United Nations Educational,
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A World of SCIENCE

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EDITORIAL

A major **security risk**

Hama Arba Diallo doesn't hesitate to draw a parallel between desertification and human security. 'It is widely recognized', remarks the Executive-Secretary of the UN Convention to Combat Desertification (UNCCD), 'that environmental degradation has a role to play in considerations of national security, as well as international stability'.

Desertification is one of the most alarming processes of environmental degradation; it contributes to food insecurity, famine and poverty, and can give rise to social, economic and political tensions that can degenerate into conflict. Each year, desertification and drought cause an estimated US$42 billion in lost agricultural production. About 41% of the Earth's surface area is made up of drylands, home to more than 2 billion people. Between 10% and 20% of these drylands are degraded or unproductive.

The sheer scope of the problem led the UN General Assembly to proclaim 2006 the International Year of Deserts and Desertification. The Year's main objective is to drive the point home that desertification poses a major threat to humanity, a threat weighted further under the scenarios of climate change and biodiversity loss.

UNCCD is the only internationally recognized, legally binding instrument addressing the problem of land degradation in dryland rural areas. Through the Global Mechanism hosted by the International Fund for Agricultural Development in Rome (Italy), the Convention endeavours to channel much-needed resources to projects combating the problem, particularly in Africa.

On 17 February, FAO appealed for US$18.5 million to help farmers, herders and others hit by drought in southeastern Ethiopia and suffering 'pre-famine conditions'. With the economies of pastoralist groups in Djibouti, Somalia and Kenya also devastated, some 11 million people in the Horn of Africa 'are at risk of food shortages'. In this issue, we examine plans by Ethiopia to improve food security and halt galloping desertification by developing its water sector within an ambitious 15-year programme. This case study is taken from the latest *World Water Development Report*, launched by the United Nations in March.

UNESCO has a long tradition in interdisciplinary drylands research that goes back to the 1950s. Today, UNESCO's Man and the Biosphere and International Hydrological Programmes are pursuing research on the sustainable management of dryland ecosystems and their water resources. Many biosphere reserves situated in the world's drylands testify to the fact that environmental conservation and sustainable development of drylands can be mutually beneficial.

UNESCO is co-organizing a major conference from 19 to 21 June in Tunis (Tunisia) on The Future of Drylands. This scientific meeting will review the current state of knowledge of dryland ecosystems and the socio-economics of dryland development, with a view to advising decision-makers.

W. Erdelen
Assistant Director-General for Natural Sciences

The shifting fortunes of **global science**


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A microbiology laboratory in Athens in 2004. Despite steep growth in recent years, GERD in Greece (0.6 % of GDP in 2001) remains the lowest of all EU15 countries, on a par with the ratios for newcomers Estonia, Lithuania and Slovakia

Remarkable growth in a small number of emerging Asian economies, led by China, is narrowing the gap with North America, Europe and Japan in research and development (R&D), according to the *UNESCO Science Report 2005*[1] published in December. The report analyses the state of science and technology (S&T) around the world through the eyes of a team of independent experts, each of whom is writing about his or her own country or region. Here are some of the report's findings.

Without a doubt, science is undergoing rapid change. By 2002, the developing countries were contributing 22% to world expenditure on R&D, compared with just 16% five years earlier. Worldwide, gross expenditure on R&D (GERD) rose sharply over the same period, from US$547 billion[2] to US$830 billion.

China becoming a force to be reckoned with

'The most remarkable trend is to be found in Asia, where GERD has grown from a world share of 27.9% in 1997 to 31.5% in 2002', notes the report. This dynamism is driven largely by China which, in 2002, counted more researchers than Japan. In the space of just five years, China has gone from contributing 3.9% of world GERD to 8.7%, a greater share than Germany (Figures I and II).

In its five-year plan to 2005, China listed information technology, biotechnology, new materials technology, advanced manufacturing technology, aerospace and aeronautics as all being fields 'in which China should aim for breakthroughs'.

Patents granted by China have nearly doubled in just four years (to 132 000 in 2002). However, whereas invention accounted for 73% of patents granted by China to foreigners in 2001, it accounted for just 5% of patents granted by China to local residents (the great majority falling into the two remaining categories of utility model and design).

'The emergence of China is not yet reflected in patent statistics', notes the report, a trend less surprising than it may seem, as patents are indicative of a mature business environment and China's Company Law dates back only to 1993. High-tech goods currently make up just 21% of China's manufactured exports[3] (enough nevertheless to place China seventh worldwide in terms of volume). 'At the same time, the dynamics are clearly visible', observes the report. 'China now imports more scientific instruments, electronics and telecommunications products and electrical machinery than Japan'.

High-tech goods have come to represent as much as 72% of Filipino manufactured exports, 50% of the total in Malaysia and 32% in Thailand. This remarkable feat is explained by the fact that 'multinationals and companies in developed countries have been stepping up original equipment manufacture operations in Asian countries'.

Asia's world share of scientific publications has gone from 16.2% to 22.5% over the past decade. China and the newly industrialized Asian economies have nearly tripled their world share of scientific publications, although India has actually lost ground (Figure III).


