, all of which are collected, quality-controlled and archived by the network. The service-oriented network works through designated national agencies and both world and national oceanographic data centres.

For details: <http://ioc3.unesco.org/iode>; <http://ioc3.unesco.org/odinafrica>; <http://ioc.unesco.org/oceanteacher>

Brunei joins UNESCO

On 17 March, Brunei Darussalam became UNESCO's 191st Member State upon signing the UNESCO Constitution in London. Just two weeks later, Brunei hosted a large regional meeting on the theme of 'Three Countries, One Conservation Vision'. Together with Indonesia and Malaysia, Brunei has been exploring the feasibility of establishing a transboundary protected area in the 'heart of Borneo', a key priority under UNESCO's Man and the Biosphere (MAB) Programme and the World Heritage Convention.

Some 52 tropical forest sites – covering close to 40 million hectares – are today inscribed on the World Heritage List but only 10 of these are to be found in Asia, even though it contains some of the world's largest remaining areas of rainforest.

The 5–6 April meeting in Brunei was hosted by Pehin Tahman Taib, Minister for Industry and Primary Resources of the Government of Brunei Darussalam, and chaired by Tan Sri Razali Ismail, President of the Malaysian branch of the World Wildlife Fund for Nature.

The overall concept of the planned transborder site is to conserve 'the heart of Borneo' by creating a territory undivided by political boundaries to ensure a common approach to conserving the region's rich variety of tropical species and ecosystems. As Stephen Hill, Director of UNESCO's regional bureau for science in Jakarta, said in his address, 'Animals and plants don't have passports'. Nor do political boundaries have much significance for many traditional communities living in border areas. In their case, noted Hill,

'the spatial reach of kinship and habitat may have preceded by centuries the geographic inscription of fence lines on abstract maps drawn up in the political state rooms of distant nation builders'.

The forests of Borneo were brought into the Berastagi Dialogue⁶ in April 2001 at a technical workshop at Lido Lakes convened by UNESCO and the Government of Indonesia with ASEAN⁷ countries to prepare cluster and transboundary Natural World Heritage nominations across the ASEAN region. Among other conclusions, the meeting agreed to prioritize the transborder nomination of the Central Borneo Montane Forests shared by Indonesia and Malaysia.

A proposal for a transboundary World Heritage nomination between Indonesia and Malaysia (Sarawak), the Transborder Rainforest Heritage of Borneo, was submitted to the World Heritage Committee in January 2004. The countries involved are preparing for an external review later in the year before the nomination is evaluated by the Committee in 2006.

For details (in Jakarta): q.han@unesco.org

Chinese Science Academy to watch over World Heritage

China has joined UNESCO's Open Initiative, which uses space technology to monitor World Heritage sites.

The agreement was signed at UNESCO Headquarters on 13 April by Guo Huadong, Deputy Secretary-General of the Chinese Academy of Sciences and Director of the Academy's Joint Laboratory for Remote Sensing Archaeology, and by Marcio Barbosa, Deputy Director-General of UNESCO. Under the terms of the agreement, China will share its extensive expertise and know-how within the framework of the Open Initiative launched by UNESCO and the European Space Agency in October 2001. The Initiative provides satellite images and expertise in space-supported conservation to developing countries, in order to help them monitor natural and cultural World Heritage sites. The Initiative also provides for the development of countries' capacities in this area.

One of the first achievements of the Open Initiative has been to provide the Democratic Republic of Congo, Rwanda

6. Launched by a meeting in December 1998, at which experts and government officials from 20 countries pledged to make safeguarding the rich variety of species and ecosystems in World Heritage tropical forests a top priority for international conservation; the meeting was co-sponsored by UNESCO, the CGIAR and the Government of Indonesia

7. The Association of Southeast Asian Nations groups Brunei Darussalam, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam

and Uganda with their first accurate maps of inaccessible mountain gorilla terrain as part of efforts to save the remaining 650 or so mountain gorillas living in nature reserves in these countries. More recent projects include a study of the biodiversity-rich Iguazu Falls in Argentina, surveillance of the ancient Machu Pichu in Peru, today threatened by landslides, and of the Altai mountains in Siberia. In the latter region, scientists will be helping archaeologists to locate numerous tombs dating from 800 BC in a race against time before melting permafrost degrades the tombs, currently well-preserved in the frozen earth.

China launched its first manned space flight in October 2003. The Chinese Academy of Sciences joins the Argentinean Space Agency (CONAE), Canadian Space Agency, Lebanese Remote Sensing Centre, the Royal Centre for Remote Sensing of Morocco and the USA's National Aeronautics and Space Administration in the Open Initiative.

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Grid power tackles brain drain in Balkans

A project to alleviate brain drain in Southeast Europe was officially extended on 12 April with the delivery of cutting-edge Grid computing technology to the Ss. Cyril and Methodius University in Skopje (FRY Macedonia) and to the Polytechnic University in Tirana (Albania).

Over the past decade, Southeast European countries affected by conflict have not only lost countless lives but also intellectual capacity. Two out of three teaching and research jobs have been lost in some universities. Scientists have either taken up positions abroad (external brain drain), or abandoned their professions for better-paid jobs in the private sector (internal brain drain). The University of Tirana, for example, lost 40% of its academic staff over this period, 90% of whom were under 40 years old. By providing state-of-the-art

Margarita is doing a joint PhD at the University of Tirana and at UNESCO's Abdus Salam International Centre for Theoretical Physics (ICTP) in Trieste (Italy). The donated Grid equipment will enable her to analyse back home in Tirana the data gathered from her research at the ICTP



Grid computing technology and seed money for exchange visits abroad to universities, the joint UNESCO and Hewlett Packard project is encouraging young scientists to stay in the region and collaborate with the diaspora.

The project was first launched in February 2004 with the delivery of Grid computing equipment to universities in Croatia, Bosnia & Herzegovina and Serbia & Montenegro (see *A World of Science* 2(3)). 'The project has resulted in the creation of websites, databases and new research projects at several of the universities involved', says Howard Moore, Director of UNESCO's Regional Bureau for Science in Europe, which is implementing the project. In Croatia, the project has allowed the University of Split to create a database and an interactive website of Croatian physicists around the world⁸ to enable the diaspora to share information with those at home. Meanwhile, the Universities of Sarajevo and East Sarajevo in Bosnia & Herzegovina have developed new e-learning programmes which have been introduced into the curricula. Instead of applying for fellowships abroad, several young engineers at the University of Belgrade have stayed home to develop e-Lab experiments using the Grid computing technology. They have created new research tools to educate other students, gaining skills and experience in the process⁹.

The project also enables scientists to undertake exchange visits and meet their fellow nationals working at major research institutions abroad. Since mid-2004, 38 such visits have taken place all around the world, leading to research partnerships with the European Laboratory of Nuclear Physics (CERN) Gelato Federation (the global research community dedicated to advancing the Linux Itanium platform), ICTP, etc.

The initiative has had an important political impact and brought people together in a region only recently divided by mistrust and unrest. In Sarajevo, for instance, the Grid project has rekindled ties between the Bosnian and Serb university communities. It has also encouraged decision-makers to take political and practical measures to reverse brain drain. Stamenka Uvalic-Trumbic, the Education specialist at UNESCO Headquarters who devised the project, notes that, 'Not only has the project strengthened scientific and education capacity at the national level but it has also re-established dialogue among young researchers after years of broken communication'.

'The project will help [local university faculties] identify international partnerships and funding opportunities, as well as address the Bologna Process and other international developments of common interest,' says Gabriele Zedlmayer, Vice-President of Corporate Affairs at Hewlett Packard. 'We also have plans to replicate the project in Africa'. See also the interview of Howard Moore on the opposite page.