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Shanghai in 2004. Chinese expenditure on R&D more than tripled between 1997 and 2002, from US$21 billion to US$72 billion. The reason for this steep rise lies not only in China's strong, sustained economic growth but also in its stronger commitment to R&D: 0.8% of GDP in 1999 and 1.2% of GDP in 2002, with plans to increase this proportion to 1.5% of GDP by 2005. China's biggest neighbour, India, itself crossed the 1% threshold in 2004 and plans to raise its own expenditure on R&D to 2% of GDP in coming years. The economies of both China and India grew by close to 10% in 2005

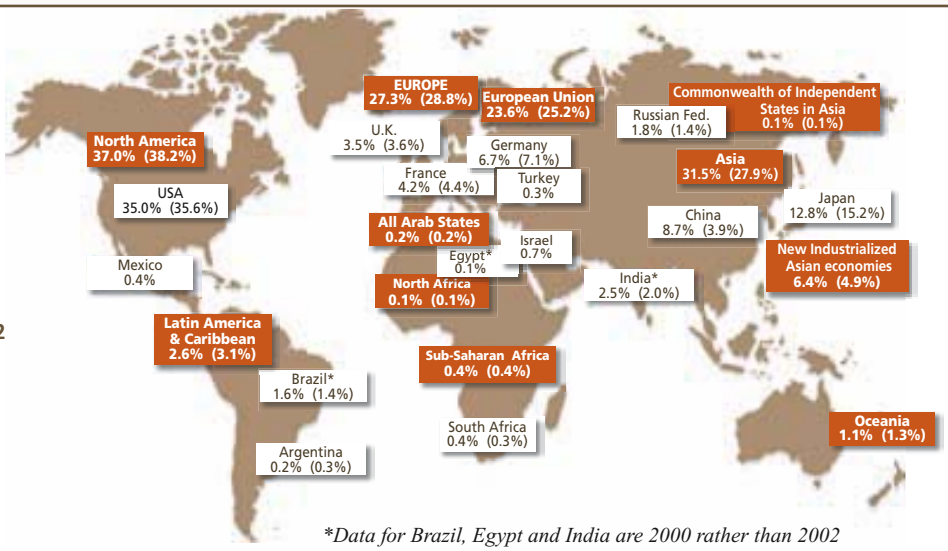


Figure I

WORLD SHARES OF GERD, 1997 AND 2002

Figures for 1997 are between brackets

Source: *UNESCO Science Report 2005*; data for 1997: *A World of Science*, January 2004

**Data for Brazil, Egypt and India are 2000 rather than 2002*

Asian science is booming but one factor overshadows this glowing picture. 'With hundreds of millions of Asian children still living in poverty', regrets the Director-General of UNESCO in his foreword to the report, 'the benefits of R&D are still not reaching large segments of the population who are deprived of such basics as good nutrition, access to safe water, sanitation and shelter'.

A less dominant Triad

The USA remains remarkably dynamic, alone representing more than one-third of the world's scientific activity, yet just 5% of the world population. This share has nevertheless been slightly eroded.

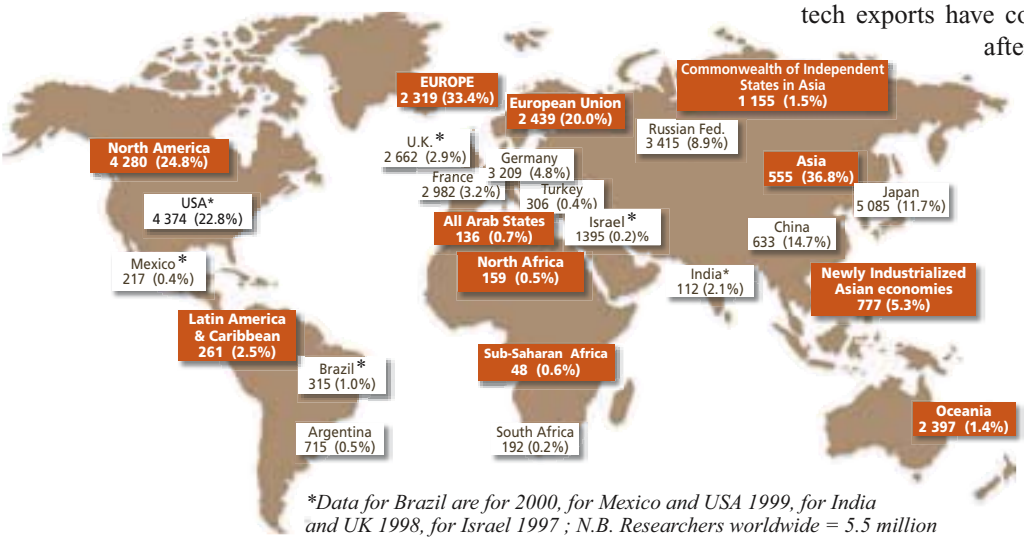
The world shares of Japan and Europe in terms of GERD are likewise diminishing, although Japan and Europe have actually strengthened their hold on scientific publications over the past decade.

Doubt and opportunity in Europe

The entry of 10 new Member States[4] in 2004 – thereby swelling the European Union's (EU's) population by 75 million (or 20%) – offers fresh opportunities for intra-European research but also reinforces disparities. Not one of the new members measures up to the EU15 average of 1.9% (GERD/GDP ratio), itself well below the R&D effort of the USA (2.8%) and Japan (3.1%).

Like Central and Eastern Europe, the Russian Federation is gradually recovering from the painful transition to a market economy following the disintegration of the Union of Soviet Socialist Republics (USSR) in 1991. After slipping from 2% to below 1% of GDP in the mid-1990s, GERD in the Russian Federation has now climbed back to 1.3% of GDP (2002). Civil R&D was allocated 15% more from the federal budget in 2004 than the previous year and, as scientists emerge from isolation, the Russian Federation's share of scientific publications is growing.

One country to watch in coming years will be Turkey (70 million inhabitants), whose 'relative growth of 9% per annum is one of the better rates in the world'. Between 1990 and 2000, GERD trebled to US$ 2.7 billion (0.6% of GDP). The business sector's share of R&D funding has also grown, from 31% in 1993 to 43% in 2001. Publications by Turkish scientists trebled between 1997 and 2002 and high-tech exports have come to represent 3% of total exports, after growing at a much greater pace (43%) than high-tech imports (16%) in the five years to 2001.