For details: www.unesco.org/venice

8. <http://okolis07.pmfst.hr/cpaw>

9. <http://automatika.ef.bg.ac.yu/eLab/eLab.htm>

Howard Moore

Making the European Research Area truly pan-European

Two years after the Stability Pact for Southeast Europe formally relegated a decade of conflict to the past, science ministers from the Balkan region voiced their needs and aspirations in November 2001 at a roundtable during UNESCO's biennial General Conference. This ministerial roundtable would launch what was to become known as the Venice Process, in reference to the host city of UNESCO's Regional Bureau for Science in Europe (ROSTE). By fostering regional co-operation, ROSTE has helped to heal some of the wounds inflicted by the violent break-up in the 1990s of the former Yugoslavia¹⁰, once a major player in European science.

Howard Moore is Director of ROSTE. Here, he explains how his team in Venice has been implementing the 'mandate' entrusted to ROSTE by the Balkan countries three years ago.

If we may begin with the political landscape, would you say that membership of the European Union is a shared ambition among those Balkan countries which are not members today?

Southeast Europe is currently made up of countries that are members of the European Union, namely Slovenia (since May 2004) and Greece, countries that have been given dates for accession to the Union, namely Bulgaria and Romania, which are due to be admitted in January 2007, and those that have applied for membership, like Turkey and Croatia. In the long term, I imagine that all the other countries in the region have hopes of acceding to the Greater Europe, in other words: Bosnia & Herzegovina, Serbia & Montenegro, Albania and FYR Macedonia.

As far as UNESCO is concerned, they are all equals: neither members nor non-members, neither accession nor pre-accession states.

Are all countries in the region part of the Bologna Process¹¹ for higher education?

The Bologna Process has been incredibly successful so far. No matter which country you visit in the region, you learn that it is busy restructuring its higher education system – and doing so over a remarkably short space of time – to bring it into line with the Bologna Process. I think that whoever was the driving force behind the Bologna Process deserves great credit. All countries have been persuaded that the harmonization of higher education systems is something to be aimed at. They have put aside national pride and any feeling that their own system is best. The Bologna Process underlies all activities of Southeast Europe now.

Southeast Europe includes countries that were created in a very violent and, by definition, hasty manner in the 1990s. As a result, you get frontiers which don't neces-

sarily respect any logic. This has had repercussions on the science set-up in the countries which made up the former Yugoslavia. Yugoslavia itself had been an important scientific country with good science institutions. It had invested in science and had an industrial infrastructure worthy of the name. State enterprises provided not only finance but also expertise.

When the break-up came, it left countries with 'different slices of the action'. Croatia, for example, happened to have a very important centre on its territory, the Rudjer Bošković Institute in Zagreb, which is today widely recognized as a centre of excellence. Other countries were not so fortunate and now find themselves without major institutions simply because of the way the country broke up. This is just one argument in favour of regional co-operation and the possible sharing of resources and expertise between countries of the former Yugoslavia and others, such as Albania, Greece, Bulgaria and Romania.

How are you fostering regional co-operation?

We recognize that not everybody can have world class facilities in all disciplines – at least not immediately. But those that do have state of the art laboratories or equipment can perhaps open their doors more to their neighbours. If this could be encouraged, it would help bring about collaboration. Let me give you an example. At ROSTE, we took a look at one discipline, which happened to be astronomy. In 2002, we sent a very experienced teacher and researcher on the subject into Bulgaria, Romania, Serbia & Montenegro and Ukraine. One of the things he recommended was that, with a rather modest outside investment, some of the facilities he saw could be upgraded significantly to allow these countries to participate in collaborative experiments.

What we did as part of the package was to finance the purchase of CCD arrays. These are cameras which essentially collect and process the information that comes

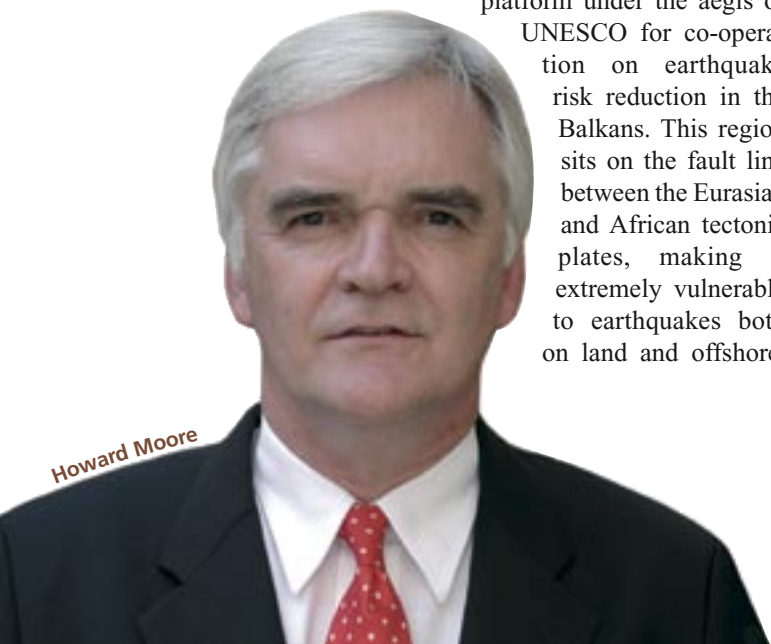
in through a telescope. One facility in particular, the Observatory of the Bulgarian Academy of Sciences in Rozhen, houses the region's largest telescope, measuring 2 m in diameter. We funded the upgrade of the facility's camera. As part of the overall agreed strategy, the Bulgarian Academy of Sciences has agreed to open the doors of the Observatory to others from Southeast Europe. The investment on our part has been more than matched by the Bulgarian scientific community itself, which has increased investment in what it now recognizes as a regional facility and is now actively seeking in-kind support for the Rozhen Observatory from abroad.

This is a good example of how UNESCO can act as a catalyst. We have also provided funding and the facilities to enable the heads of the various observatories to get together for the first time as a group and talk. We have encouraged the setting up of a regional committee for astronomy which is now meeting regularly to plan research projects. One immediate result has been a very sound collaborative research project on tracking small bodies and observing variable stars involving the institutions of ten countries, a project submitted in response to the first call for proposals by the International Basic Sciences Programme¹². In astronomy, there is an enormous amount of valuable data to be analysed through collaborative work. What we have achieved in astronomy in the region can, I believe, be replicated in other disciplines. What is important is to target the right area of research and the right institutions.

Which discipline will you be targeting next?

I can't say which discipline we shall be looking at next but let me tell you about one fairly recent development. With my colleague Badaoui Rouhban, Chief of the Section for Disaster Reduction at UNESCO, we have prepared a proposal for the establishment of an intergovernmental

platform under the aegis of UNESCO for co-operation on earthquake risk reduction in the Balkans. This region sits on the fault line between the Eurasian and African tectonic plates, making it extremely vulnerable to earthquakes both on land and offshore.



Howard Moore

The latter can of course generate tsunamis, an additional risk for countries with a coastline like Croatia, Serbia & Montenegro or Italy. Since last December's Asian disaster, there has been a much greater awareness of the potential dangers from tsunamis in the Adriatic and Mediterranean.

According to Badaoui Rouhban, Southeast Europe has enjoyed a period of quiet and should now almost 'expect' a major earthquake to occur near a Balkan city in the fairly near future, although no-one can predict exactly when. What can Balkan cities do to prepare for the worst?

Yes, that is the message he is dealing. In Southeast Europe, we have had a number of large earthquakes in recent decades, with the one in Skopje (FYR Macedonia) in 1960 foremost in people's memory. This event destroyed 80% of the city and killed more than 1000 people. More recently, the 7.4 magnitude earthquake in western Turkey in 1999 killed more than 15 000.

I think all cities are duty-bound to do something about their detection methods, risk assessment and so on. There have, of course, been a lot of initiatives already at the national and international levels on earthquake risk reduction in particular. In Romania, a good deal of work was done after their 6.4 magnitude earthquake in Bucharest in 1977.

I believe that, through the earthquake platform outlined above, UNESCO can bring to bear its experience of developing warning systems, hazard zonation systems and so on. The added value of UNESCO is that it can provide not only equipment and scientific and technical expertise but also education and expertise from the fields of communication and the social sciences.

Since ROSTE was established in 1988, much of our work has been concerned with research training and institution-building or upgrading. We are fortunate in receiving generous extrabudgetary support on an annual basis from the Italian government to the tune of 1.3 million euros for our natural science and culture programmes.

In a region where the recent conflict has driven a wedge between religious communities and between neighbours, how do you go about bringing scientists together?

Much of the capacity-building I have spoken of takes the form of summer schools and workshops. We organize these in the Balkans themselves rather than sending students outside the region, not just for economic or logistic reasons but also because we believe the Balkan institutions should have the opportunity to learn how to put this training together themselves. This approach has the added advantage of bringing students from the same region together when they would not otherwise have much opportunity to mix. In addition to fostering informal networking, this approach

sows the seeds of mentoring by helping young scientists to forge ties with experts that often stand the test of time.

Speaking of networking during these training courses, I recently met a young married couple in Albania, she a physicist and he a computer scientist. They told me they had met at a Four Seas Conference on Physics we had supported in Thessaloniki, Greece!

Would you say that one of the issues of greatest concern to the region is brain drain?

Brain drain does indeed remain a chronic problem, although firm statistics are hard to come by. Brain drain is not just brought about by low salaries. People also need modern equipment, access to scientific literature and to be able to exchange information and experience.

In passing, I should perhaps point out that it is important to distinguish between brain drain and mobility. Science requires interaction with others. To know who is doing what, and how, scientists cannot stay cooped up in their faculty; they have to move around. Together with organizations like the Marie Curie Fellowship Association, ROSTE is looking at how best to foster appropriate and pain-free mobility within Europe. Countries realize that, if the European Research Area¹³ is to work, it has to be truly pan-European and that means using the talent from every corner of Europe.

To help combat brain drain, our office in Venice has also been working in partnership with the private company Hewlett Packard since 2003 on a project to provide up-to-the-minute grid computing equipment to universities in the region (see p. 12).

The Seventh EU Framework Programme beginning in late 2006 will grant access to scientists from Southeast Europe wishing to participate in the Union's scientific programmes. Often, however, what these scientists lack is the experience in making grant applications, which seem to get more and more complicated by the year. Equally, science managers in these countries lack experience in running international research programmes. Here, we hope in the near future to hold a training workshop on the subject for the benefit of individuals in Southeast Europe.

Still in the science policy arena, the Venice office is ready to advise governments on science policy matters, upon request. We are, for example, currently advising Bosnia & Herzegovina on the possible restructuring of its science system within the framework of the long-awaited national law on science.

Turning to the environment, could you describe briefly the projects ROSTE is involved in?

We recognize that Southeast Europe is both culturally and environmentally diverse. The region has a variety of natural features that include gorges, woodland, coastlines and mountains. Since most natural resources do not respect our artificial human-drawn frontiers, international collaboration is essential to study and manage them properly. They also

need to be protected in a co-ordinated way, such as through transboundary biosphere reserves or world heritage sites. For example, my office has long been associated with international collaborative research on the Danube basin.

Recently, Serbia & Montenegro asked us for help in protecting Skadar Lake shared by Montenegro and Albania, which is polluted. The lake is an important site from a hydrological perspective but also from a cultural viewpoint, as there are many monasteries and other cultural sites dotted around its shores.

ROSTE can provide a real service to Member States in the form of holistic advice on cultural and ecological tourism that is much needed in Southeast Europe. For example, Croatia has a wonderful coastline with enormous potential for tourism but this must be developed in a sustainable manner. We are in the process of developing a management planning tool for Croatia's coastline based on Geographical Information System (GIS) technology. The Italian government has been funding the 'Croatian module', as we call it, to be handed over to the Croatian environmental agency once completed for use in their coastal management planning. We hope later to provide a similar service to Serbia & Montenegro and Albania, which share the same coastline. Another project, again with Italian financial backing, seeks to develop environmental education for sustainable development in the Western Balkans.

Interview by Susan Schneegans

10. Editor's note: During the 1990s, civil war led to Yugoslavia being broken up into the following independent states: Bosnia & Herzegovina, Croatia, FYR Macedonia, Serbia & Montenegro and Slovenia

11. Editor's note: Some thirty European countries have embraced the Bologna Process to create a European Higher Education Area by 2010. This pan-European process was launched in 1999 when countries pledged to reform the different national systems of higher education to ensure that all: use a common framework based on three degree cycles (Bachelor's, Master's and Doctorate) and a system of accumulation and transfer of credits within Europe; improve mobility within Europe and; ensure high academic standards

12. Editor's note: The IBSP was launched by UNESCO in 2003 to promote excellence in national science. It adopts a region-specific approach, the central role being played by existing centres of excellence or benchmark institutions in the basic sciences and science education. Read the interview in A World of Science 1(1), October 2002

13. Editor's note: The concept of the European Research Area was defined in 2000 with the launch of the Lisbon Process. Among other things, the Process sets a goal for each country to devote 3% of its GDP to R&D by 2010, with two-thirds of investment coming from industry. Even for the European Union, this is an ambitious goal. If the European Union average currently stands at about 1.8%, one-third of countries devote less than 1% of GDP to R&D. In Southeast Europe, only Croatia and Slovenia cross the 1% threshold



- | | |
|---------------------------|----------------------|
| Regional Scale | Local Scale |
| ■ Africa south of Equator | ▲ Gauteng |
| Basin Scale | ▲ Great Fish River |
| ■ Gariep Basin | ▲ Lesotho Highlands |
| ■ Zambezi Basin | ▲ Richtersveld |
| | ■ Gorongosa-Marromeu |

Assessing **how nature supports people** in Southern Africa

The *Southern African Millennium Ecosystem Assessment (SAfMA)*, from which the following excerpt is taken, is one of approximately 30 sub-global assessments linked to the Millennium Ecosystem Assessment. Completed in 2004, the four-year assessment of southern Africa evaluated three core ecosystem services – freshwater, food and biodiversity – and the impact of these on people’s lives. The assessment’s conclusions present a paradox: strong potential for sustainable development and food security, on the one hand, and a population living beneath the bread line that is benefiting little from these ecosystem services, on the other.

The SAfMA study area. The different scales (regional, basin and local) were chosen to make it possible to investigate different ecological processes on the scales at which they take place and to help ensure that perspectives of ecosystem users at any given scale were reflected in the analysis and conclusions at other scales. Note that the Gariep basin extends beyond the area assessed (indicated by a dotted line).

The Millennium Ecosystem Assessment (see also p. 8) defines ecosystem services as the benefits people obtain from ecosystems. These include both physical products, such as food, timber and water, which are sometimes referred to as ‘goods’, and less tangible but nevertheless essential services, such as soil fertility, climate regulation and cultural values. Underpinning many ecosystem services is the biological diversity that allows ecosystems to work reliably and efficiently.

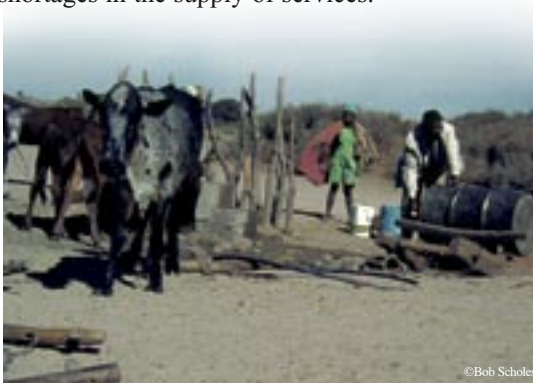
SAfMA assessed three ecosystem services on scales ranging from local communities to the subcontinent: freshwater, food and biodiversity. In addition, woodfuel and less tangible cultural services were assessed by multiple SAfMA studies. Variability in the supply of, and demand for, ecosystem services showed up on all three scales of the assessment, implying that, at all levels, management is most effective if applied in a targeted manner. In southern Africa, access to ecosystem services, determined by such factors as poverty and land entitlements, is often more limiting than physical shortages in the supply of services.