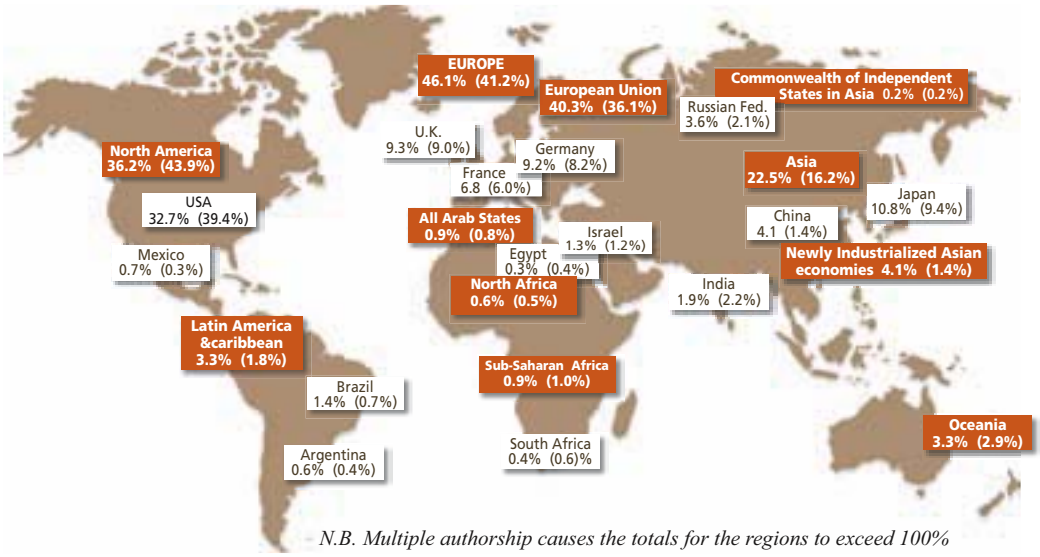
**Data for Brazil are for 2000, for Mexico and USA 1999, for India and UK 1998, for Israel 1997 ; N.B. Researchers worldwide = 5.5 million*

Figure II

RESEARCHERS IN THE WORLD, 2002

Per million inhabitants and as a world share (between brackets)

Source: *UNESCO Science Report 2005*



N.B. Multiple authorship causes the totals for the regions to exceed 100%

Figure III

WORLD SHARES OF SCIENTIFIC PUBLICATIONS, 1991 AND 2001

Figures for 1991 are between brackets

Source: *UNESCO Science Report 2005*

'Latin America not getting it together'

Latin America and the Caribbean accounts for just a fraction of world GERD and this share appears to have slipped between 1997 and 2002 (from 3.1% to 2.6%). Just three countries – Brazil, Mexico and Argentina – contribute 85% of the total. In the Caribbean, only Cuba[5] meets the regional average for GERD of 0.6% of GDP.

'The world is globalizing and Latin America is not even getting it together', regrets the report. This is explained by the fact that attempts at intra-regional integration have come up against persistent 'obstacles connected with development problems and political and financial instability'.

Having a small pool of researchers has not prevented Latin America from increasing its share of world publications between 1991 and 2001. Although Latin American scientists still co-author papers predominantly with their counterparts from Europe and North America, collaboration among Ibero-American colleagues has progressed, as has co-authorship with Asian scientists: from *circa* 6% in 1997 to over 18% in 2001.

Better prospects for Africa?

Africa remains a continent of stark contrasts. Whereas 'many countries are struggling simply to get back to where they were in the 1970s and 1980s[6], South Africa and Egypt can boast of more solid research systems.

South Africa contributes 90% of GERD south of the Sahara, with research capabilities that span aeronautics, nuclear engineering, chemistry, metallurgy, agriculture and medicine. By contrast, research in median Africa tends to be circumscribed to the two latter fields.

Egypt stands out in North Africa for the strength of its research apparatus, most productive in chemistry and engineering. Scientific output in the Maghreb, where countries have only been developing their national research systems since the 1970s, has been growing however by 10% a year since 1980. These countries have good capacities in medicine, agriculture, physics, chemistry and engineering.

A relative newcomer to the African landscape, the New Partnership for Africa's Development (NEPAD) encompassing 53 countries was launched by the African Union in 2001. The report argues that NEPAD has greater prospects for success than previous reform efforts because it 'emphasizes sensible goals'. NEPAD's plan of action for S&T ties investments to such immediate needs as poverty elimination, improvements in public health, access to safe drinking water and environmental protection. It also promotes regional centres of excellence as a key strategy for boosting African collaboration and both South–South and North–South co-operation.

Of note is the growing number of Academies of Science on the African continent, including the Arab Academy of Sciences founded at the initiative of UNESCO in 2002 and headquartered in Lebanon. The founding of the Zimbabwe Academy of Sciences in 2004 brought the number of Sub-Saharan Academies to ten. Unfortunately, many of these Academies are 'starved of cash, recognition and influence'.

Johannesburg in 2004. South Africa devoted US$3.1 billion to R&D in 2002, the equivalent of 0.7% of GDP

A more competitive global environment

Globalization is offering new opportunities through greater international cooperation. This is 'not only helping countries to catch up but is also becoming indispensable to the very exercise of science'. But globalization is also bringing its own set of challenges, not least of which is a more competitive environment.

In the USA for example, 'research universities face increasing international competition, despite their high quality'; over the past decade, Asia's world share of scientific publications has grown substantially and Europe has overtaken the USA. 'If one limits this survey to publications and citations in the highest impact journals, however, the USA remains very much in the lead', notes the report.

India has now been overtaken by China in terms of publications registered in the Science Citation Index of the Institute of Scientific Information (USA). Over the past five years, S&T policy in India has focused on intellectual property management favourable to patents. However, with scientific publications stagnating, this strategy is now being questioned in Indian S&T circles.