Lack of access to safe water a leading cause of infant mortality

All the major river systems in southern Africa are shared by several countries. The region has some of the most advanced international river basin organizations and agreements in the world. Most of Africa south of 17°S (Namibia, Botswana and Zimbabwe southwards) is already water-scarce by international standards. This part of the region is becoming progressively more vulnerable to development-limiting water shortages as a result of population growth, rising water use per capita and the anticipated effects of climate change. People in this part of the region are highly dependent on groundwater, which is used unsustainably in most areas and is becoming increasingly polluted. The area north of 17°S has an abundant water supply but one that is often contaminated with debilitating human pathogens.

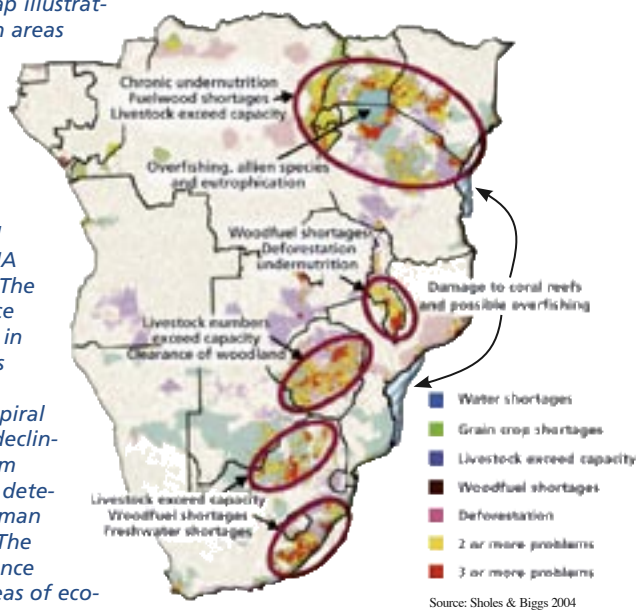
Adequate access to safe water also means that women and children can spend less time collecting water and focus on other activities. Degradation of freshwater ecosystems through excessive water removal, erosion of the catchments and pollution from mining, industry, agricultural run-off

In the central Kalahari region, water is often available only in the form of groundwater and has to be transported substantial distances by, in this case, an oxen sled



A catch of fish locally known as kampango, on the shores of Lake Malawi. Fish is a major source of protein for the majority of Malawi’s population but stocks are threatened by overfishing

Synthesis map illustrating the main areas of concern regarding ecosystem services in relation to human well-being, as identified by the SAfMA assessment. The co-occurrence of problems in several areas suggests a downward spiral of poverty, declining ecosystem services and deteriorating human well-being. The correspondence between areas of ecosystem service loss and social conflict is suggestive of a link in both directions: conflict creates conditions promoting ecosystem degradation and environmental resource depletion could be a cause of conflict.



Source: Sholes & Biggs 2004



© Paul Desanker

Young girls collecting firewood for the evening meal in a village in Malawi's Salima District. The large trees in the background are baobabs. Firewood is collected from deadwood in the forest

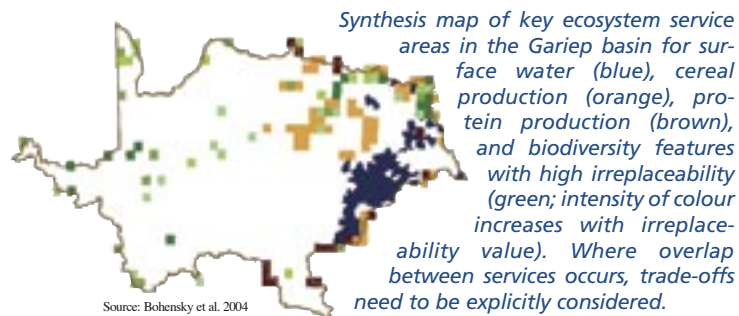
Insufficient protein is a particularly serious and growing problem, especially in the nitrogen- and phosphorus-poor areas north of the Zambezi, where diets are based on root crops rather than cereals. There is a large but poorly documented reliance on wild plants and animals as food sources in the SAfMA region. Freshwater fisheries are overexploited and evidence suggests that the same holds for the marine fisheries on the east coast. Domestic livestock (particularly cattle) are a central component of the livelihoods and identity of rural communities in many parts of southern Africa. Since excessive cattle densities can result in land degradation, important trade-offs exist between the cultural and economic services delivered by livestock and other ecosystems services, such as water, crops and biodiversity.

Expansion of degraded lands largest immediate threat to biodiversity

The biodiversity of southern Africa is unusually high in terms of both species and ecosystem types. With certain notable exceptions, the region's biodiversity is in remarkably good condition. It forms the basis of the burgeoning nature-based tourism industry, besides making important contributions to food supply and traditional medicines.

The biodiversity of southern Africa is unusually high [and], with certain notable exceptions, in remarkably good condition.

SAfMA developed several innovative ways of measuring the condition of biodiversity. These analyses highlighted the fact that the impact of humans on biodiversity is selective, focusing on particular groups of species, usually large-bodied ones, and specific ecosystems, such as grasslands and wetlands. Urban spread, expansion of crop agriculture and plantations all lead to habitat loss but the largest immediate threat to biodiversity is the expansion of degraded lands into sustainably used areas. The mechanism of degradation can involve over-exploitation (of trees, fish, grass, soil or water), destructive logging, fish-



Synthesis map of key ecosystem service areas in the Gariep basin for surface water (blue), cereal production (orange), protein production (brown), and biodiversity features with high irreplaceability (green; intensity of colour increases with irreplaceability value). Where overlap between services occurs, trade-offs need to be explicitly considered.

Source: Bohensky et al. 2004

and human waste leads to a greater flood risk, reduced water storage capacity, loss of aquatic biodiversity, loss of recreational amenities and declines in freshwater and coastal fish stocks, which in turn affects food security.

Insufficient protein a serious and growing problem

The region covered by the SAfMA study is one of the most food-insecure parts of the world, despite the fact that the region has the potential to produce enough food for its population, now and in the future. Political, infrastructural and economic factors have prevented this potential from being realized. There is an alarming level of undernutrition in the region. Without decisive intervention, tens of millions more people will be food-insecure by 2020.

The region is one of the most food-insecure parts of the world, despite [having] the potential to produce enough food for its population, now and in the future.

Why it is essential to understand natural processes

The underlying biological and physical processes that deliver services from ecosystems work on various spatial and time scales: some are regional (e.g. climate) while others are local (e.g. groundwater recharge); some are slow (e.g. soil formation), and others fast (e.g. plant growth). Similarly, the human systems that use and manage ecosystem services (e.g. national and local government authorities) also have characteristic areas of authority and response times. Getting the linked human–ecological system to work together well often requires the human system and ecosystem scales to be matched, for instance by managing shared river basins through multinational institutions.

Ecologists no longer believe that nature always remains in balance if left to its own devices. Once ecosystems pass a certain threshold as a result of disturbance, they may not return to their previous level of service provision within a reasonable period of time. Accelerated soil erosion, salinized irrigated croplands, destructive logging and over-fishing are examples of disturbances that may lead to downward-spiralling degradation that is difficult to reverse. Policy-makers face the challenge of improving human well-being without reducing the resilience of the coupled human–ecological system to withstand such natural and human-induced disturbances.



© Christo Fabricius

Daisy, a traditional healer, at a sacred pool in Cathcartvale, Eastern Cape, South Africa. Cultural landscapes such as sacred pools and forests are inaccessible at certain times of the year, or only accessible to

select groups like healers. As a consequence, harvesting of resources is limited and these landscapes serve as important areas for ecosystem renewal during times of crisis, such as severe droughts

ing or agricultural practices, the invasion of alien species and pollution from industries, mines, croplands or urban areas. In the longer term, climate change has the potential to endanger thousands of species in the region and have a serious impact on people and the economy.