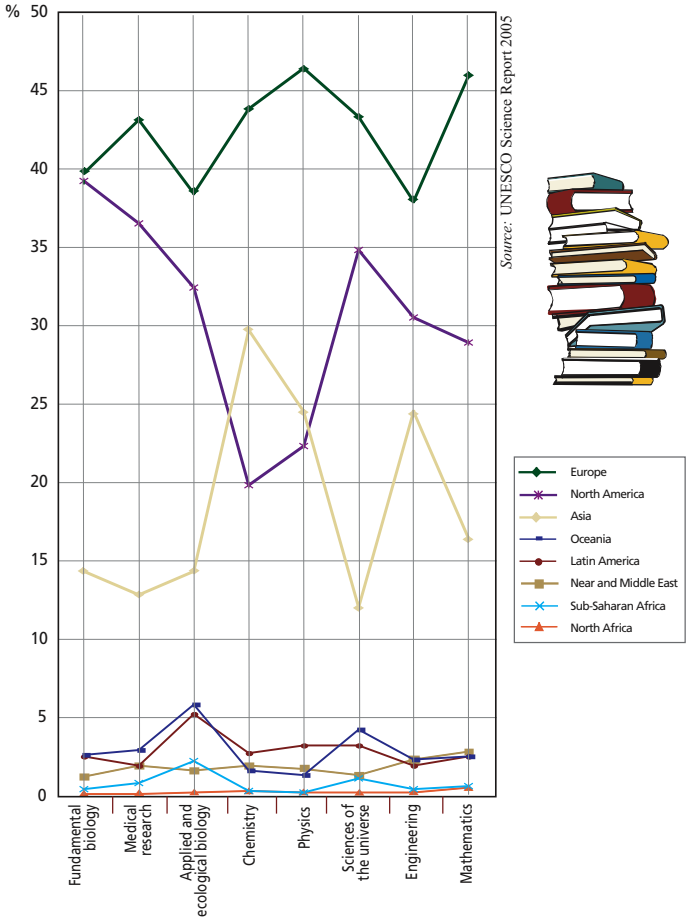


Figure IV **WORLD SHARES OF SCIENTIFIC PUBLICATIONS, 2001**
By discipline

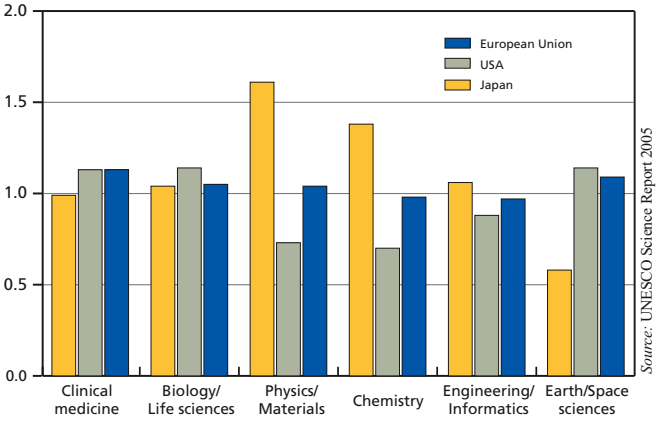


Figure V **SCIENTIFIC PROFILES OF THE TRIAD, 2002**

The USA could be described as 'Japan's opposite', insofar as it shows a strong leaning towards research in life sciences and Earth/space sciences but accords a low priority to physics/materials science and chemistry. The EU, on the other hand, maintains a balance in all six scientific fields (Figure V). The new members should enhance the EU's dominant position in publications, as their strengths lie in mathematics, physics and chemistry. However, at a time when Europe is losing ground in technology, the new members are unlikely to make a difference. In technology and innovation, the USA remains unrivalled.

This said, even US companies 'are running harder to succeed against global competitors in technology'. Moreover, after decades of strong growth, industrial R&D in the USA has got off to a slow start in the new century: expenditure has declined three years in a row and 'more companies [were] planning to reduce R&D expenditure [in 2004] than to increase it', according to an Industrial Research Institute survey.

The Russian Federation is now entering the innovation market, despite problems which impinge on the country's competitiveness, such as inertia in modernizing heavy industries inherited from the Soviet era or in adapting the country's intellectual property law to the market economy. By 2001, 27% of Russian entities performing R&D were privately owned.

Brain drain a persistent problem

Brain drain continues to plague many countries. Even India, which can boast of remarkable achievements in software development[7], space, biotechnology and pharmaceutical research, still sees many of its highly trained graduates lured abroad, mainly to the USA.

This shows that having a strong university system may be one bulwark against brain drain but is not sufficient in itself to overcome the problem. The example of China, where 'approximately one-third of those who go abroad are returning every year', illustrates that higher development at home

constitutes the single most effective magnet for attracting researchers back to their country of birth.

US institutions draw their largest foreign contingents of students from China and India. There are concerns in the USA that 'more stringent and protracted procedures for obtaining US entry visas since the terrorist attacks of 2001' could dissuade students from applying for a visa. The number of applications for student visas has already dropped to 236 000 (2003), from 320 000 in 2001.

The socio-economic trauma of transition to a market economy led to a veritable haemorrhage of researchers in the Russian Federation and former satellite states of the Soviet Union in the 1990s, through both internal and external brain drain. The number of Russian researchers, for instance, shrank from 878 000 in 1991 to 519 000 in 1995 (*World Science Report 1998*), before stabilizing at around 492 000 (2002). Brain drain has also levelled off in Central and Eastern Europe but continues to pose a major headache in South-East Europe.

Today, the Russian Federation represents the fourth-biggest pool of researchers in the world, behind the USA, China and Japan. The socio-economic status of Russian researchers remains low, however, and each disposes of much less funding for R&D than his or her counterparts in developed countries.