Southern-hemisphere Africa to remain heavily dependent on wood and charcoal

Southern-hemisphere Africa will continue to be heavily dependent on wood and charcoal as an energy source in the coming decades. The woodfuel crisis predicted in the region two decades ago has not materialized as a general collapse, although there are many examples of local-to-district-scale shortages, which are a significant cause of woodland and forest degradation around urban areas. SAfMA found that, on the regional scale, more wood was grown than was consumed and that the places where shortages were likely to occur could be accurately predicted.

Cultural services highly valued

SAfMA found that the cultural, spiritual, aesthetic and recreational use of ecosystems are highly valued by all communities, of all income levels but in different ways. Traditional local communities recognize and protect sacred sites such as pools or groves, whereas affluent urban communities tend to campaign for national parks. These forms of ecosystem use usually have a positive effect on ecosystem resilience and often focus on protecting key resource areas, protecting specific species and enhancing landscape diversity. Collectively, these ultimately reduce the vulnerability of ecosystems and people in the region.

Key goals will not be met

At least four of the eight Millennium Development Goals will not be met in southern Africa unless decisive action is taken to stabilize ecosystem services. These are the Millennium Goals of reducing hunger and child mortality, combating diseases and ensuring environmental sustainability (see p. 9).

At least four of the eight Millennium Development Goals will not be met in southern Africa unless decisive action is taken to stabilize ecosystem services.

A sector-by-sector approach to the management of natural resources is being replaced by more integrated – as well as more sustainable and equitable – policies based on the ecosystem concept. Integrated management enables a single, co-ordinated response to satisfy multiple objectives. The multi-agency Working for Water Programme in South Africa, for example, creates a synergy between water and social development, through job creation, poverty relief and ecosystem rehabilitation. This model is being extended to include the management of fire and of coastal ecosystems.

Giving all parties a stake

In southern Africa, institutions are being created to respond on scales that more closely match those of ecological and social processes, on the premise that ecosystem services will be most effectively managed by giving all affected parties a stake. Management of several southern African river basins is moving towards both devolution, where decision-making occurs on the local catchment scale, and evolution, where international river basin organizations are being formed to manage river basins shared by multiple countries. Transboundary Conservation Areas and Spatial Development Initiatives are other examples of responses that consider the spatial extent of ecosystem processes and their benefits for human well-being.

The dilemma of trade-offs

The most difficult decisions involve trade-offs, where promoting one benefit results in a decrease of other benefits. Since



Reeds being dried in preparation for use in construction, in the Caprivi region of northern Namibia



Sorghum (*Sorghum vulgare* or *Sorghum bicolor*) is a grass (Family Poaceae), the seeds of which are used to make a flour and as cattle feed. It is an important food crop in Africa, Central America and southern Asia and is the fifth major cereal crop grown in the world. Sorghum originated in eastern Africa and first diverged from the wild varieties in Ethiopia 5000 years ago. It grows well in hot arid or semi-arid areas (Source: <http://Wikipedia.org>)

diverse actors with different values and objectives are involved, mediating trade-offs can be a contentious and conflict-ridden process. Decision-makers bear a special responsibility when the loss of benefits is borne by disadvantaged or unrepresented stakeholders, including youth and future generations. Decisions need, as far as possible, to consider the full costs and benefits of the actions they promote. Moreover, pricing policies should reflect the full cost of the resource.

There is frequently a trade-off between biodiversity conservation and the need to earn a livelihood from the land. Granting use rights to wildlife has been one solution to this dilemma in southern Africa. In Namibia and South Africa, for example, private landowners have had the right to use and manage wildlife on their land for decades; the result has been a doubling of protected land, coupled with greater economic benefits. In Zimbabwe, the Campfire programme has granted similar rights to communities on the periphery of national parks or hunting reserves. Transferring rights to own and manage ecosystem services to private individuals or communities gives them a stake in conserving those services but can backfire in the absence of adequate levels of institutional support. For example, the long-term viability of the Campfire programme has been severely



A family in Mozambique. Human well-being in southern Africa is low relative to the rest of the world when measured in terms of longevity, per capita income or levels of education¹⁴. Low levels of well-being can make it difficult to focus resources on protecting ecosystem services. This can lead to a downward spiral of ecosystem degradation and declining well-being through the creation of a 'poverty trap'. On the other hand, if appropriate interventions are made, it can drive an upward spiral of healthy ecosystems and rising well-being

challenged by the government's repossession of land given to communities.

Uncertainty calls for flexibility

Given that we cannot accurately predict changes in ecosystem services, response strategies that maintain flexibility tend to be better able to deal with unexpected events. Scenario analysis has been increasingly used as a way to explore the consequences of uncertainties stemming from political, social, economic and environmental forces. SAfMA created scenarios that link these forces to ecosystem services and human well-being. Approaches varied from adaptation of existing scenarios to the use of participatory theatre.

Cultural practices represent an important long-term adaptive response to uncertainty at the local level, by regulating the use of the landscape and its resources. AmaXhosa communities in the Great Fish River basin in South Africa have strong beliefs about taboo areas such as sacred pools and forests, which serve as important sites of ecosystem renewal during times of crisis, such as severe droughts. Adaptive management, long practiced by local communities, is now being incorporated into formal institutional policies and governance arrangements.

Read the full report:

www.millenniumassessment.org/en/subglobal.safma.aspx

Adapted from the Summary for Decision-makers of the integrated report Nature Supporting People: The Southern African Millennium Ecosystem Assessment, prepared by the SAfMA team.

14. Editor's note: Mean life expectancy in the 19 countries of southern Africa is just 42 years, with a high of 57 in Gabon and a low of 33 in Zambia and Zimbabwe. Under-five mortality ranges from 65 per 1000 live births in South Africa to 260 per 1000 live births in Angola. Net primary enrolment varies from a low of 35% in the Democratic Republic of Congo to a high of 93% in Swaziland, with several other countries having enrolment rates of 80% or more: Botswana, Gabon, Malawi, Rwanda, South Africa and Zimbabwe. Data source: UNESCO (2003) Gender and Education for All: the Leap to Equality. EFA Global Monitoring Report; UNDP (2004) Human Development Report

Buried treasure in the Americas

In August 2004, two neighbours sat down to discuss their 'buried treasure': aquifers running under the mountainous and coastal regions of the Caribbean island of Hispaniola. The two neighbours were French-speaking Haiti and Spanish-speaking Dominican Republic. They were joined at the table by scientists from UNESCO's International Hydrological Programme (IHP) and the Organization of the American States (OAS). This first meeting would lead, weeks later, to a signed agreement between the two countries to work together on a joint pilot project for managing their shared aquifers sustainably, in a determined effort to combat land degradation, excess erosion, sedimentation – and poverty.

The project site is the island's central region and the northern coast along the border between Haiti and the Dominican Republic. The central region is a predominantly mountainous area where extensive deforestation has scalped the rolling hills, damaging the health of ecosystems and exposing the region to climatic fluctuations.

The project focuses on two key sources of freshwater for Haiti and the Dominican Republic, the Artibonito and Masacre transboundary aquifers. If exploited in a sustainable way, these aquifers could alleviate widespread poverty – some 80–90% of Haitians live beneath the poverty line –, improve health and reduce vulnerability to natural hazards.

A programme for the Americas

The Caribbean case study was identified within a global UNESCO programme for Internationally Shared Transboundary Aquifer Resources Management (ISARM). ISARM fosters collaboration among countries sharing the same resource to achieve consensus on legal, institutional, socio-economic, scientific and environmental issues. In the Americas, ISARM is jointly co-ordinated by UNESCO and OAS. The Caribbean case study is being executed by OAS, UNEP and UNESCO's IHP, with \$1 million in funding from the Global Environment Facility (GEF). In other regions of the world, ISARM involves different international bodies, notably FAO, the UN Economic Commission for Europe (UNECE) and the International Association of Hydrogeologists.



This mountainous region along the Haitian–Dominican border represents the recharge zone of the Artibonito aquifer. It has been devastated

by extensive deforestation. Large amounts of eroded sediments are washed into the Artibonito, the largest in Haiti, where they then accumulate

Since its inception in 2002, the ISARM Americas Programme has been helping countries in the region to identify transboundary aquifers. Currently, 26 countries from the continent are generating and exchanging data within ISARM. This hemispheric effort has spawned the preparation of an Inventory of Transboundary Aquifers for the Americas and the identification of 'critical case studies' that would make good pilot projects. The Yrenda-Toba-Tarijeno aquifer shared by Bolivia, Argentina and Paraguay is one such case (see overleaf *Under the Gran Chaco plain*). The Caribbean project is another.

A project 'built from love'

*'El proyecto de acuíferos transfronterizos es un proyecto creado con amor'*¹⁵, enthused Jose Febrillet, ISARM National Co-ordinator for the Dominican Republic in an interview in August 2004. 'One of the most important objectives is to avoid conflicts along the border separating the two countries. We know that the areas along the country border are the most fragile. If we don't share the available water, we will end up generating potential conflicts. The projects for water are the spearhead for the development of these border areas, which, in general, are the poorest and most neglected zones in the countries, at least on our continent [...] At the moment, 5% of the vegetation cover in the "border area" lies in Haiti and 16.7% in the Dominican Republic. The Haitian people daily cross the border to gather firewood for cooking, thereby destroying the vegetation on the other side'.

The Caribbean pilot project will identify legal loopholes (see overleaf *What are transboundary aquifers?*) and use scientific and technical know-how to solve problems. One example is the intrusion of seawater into shallower aquifers along the northern coast, as in the case of the Masacre transboundary aquifer. Both countries are presently concentrating on exploiting coastal unconfined aquifers by constructing shallow wells. The water drawn is used mostly for domestic purposes. Pumping this water has caused seawater to flow inland, making the groundwater saline. The project will monitor the level of saline intrusion and

¹⁵. *'The transboundary aquifers project is a project built from love'*



© Michela Miletto

In Haiti, groundwater is often the only source of drinking water. Sediment loads in rivers and the lack of any waste collection and treatment system are threatening people's lives and the health of ecosystems

help the countries to design a proper management tool for coastal aquifers that determines the maximum permissible limit of seawater intrusion for the aquifer.

The project will also strengthen the institutions responsible for water resource management through training and greater institutional collaboration. It will also help to improve governance of water resources by facilitating dialogue among the different stakeholders: governmental decision-makers, water managers, users and the private sector. The aim is to involve the users, particularly in local communities, in decision-making over shared waters.

Joint sustainable management of shared groundwater will help to mitigate the devastating rate of land degradation and protect the ecosystems associated with groundwater, such as the wetlands located to the north in the centre of the island.

In the Artibonito Basin, geological evidence indicates that large quantities of renewable freshwater could be stored at depth in the carbonatic formations that underlie the recent covering of clastic sediment. The project will evaluate this potential resource from both a technical and economic perspective.

An island battered by the elements

The island of Hispaniola is highly exposed to destructive hurricanes and heavy rainfall alternating with periods of prolonged drought. These climatic extremes wreak havoc, causing countless deaths, economic losses and further degradation of the environment. In 2004 alone, the island was martyred twice, first by torrential rains which killed over 3300 people along the border between Haiti and the Dominican Republic in May after two rivers burst their banks, then again four months later, by Tropical Storm Jeanne, which devastated the town of Gonaïves, killing about 2000 Haitians. Deforestation was largely responsible for the high death toll in May; the lack of vegetation not only allowed water to flow unimpeded but also favoured mud- and landslides that buried many victims.

The Hispaniola project will test different schemes for managing groundwater recharge in specific aquifers, to see how effectively these can reduce the vulnerability of these two countries to extreme climatic conditions. Some techniques for enhancing aquifer recharge while mitigating the effects of extreme weather events like floods are quite straightforward and based on low-technology structures. In fact, most are traditional and have been used for centuries, like surface impoundments (or barriers) on stream beds that capture water and slow down run-off. The stored water slowly infiltrates the soil to recharge unconfined aquifers. The same is true of percolation ponds or basins, which either store rainwater directly or recover it via drains and guttering from the roof.

Home to one-third of the world's water

The American hemisphere has been blessed by an abundance of freshwater and luxuriant vegetation. In Latin America alone, rivers like the Amazon, Orinoco, Sao Francisco, Parana, Paraguay and Magdalena carry about 30% of the world's continental surface water.



© Michela Miletto



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Scenes from the Haitian village of Belladere on the central border. Four rural areas on the island of Hispaniola have been chosen for demonstrations of how better land-use practices and more sustainable management of water resources can generate more food and higher income. Rural communities in these areas will be taught techniques for collecting and conserving water to reduce over-use and improve distribution for domestic purposes and agriculture. Each community will also participate in building shallow water

wells and simple sanitation, waste collection and disposal systems which should not only improve their health but also protect the environment from further degradation. Communities will share their experiences at workshops and meetings run by the municipality. The four areas correspond to small regions facing each other along the central and northern border: the Artibonito sub-basins of Guayamouc River on the Haitian side and of Macasia River in the Dominican Republic; the Marion area along the Haitian border and the Chacuey area across the border in the Dominican Republic, both located in the Masacre River basin, along the north coast of the island. In these extensively degraded areas, good quality water is hard to come by, so the population relies primarily on groundwater for its needs

It is perhaps less well-known that Latin America harbours approximately 5 million km² of arid and semi-arid lands. These regions include northeastern Brazil and large parts of Argentina, Chile, Bolivia and Peru. In these areas, nearly one-third of the total water supply comes from aquifers. As much as 60% of the urban centers in the state of São Paulo in Brazil, for example, are served by groundwater sources, which supply freshwater to a population of 5.5 million. Their role is expected to increase even further in years to come, as water scarcity and greater climatic fluctuations become major global concerns.

Many American aquifers are currently being mined beyond their recharge capacity or are threatened by uncontrolled pollution, such as the aquifer beneath Mexico City. As a result of over-mining, the city has experienced serious problems with subsidence. At times, the land has subsided by as much as 7.5 m, as in the city centre. This has caused damage to infrastructure, building foundations and sewer systems. Withdrawal has ceased in certain areas, including the city centre, and measures have been taken to compensate for the water shortage; these include drawing from wells at the periphery and constant monitoring of wells. This has slowed down the subsidence of the city centre to about 3 cm annually. However, in a megacity like Mexico City with its 18 million inhabitants, the population has no choice but to rely on the aquifer; moreover, in the suburbs to which wells have been relocated, subsidence is continuing at a rate of 45–60 cm each year.

The Hueco-Bolson is another urban aquifer threatened by over-exploitation. Shared by the towns of Ciudad Juarez and El Paso in the arid border regions of Chihuahua in Mexico and Texas in the USA, it is currently the sole source of water for Ciudad Juarez and accounts for 30% of the domestic water supply for the city of El Paso. Pumping from the Hueco-Bolson by El Paso peaked at a high of 98 700 000 m³ in 1989 but had been halved by 2002, thanks to conservation efforts, quality wastewater treatment and artificial recharge of the aquifer.

Fortunately, the gigantic Guarani¹⁶ aquifer system shared by Argentina, Brazil, Paraguay and Uruguay is not plagued by these severe problems. Covering an area of 1.2 million km², it boasts good-quality water in sufficient quantities to supply 360 million people on a sustainable basis. This notwithstanding, some hot spots of pollution have been detected in the Guarani recharge and extraction areas.