The free market ethos which accompanied globalization after 1980 has been particularly devastating for Africa, having led to a disengagement of government on a continent where the private sector was unable to fill the void. 'To avoid humiliation and a huge downgrading of their social position, many academic figures emigrated', either to the North or to 'other African countries where pay was higher', recalls the report. Although African scientists acknowledge a high degree of job security, 52% of them in the Republic of South Africa are dissatisfied with their salaries, according to a 1999 survey, compared to 69% in North Africa and 92% in median Africa.

The importance of a national vision

The report underscores the importance of a national vision. In Africa, for example, the S&T market is dominated by international donors, aid programmes and multinational companies. The incentives they provide to African researchers bear little fruit because they are not matched by national S&T systems capable of offering careers.

Similarly, in the Arab region, the main input to technology comes from turnkey investments by large foreign companies and the technology thus acquired fails to take root. 'In the past three decades, the Arab world has spent US$1 000 billion on turnkey projects, more than 20 times the amount spent within the Marshall Plan to rebuild Europe after the Second World War', states the report. It warns that 'Arab economies dependent on oil and mineral resources will not be able to sustain development as resources become depleted' because S&T are not a priority item on the agenda of Arab political leaders.

Even in Latin American countries with a more developed S&T sector, caution is recommended where international collaboration is concerned, as 'this should bring not merely technology transfer but also capacity-building'. The report points to 'untapped potential in Latin America and the Caribbean for the horizontal transfer of knowledge and technologies under mutually advantageous conditions'.

One example of how technology transfer can pervert the cause of development is the plan by the Ford Motor Company in the 1970s to have different parts of the Ford model made in different Asian countries. 'The plan exploited economies of scale by producing large quantities of the same part in one location and made sure no country acquired the technology to make a complete car', the report recalls. External influences are expected to diminish in East and South-East Asia, where they 'have tended to be divisive'. Countries 'have reached capabilities that make S&T cooperation [within the region] feasible but it is still a daunting task to identify meaningful areas for synergistic collaboration', notes the report.

The Indian exception

The global patent system remains the object of passionate debate. 'Ever more parties recognize that the ... Agreement on Trade-Related Intellectual Property Rights (TRIPS) cannot adequately and fairly cope with issues such as the patentability of genes and natural resources', observes the report. One burning issue in recent years has been the need to find affordable solutions for treating infectious diseases plaguing the developing world.

'The Indian exception' illustrates the struggle by some countries to adapt the global patent system. The Indian Patents Act of 1970 had effectively permitted 'reverse engineering' by not allowing product patents in drugs, food and chemicals but only process patents in these fields for up to seven years. This had enabled India to become self-sufficient in every essential drug and to gain 8% of the world pharmaceuticals market.

A patent ordinance effective since 1 January 2005 has brought India into conformity with TRIPS by amending the Patents Act of 1970. The new ordinance extends product patent protection to all fields of technology, including medicine, food and chemicals, for 20 years. It includes a provision for granting compulsory licences for export of medicines to countries with insufficient or no manufacturing capacity, in accordance with the 2001 Doha Declaration on TRIPS and Public Health. This means that Indian companies will be able to produce and export AIDS drugs to African and South-East Asian countries.

In India, there are hopes that the new ordinance will encourage domestic pharmaceutical companies to emphasize R&D-based innovative growth, thereby enabling the country to 'become a global research hub'.

Patent or perish?

Has academia become *too much* a department of industry? The report posits that 'the stronger ties between companies, universities and research institutes have brought centre-stage a number of crucial issues touching upon the very essence of public sector responsibilities. The quest for patentable research results or for income from clinical trials for example…has led entire university departments around the world into a grey area where values such as independence, integrity, collaboration, openness and public availability of results acquired by public money are put at risk'.

This has in turn spawned attempts to establish a new equilibrium where 'on the one hand, those values proper to academic activities are safeguarded and, on the other hand, the value of the results of research is recognized more explicitly'.

Finding an optimum balance

One universal factor emerging from the report is the importance of the private sector in sustaining R&D. The report cautions, however, that, since such funding is inevitably oriented towards short- and medium-term applications seeking rapid returns on investment, basic research everywhere needs to be able to rely on consistent public funding. (Even in the USA, 60% of all university research is funded by the federal government.) This is why a strong science policy remains essential to maintaining a coherent national science sector.

'China's small allocation to basic research (6%) is well out of line with practice in other countries', observes the report. This policy stems from a decision dating back to 1985 to emphasize the commercialization of S&T. (Enterprises now perform 61% of R&D in China.) 'There is now much debate among the scientific community in China as to whether a more balanced approach should be taken'.

In recognition of the fact that basic academic research is a source of technological opportunity, both the USA and Japan have set up Technology Licensing Offices in universities in recent years. In India, high-tech 'biotech clusters' have been developed in Bangalore, Hyderabad ("Genome Valley") and Delhi, home to India's major universities and government-supported laboratories. In these research hubs, public–private partnerships generate venture funds for innovation in biotechnology.

The lack of an R&D environment on campus poses a big problem in the Arab States, where the relationship between university research, teaching and industry is 'a three-way divorce'.

One handicap for Europe is the duplication of research, owing to the large number of research bodies compared to the USA. 'There seems to be agreement on the need for a European Research Council … which would create a 'uniform attractive force for the best scientists'.

The relative weakness of private sector involvement in research is one reason why Europe is lagging behind North America overall. The report notes that only 56% of R&D funding in the 15-member EU came from industry in 2001, compared to 66% and 69% in the USA and Japan respectively. In this context, the EU's declared goal of seeing its Member States devote 3.0% of GDP to GERD by 2010 seems overambitious, especially as two-thirds of this funding is to come from industry.