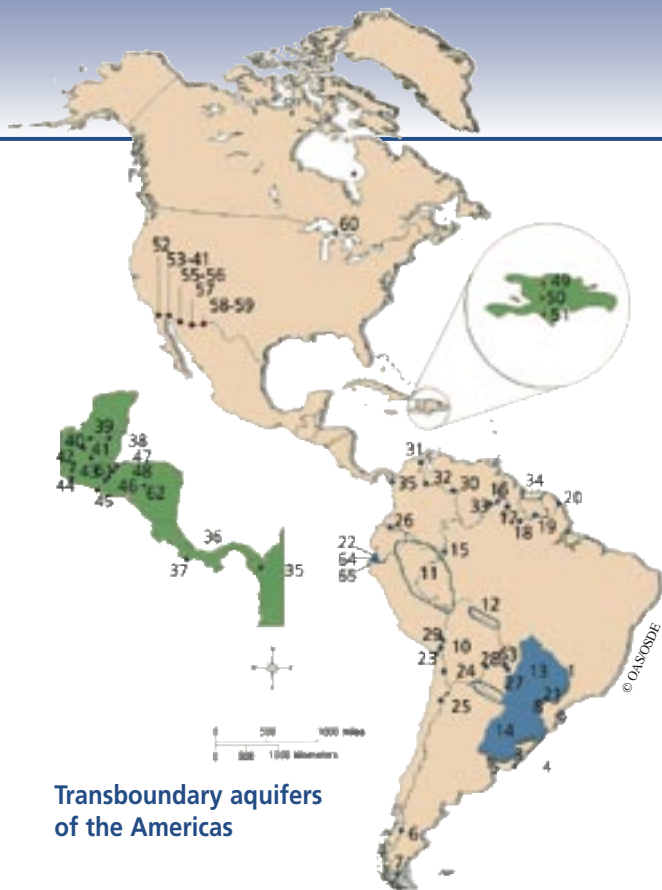
16. *The Guarani Aquifer System (SAG) Project launched in 2002 is the first in the Americas to focus on transboundary aquifers and one of the first “multi-country” initiatives being undertaken worldwide. The project was launched by the Governments of Argentina, Brazil, Paraguay and Uruguay, in collaboration with the World Bank and OAS and with GEF funding. The project seeks to delineate and implement a common institutional framework for managing and preserving the Guarani Aquifer for current and future generations*

N°	Transboundary Aquifers	Countries
NORTH AMERICA		
52	Tijuana	Mexico USA
53	Valle de Mexicali	Mexico USA
54	Valle San Luis Rio Colorado (Yuma)	Mexico USA
55	Rio Santa Cruz	Mexico USA
56	Nogales	Mexico USA
57	Rio San Pedro	Mexico USA
58	Conejos – Medanos	Mexico USA
59	Bolson (Valle de Juarez)	Mexico USA
60	Cambrian – Ordovician	Canada USA
CENTRAL AMERICA		
36	Sixaola	Costa Rica Panama
37	Coto	Costa Rica Panama
38	Hondo San Pedro	Guatemala Mexico
39	San Pedro	Guatemala Mexico
40	Usamancita	Guatemala Mexico
41	Chixoy Xacibal	Guatemala Mexico
42	Selegua Cuilco	Guatemala Mexico
43	Coatan Suchiate	Guatemala Mexico
44	Bajo Suchiate	Guatemala Mexico
45	Cuenca La Paz (Ahuachapan Las Chinamas)	El Salvador Guatemala
46	Alto Paz Ostua/Metapan	El Salvador Guatemala
47	Motagua Norte	Guatemala Honduras
48	Motagua Sur	Guatemala Honduras
61	Olopa	Guatemala Honduras
62	Rio Negro	Honduras Nicaragua
CARIBBEAN		
49	Artibonito	Haiti Dominican Republic
50	Masacre	Haiti Dominican Republic
51	Pedernales	Haiti Dominican Republic
LATIN AMERICA		
1	Guarani	Argentina Brazil Paraguay Uruguay
2	Yrenda Toba Tarijeno	Argentina Bolivia Paraguay
3	Salto Chico Salto Chico	Argentina Uruguay
4	Litoraneo Chuy	Brazil Uruguay
5	Litoral Sistema Acuífero en Areniscas Cretácicas	Argentina Uruguay
6	Probable	Argentina Chile
7	El Condor	Argentina Chile
8	Caiua	Argentina Brazil Paraguay
9	Serra Geral; Serra Geral Arapey	Argentina Brazil Paraguay Uruguay
10	Ignimbritas Cordillera Occidental	Bolivia Peru
11	Solimoes	Bolivia Brazil Colombia Ecuador Peru
12	Jaci Parana y Parecis	Bolivia Brazil
13	Pantanal	Bolivia Brazil Paraguay
14	Permianos	Brazil Uruguay
15	Ica	Brazil Colombia
16	Sedimentos Paleo Proterozoicos	Brazil Guyana Venezuela
17	Serra do Tucano	Brazil Guyana
18	Boa Vista	Brazil Guyana
19	Sem Denominacao	Brazil Surinam
20	Costeiro	Brazil Guyana (F)
21	Furnas e Altos Gracias	Brazil Paraguay
22	Zarumilla Machala	Ecuador Peru
23	Concordia Caplina	Chile Peru
24	Ascotan Silala Ollague	Bolivia Chile
25	Puna	Argentina Chile
26	Tulcan	Colombia Ecuador
27	Coronel Oviedo Basamento Cristalino	Brazil Paraguay
28	Agua Dulce Palmar de las Islas	Bolivia Paraguay
29	Titicaca	Bolivia Peru
30	Arauca	Colombia Venezuela
31	Guajira	Colombia Venezuela
32	San Antonio Urena Santander	Colombia Venezuela
33	Sedimentos Grupo Roraima	Brazil Venezuela
34	Zanderji; Coesewijne; A sand	Guyana Surinam
35	Jurado	Colombia Panama
63	Rio Negro Itapucumi	Bolivia Paraguay
64	Tumbes Puyango	Ecuador Peru
65	Chira Catamayo	Ecuador Peru

Source: OAS/OSDE

The problem of water scarcity in the arid and semi-arid regions of the Americas is compounded by growing population, agriculture, industry and pollution, the latter of which is spreading infectious diseases that strike mainly the poor. In the semi-arid region of Gran Chaco Americano, where nearly the 80% of the rural population lacks access to drinking water, the population is growing at an average rate of 2.6% per year. In the Paraguayan Central Chaco area, the birth rate is highest among the indigenous groups (3.5%), who represent about half the total population. In recent years, there has been a rise in contagious diseases, caused by a lack of drinking water, poor hygiene and malnutrition. Children are the most vulnerable to scourges like hepatitis, cholera, parasitosis and respiratory infections.

This beautiful land and its once fertile soils are witnessing progressive desertification, the result of over-exploitation of forests, wildlife and fish taken from lagoons and wetlands. (*Chaco* means “hunting land” in Quetchua.) Aggressive, extensive agriculture, coupled with poor, fragmented land and water management practices, has degraded all the ecosystems in the region, generating erosion and salinization of the soils, and contaminating the shallow aquifers.



Transboundary aquifers of the Americas

As of May 2005, 65 transboundary aquifers had been identified within the ISARM Americas Programme. The large blue mass is the Guarani Aquifer, currently the only transboundary aquifer in Latin America whose limits are almost totally known

The indigenous groups living in the area suffer most from this situation. The loss of natural resources is causing food insecurity in these extremely poor communities and modifying their traditional customs. Many of the ethnic groups, including the Guaraní-Ñandeva, Guarayo, Ayoreo, Sanapaná, Toba-Maskoy, Angaité and Manjuy, are migrating from one part of Gran Chaco to another in search of a healthier environment and better standard of living.

Under the Gran Chaco plain

The second example of a ‘critical case study’ being conducted by ISARM concerns Yrenda-Toba-Tarijano (SAYTT), a wide transboundary aquifer system beneath the Gran Chaco plain. This aquifer is part of the La Plata Basin and extends into Bolivia, Argentina and Paraguay over 350 000 km², covering about 40% of the Gran Chaco. The Bolivian portion may be limited to about 30 000 km² (9% of the whole) but is nevertheless of key importance. Located in the pre-andean hills, it is a highly vulnerable recharge area for the aquifer. From the Andean mountain ranges, groundwater flows eastwards to the plain to feed a series of humid zones and eventually discharges into the Paraguay-Parana river.

It is highly likely that the Yrenda-Toba-Tarijano aquifer system contains most of the freshwater reserves in the region, although its potential is not well-known. The three countries sharing the aquifer system have sought to draw attention to it by proposing the Yrenda-Toba-Tarijano for a critical case study within the ISARM Americas Programme. In August 2004, a workshop in Tarija (Bolivia)

came up with a basic framework for the pilot project on the transboundary aquifer within the larger GEF-funded project covering the entire La Plata Basin. The La Plata Project will identify joint water management priorities and establish a framework enabling the region to adapt to the multiplication of major floods and droughts, due to El Niño and other events, and to prevent contamination from excessive sediment loads in the La Plata estuary.

The pilot project on the Yrenda-Toba-Tarijano aquifer¹⁷ is being developed within a fund provided by the Italian Ministry of the Environment to strengthen the joint management of shared groundwater. The project will provide a comprehensive understanding of the aquifer system and should guide efforts to establish mechanisms for managing other aquifers in the La Plata Basin more sustainably.

Forging ahead

Even as countries in Latin America and the Caribbean are executing their respective case studies, the ISARM Americas Programme is forging ahead, leveraging interest in the scientific, legal and institutional aspects of aquifer management, to make sure that governments do not overlook the ‘treasure’ beneath their feet when devising national and international water management plans and policies.

Michela Miletto¹⁸

What are transboundary aquifers?

Aquifers are bodies of permeable rocks which stock significant quantities of groundwater. The water quality is often very good and can be used directly for human consumption. Aquifers are, however, also extremely fragile systems: once depleted or polluted, they may take centuries to recover.

Many of the world’s major aquifers are shared by two or more countries. As with any transboundary resource, transboundary aquifers require collaboration among various echelons of land and water management structures and institutions both within a country and among the neighbouring countries. This challenge is compounded by the fact that there are no international conventions or clear legal frameworks specifically addressing transboundary aquifers, although these exist for rivers.

The United Nations International Law Commission recently designated a special sub-committee to review existing laws governing shared natural resources, with special attention being paid to transboundary aquifers; UNESCO’s IHP is assisting in the process by drafting articles that might form the core of a future convention on transboundary aquifers and their management.

17. Executed by Bolivia, Argentina and Uruguay, in co-ordination with the La Plata Basin Intergovernmental Commission and with support from UNEP and OAS, and GEF funding

18. Senior Environmental Specialist within the Office for Sustainable Development and Environment of the OAS and liaison officer for the ISARM Americas Programme: m.miletto@oas.org

Diary

11–22 July

Albert Einstein's century

Two symposia, one for the general public (11–15) and the second for scientists (18–22), on: theory of gravitation, Brownian motion, the nature of the quantum world, cosmology, etc. Speakers include Nobel and Field laureates. Co-organized by French CNRS and UNESCO. Paris. www.einstein2005.obspm.fr

20–23 July

Asian Mathematical Conf.

National University of Singapore: jakarta@unesco.org

25–29 July

Frontiers of Physics

Intl. meeting. Kuala Lumpur (Malaysia): jakarta@unesco.org

28–30 July

GLOCHAMORE

Process Studies along Altitudinal Gradients, 4th thematic workshop of GLOCHAMORE project to detect, monitor and manage global climate and

socio-economic change in mountains (Switzerland). The ultimate objective is to develop an integrative research strategy for mountain biosphere reserves and similarly managed areas. The four workshops will culminate in an Open Science Conf. (2–6 Oct.): www.mountain.conf.uhi.ac.uk/

14 August – 3 September

GRASP Exhibition

Great Apes Survival Project (GRASP) exhibited at UN Pavilion at World Expo 2005 on Nature's Wisdom. In English and Japanese. Aichi (Japan): www.expo2005.or.jp

23–24 August

Robot Camp for Children

ASEAN–UNESCO working group meeting with university professors in robotics from Asia–Pacific and private companies to plan summer camp in 2006 within UNESCO University–Industry partnership (UNISPAR) programme to build awareness of hands-on (learning by doing) S&T curricula in formal education. Jakarta: m.nakata@unesco.org

30 August – 3 September

Conservation and Sustainable Development of Island Biosphere Reserves

9th meeting, East Asian Biosphere Reserve Network. Korean Nat. Comm. for UNESCO, Jeju Regional Govt. Jeju Island Biosphere Reserve (Rep. Korea): jakarta@unesco.org; beijing@unesco.org; skshim@unesco.or.kr

5–9 September

GRASP intergovernmental meeting

Governments from 23 Great Ape range states, 6 current and 15 potential donor countries, to finalize blueprint for conserving Great Ape populations. Kinshasa (DRC): s.mankoto@unesco.org; sc.eco5@unesco.org

13–29 September

Executive Board

172nd session of UNESCO's governing body. Precedes General Conf. of 191 Member States meeting to adopt programme and budget for 2006–2007. UNESCO Paris: www.unesco.org

New Releases

Open Access and the Public Domain in Digital Data and Information for Science

Eds J. Esanu and P. Uhler. The National Academies Press. English only, 184 pp. ISBN.0-309-09145-4

The proceedings of a meeting at UNESCO in April 2003 which expressed concern at the growing tendency of governments to treat public-funded research as a commodity and the implications for scientists in developing countries, in particular, of growing restrictions on access to digital data and information. 'How do we preserve and promote access to open science without unduly restricting commercial opportunities and the moral rights of authors?' asked the meeting, co-organized by UNESCO, ICSU and its CODATA committee, US National Academy of Sciences and ICSTI. See *A World of Science* 1(4), July 2003. Download free of charge from: www.nap.edu/html/openaccess/

Education for Rural People

Online toolkit by UNESCO and FAO offering formal and non-formal education on agriculture, forestry and fisheries, plants, biodiversity, food and nutrition, HIV/AIDS, rural finance, agro-business and marketing, etc. Covers primary, secondary and vocational education, farmers' field schools and teachers' training. Mostly in English but some items in other languages, including local ones. User contributions appreciated. Download from: www.fao.org/sd/erp/ERPtktoolkit_en.htm

La fuite des compétences en Afrique francophone

UNESCO study on brain drain in French-speaking Africa, with Ahmadou Lamine Ndiaye, former Rector of University of Saint Louis in Senegal. French only, 35 pp. - Overviews trends, problems related to loss of human and economic capital, political issues, proposes solutions such as centres of excellence, incentives to entice the diaspora back to Africa, etc. Download from: www.unesco.org/education/wche

The Canoe is the People

Indigenous Navigation in the Pacific

Interactive CD-ROM produced by UNESCO's Local and Indigenous Knowledge Systems (LINKS) project. Due for release in September in English, with some indigenous language content.

Thousands of years ago, when most European sailors were still hugging the coast, the island peoples of the Pacific held the knowledge and skills to explore the great ocean paths around and beyond their homes. Pacific peoples built and navigated their canoes with their own sophisticated techniques, using the seas, skies and sea life to guide them. Through text, images, videos and animations, this CD-ROM explores the knowledge and know-how of Pacific Islanders about island origins, canoe construction and ocean voyaging, including the recent voyaging revival. Although particular attention is paid to the island of Satawal in the Caroline Islands (Federated States of Micronesia), where navigational knowledge is still very much alive, the CD-ROM covers the entire Pacific. Designed primarily to stimulate the interest of Pacific youth in the knowledge of their elders but also of interest to a wide audience. To be distributed to Pacific schools in 2006 along with a Learning Resource Pack containing a teacher manual and student workbooks.

... for the young

YouthXchange

Training kit on sustainable consumption designed by Media Ecology Technology Association with Consumers International, UNEP and UNESCO as contribution to Decade of Education for Sustainable Development. Consists of hard copy guide and multimedia website. Includes facts and figures atlas, test and game, best practices, links to interesting websites, frequently asked questions: www.youthxchange.net/youth.htm; see also: www.unesco.org/education