A number of European States are nevertheless leaders in innovation. Sweden tops the list, followed by Finland, Switzerland, the UK and Denmark. Sweden and Finland share the distinction of having a small population (*circa* 9 million and 5 million respectively) and of devoting two of the highest percentages of GDP to R&D in the world: 4.3% and 3.4% respectively. Elsewhere in Europe, observes the report, Germany, the Netherlands and France are losing momentum in innovation, even as Portugal, Romania and Turkey, among others, are narrowing the gap.

Susan Schneegans and Roni Amelan[8]

To download the report:
www.unesco.org/science/science_report2005.pdf;
To order a copy: www.unesco.org/publishing

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1. *The* UNESCO Science Report 2005 *is the fourth in a series. Its predecessor, the* World Science Report*, was published in 1998. Data for 1997 in the current article are taken from a study comparing global R&D input in 1997 and 2000; this survey by the UNESCO Institute for Statistics was published in* A World of Science *2(1), January 2004*
2. *All US$ are purchase power parity dollars*
3. *According to Chinese statistics, high-tech exports fall into the categories of computers and telecommunications, life sciences, electronics, weaponry, computer-integrated manufacturing, aeronautics and space, opto-electronic technology, nuclear technology, biotechnology and materials design*
4. *Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia*
5. *On Caribbean science, see* A World of Science*, 4(4), October 2005*
6. *This is the case of Nigeria, for instance, which undertook a reform of its science system in 2004 that includes a joint review of investment, industry and innovation by UNESCO, UNCTAD, UNIDO and WIPO. One aim of the reform is to use strong oil receipts to diversify the economy*
7. *India's software market quadrupled in value to US$20 billion between 1997 and 2003*
8. *UNESCO Press*

Progress towards **ocean targets** too slow

Progress in improving management of the world's oceans and coastlines is sluggish. That is the verdict of 400 ocean experts and decision-makers from 78 countries who attended the third global conference on oceans, coasts and islands at UNESCO in Paris from 23 to 28 January, on the theme of Moving the Global Oceans Agenda Forward[9].

The conference took stock of progress in achieving the objectives fixed by the international community at the World Summit on Sustainable Development in Johannesburg in 2002 and via the Millennium Development Goals[10].

The experts warn that:

- the target of eliminating illegal fishing and fishing overcapacity by 2004 and 2005 respectively has not been met, with 75% of fish stocks are either being fully exploited or overfished. For participants, the Johannesburg targets are unrealistic;
- national action to meet the fisheries goals is insufficient. The Organisation for Economic Cooperation and Development (OECD) and the FAO have put together a task force to examine how to stem illegal, unreported and unregulated fishing in the high seas. Led by UK Environment Minister Ben Bradshaw, the task force is due to present a blueprint for action in March;
- the world's 43 Small Island Developing States (SIDS), which have stewardship over vast areas of the oceans, are having difficulty enforcing conservation policies and controlling developments in their marine environment due to logistical and financial constraints exacerbated by the recent cutback in overseas development assistance;
- the goal of establishing representative networks of marine protected areas by 2012 will only be met in 2085 at the present rate of designation, according to a study presented to the conference;
- there is no international body responsible for tracking progress in establishing ecosystem management and programmes in integrated coastal and ocean management, nor any regular collection of information on the socio-economic well-being of coastal communities;
- there is no international body responsible for dealing with bioprospecting beyond national jurisdiction, nor any internationally agreed definition of what marine bioprospecting covers. This stems partly from the fact that distinctions between marine scientific research and bioprospecting are blurred, it being difficult to ascertain the intent of research from the outset.

The experts also point to progress in some areas:

- half of SIDS have adopted ecosystem-based management and coastal and ocean management programmes;
- 60 states have initiated national plans of action to address land-based sources of marine pollution, which account for 80% of ocean pollution;
- Australia, Palau, the Cook Islands and Costa Rica, among others, have begun establishing marine protected areas to preserve marine and coastal biodiversity;
- 14 countries were making "good progress" in implementing integrated water resource management (both marine and land-based), 51 have "taken some steps," and a further 43 are in the initial stages;
- South–South cooperation among SIDS on marine issues is growing, notably with the establishment of a Consortium of Universities linking the Pacific, Caribbean and Indian Oceans;
- initially set for 2004, the establishment of a process for regular, global reporting on the marine environment, including socio-economic aspects, has finally taken off after initial delays due to differences of opinion among the countries concerned.

Read the panels' reports: http://ioc.unesco.org/globalforum; for the international marine environment targets: www.globaloceans.org; read also The Last Frontier *on p. 16.*

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Barrier Reef Reserve in Belize

Water: a crisis of governance, says UN report

One-fifth of the planet's population still lacks access to safe drinking water and 40% is deprived of basic sanitation, warns the United Nations' second *World Water Development Report*. Largely responsible for this situation are 'mismanagement, corruption, lack of appropriate institutions, bureaucratic inertia and a shortage of new investments in building human capacity, as well as physical infrastructure.' The report was presented to the 4th World Water Forum in Mexico City on 22 March by UNESCO's Director-General on behalf of the United Nations.

Entitled *Water, a Shared Responsibility*, this latest edition of the triennial report[11] focuses on the importance of governance in managing the world's water resources and tackling poverty. Governance systems, it says, 'determine who gets what water, when and how, and decide who has the right to

Quick factsheet

- Although, globally, there is plenty of freshwater, the WHO/UNICEF Joint Monitoring Programme estimates that 1.1 billion people still lack access to clean drinking water and that some 2.6 billion go without basic sanitation. Over half of these people live in China or India.
- The world will need 55% more food by 2030. This translates into an increasing demand for irrigation, which already claims nearly 70% of all freshwater consumed for human use. Some 850 million people still do not have enough to eat.
- Half of humanity will be living in towns and cities by 2007. By 2030, this will have risen to nearly two-thirds, two billion of whom will be living in squatter settlements and slums.
- Over two billion people in developing countries lack access to reliable forms of energy. Europe makes use of 75% of its hydropower potential, Africa just 7%.
- In many parts of the world, a colossal 30–40% or more of water goes unaccounted for, through water leakages in pipes and canals, and illegal connections.
- It is estimated that political corruption costs the water sector millions of dollars every year and undermines water services, especially those to the poor. The report cites a survey in India for example, in which 41% of the customer respondents had made more than one small bribe in the past six months to falsify metre readings; 30% had made payments to expedite repair work and 12% had made payments to expedite new water and sanitation connections.

Source: UN (2006) Water, a shared responsibility. Second World Water Development Report. UNESCO Publishing.

©FAO

Lebu River Valley in Ethiopia, a country which has sufficient water resources to feed its growing population. Why then is it caught up in a cycle of drought and famine? Find out on p. 15

water and related services.' Such systems are not limited to 'government' but include local authorities, the private sector and civil society. They also cover a range of issues intimately connected to water, from health and food security to economic development, land use and the preservation of the natural ecosystems on which our water resources depend.

The Johannesburg Plan of Implementation (2002) called on countries to develop integrated water resources management and water efficiency plans by 2005. Only about 12% of countries have done so to date, although many have begun the process.

Financial resources are also stagnating: total overseas development assistance to the water sector in recent years has averaged US$3 billion a year with an additional US$1.5 billion allocated to the sector in non-concessional lending, mainly by the World Bank. However, only 12% of these funds reach those most in need and only 10% supports development of water policy, planning and programmes.

Private sector investment is declining: during the 1990s, the private sector spent an estimated US$25 billion in water supply and sanitation in developing countries, mostly in Latin America and Asia. However, many big multinational water companies have begun withdrawing from, or downsizing, their operations in the developing world because of the high political and financial risks.

To consult the report: www.unesco.org/water/wwap

A global plan to **curb landslide losses**

A Global Action Plan to reduce both human and financial losses caused by landslides was adopted in Tokyo (Japan) on 20 January, at an international meeting held under the auspices of UNESCO and in conjunction with the UN International Strategy for Disaster Reduction.

The meeting also set up a global network of International Programmes on Landslides. Based at Kyoto University in Japan, the network will function under the aegis of UNESCO and other international bodies.

The Global Action Plan foresees strengthening human resources and boosting funding to ensure adequate risk assessment and identify hazard zones. It will also foster the drawing-up of appropriate building codes, safety regulations and response plans. To reduce landslide risk, the Plan will also target local institutes and universities, encouraging them to develop expertise and early warning measures. In parallel, the Plan will foster education and research.

Almost a year to the day after the UN World Conference on Disaster Reduction in Kobe (Japan), close to 100 experts from 14 countries spent three days at the United Nations University setting international priorities for mitigating losses due to landslides.

Landslides are the seventh most deadly natural hazard in the world, after droughts, windstorms, floods, earthquakes, volcanic eruptions and related disasters and extreme temperature. On average, a single landslide claims 800–1000 lives.

Landslides and mudslides can be triggered by heavy rain, as in the case of the tragic mudslide last February in the Philippines, or by rapidly melting ice or snow. They can also occur when an overflowing crater lake sends large amounts of earth, rock, sand or mud down mountain slopes, especially slopes covered in sparse vegetation where there is little to slow the movement of the slide. Landslides and mudslides can reach speeds of over 50 km/h and bury, crush or carry away people, objects and buildings. They also threaten some of the world's most precious cultural sites, including several UNESCO World Heritage sites.

Episodes of heavy rainfall are becoming more intense and more frequent. This trend is drastically increasing the number of casualties associated with landslides, especially in developing countries where pressure on land often leads to the cultivation of slopes, an activity conducive to disastrous landslides. All regions experience landslide disasters but the damage they cause is most acute in developing countries, where the knowledge base required to identify landslide-prone areas is often either non-existent or fragmentary. With climate change, landslides could also be caused by new factors.

For details: http://icl.dpri.kyoto-u.ac.jp; b.rouhban@unesco.org; www.unesco.org/disasters

The life sciences fête five **women pioneers**

In the run-up to this year's World Day for Women on 8 March, five laureates from as many continents travelled to UNESCO in Paris to receive their L'ORÉAL-UNESCO Awards For Women in Science on 2 March. Each woman takes home US$100 000.

Prof. Habiba Bouhamed Chaabouni from Tunisia is the Laureate for Africa. A clinical geneticist at the University of Tunis, she is recompensed for her contribution to the analysis and prevention of hereditary disorders.

Prof. Jennifer Graves from Australia is the Laureate for Asia-Pacific. Head of the Comparative Genomics Research Group and ARC Centre for Kangaroo Genomics at the Australian National University in Canberra, she is recompensed for her study of the evolution of mammalian genomes.

Prof. Christine Van Broeckhoven from Belgium is the Laureate for Europe. She is rewarded for her genetic analyses of Alzheimer's and other neurodegenerative disorders. (Alzheimer's affects men and women in later life.) She is a molecular biologist and geneticist at the University of Antwerp, Research Director at the Institute Born-Bunge and Scientific Director of the Department of Molecular Genetics at the Interuniversity Institute for Biotechnology, Flanders.

Prof. Esther Orozco from Mexico is the Laureate for Latin America. Her award comes in recognition of her discovery of the mechanism and control of infections by amoebae in the tropics. She is a molecular pathologist in the Department of Experimental Pathology at the Centre for Advanced Research (CINVESTAV) within the National Polytechnic Institute in Mexico City.

Prof. Pamela Bjorkman is the laureate for North America. She is recompensed for her discovery of how the immune system recognizes targets. She is a biologist at the Howard Hughes Medical Institute of the California Institute of Technology (CalTech) in Pasadena, USA.

The five women received their awards from the hands of Sir Lindsay Owen-Jones, Chairman of L'ORÉAL, and UNESCO Director-General, Koïchiro Matsuura. The laureates were selected by an international Jury made up of 15 eminent scientists from the life sciences and presided by Prof. Günter Blobel, 1999 Nobel Prize in Medicine.

The amount of this year's UNESCO-L'ORÉAL International Fellowships has doubled to US$40 000 for use over a maximum two-year period. The fellowships were awarded to 15 promising young women life scientists at UNESCO in Paris on 1 March. Each of the new Fellows – three from each continent – is conducting a doctoral or post-doctoral research project.

In addition, nearly 60 L'ORÉAL National Fellowships have been allocated in 20 countries, thanks to the invaluable support of National Commissions for UNESCO.

As part of UNESCO's 60th anniversary celebrations, L'ORÉAL and UNESCO paid a special tribute on 2 March to Prof. Christiane Nüsslein-Volhard, 1995 Nobel Prize in Medicine, 'for her efforts in supporting highly qualified women with children to facilitate their progress in science.' The tribute was accompanied by a $100 000 donation to the Christiane Nüsslein-Volhard Foundation.

For details: www.forwomeninscience.com; r.clair@unesco.org;

A tsunami warning system for the Caribbean

The Tsunami and other Coastal Hazards Warning System for the Caribbean and Adjacent Regions was launched in Bridgetown (Barbados) from 10 to 12 January with the first meeting of the system's Intergovernmental Coordination Group (ICG). This latest system is a landmark in UNESCO's Global Strategy for the Establishment of a Tsunami Early Warning System in the Pacific and Indian Oceans, as well as in the Northeast Atlantic and Mediterranean.

About ten major tsunamis have been recorded in the northern Caribbean since the arrival of Italian explorer Christopher Columbus in 1492. The most recent claimed 1800 lives in 1946; it was triggered by an earthquake in the Dominican Republic. Recent studies point to risks linked to shifts in the North America and Caribbean tectonic plates and to major undersea landslides off the northern shore of Porto Rico. The region counts 35 million inhabitants.

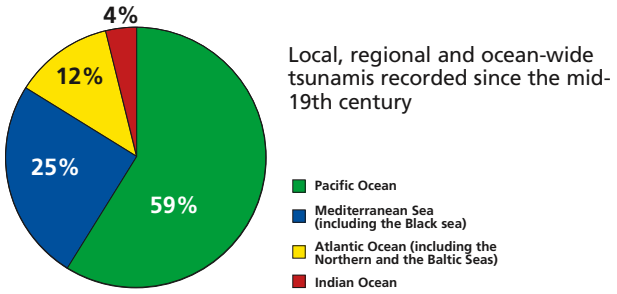
Representatives of 30 countries from the Caribbean and Central America, as well as from the USA, took part in the ICG meeting, which follows on from last June's international conference in Mexico City for the development of a warning system in the region. The Bridgetown meeting was organized by the Intergovernmental Oceanographic Commission of UNESCO, WMO and the UN International Strategy for Disaster Reduction.

In Bridgetown, participants determined a plan of action for risk assessment, collection and sharing of data and emergency management for tsunami warnings as part of a multi-hazard

warning system. They also reviewed progress in implementing warning systems in other parts of the world.

The Indian Ocean Tsunami Warning and Mitigation System is expected to be fully operational by July 2006. At the time progress was last assessed in Hyderabad (India) in December, 26 real-time sea-level stations had been established or upgraded in the countries of the Indian Ocean, as well as 25 seismic stations. Twenty-five countries have established communications centres to receive advisories, based at this stage on seismological information from the operational centres serving the Pacific in Hawaii and Tokyo; improvements have been made to the Global Telecommunications System to allow it to carry tsunami-relevant information; experiments are being conducted to test communication links for the transmission of seismic information in real-time; and several countries in the region are working on the deployment of deep-ocean tsunami detection (DART) buoys.

Distribution of tsunamis around the world



The Tsunami Early Warning System for the Mediterranean and Northeast Atlantic was launched in Rome (Italy) last November by experts and delegations from 23 countries. An initial system is expected to be operational by December 2007. This region has experienced 37% of all recorded tsunamis (see diagram). In 1755, the city of Lisbon (Portugal) was destroyed by a tsunami resulting from a major earthquake along the Azores–Gibraltar fault. In another event in 1908, 85 000 people died in Messina (Italy). There are also records of major to local events along the coasts from Norway to the Marmara and Black Seas.

For details: http://ioc3.unesco.org/cartws

New Cameroon centre joins fight against AIDS

A sub-regional AIDS centre opened its doors on 23 February in Cameroon, a country where 12% of the population is living with the virus. The new centre will focus on prevention, scientific research and training.

Located in a brand new medical complex near the capital city of Yaoundé, the centre has been funded jointly by the Government of Cameroon, the Italian Health Institute, UNESCO extrabudgetary funds donated by the Italian government and by the World Foundation for AIDS Research and Prevention.

The development of a vaccine to protect breastfed babies from contracting HIV/AIDS will be one research focus of the new centre. This is because even children born free of the virus are often infected later via breast milk. Each year, some 800 000 African babies contract the virus, either during pregnancy, birth or via breastfeeding. Even when Nevirapine is administered to women shortly before delivery, the treatment does not entirely eliminate the risk of transmission from mother to child, although it does reduce the rate of infection from 25% to just 3–5% of babies. Unfortunately, very few African women receive any treatment whatsoever during pregnancy.

Pre-clinical basic research on the development of possible candidate components of a pediatric vaccine began in 2002 through the UNESCO Families First Africa Project supported by extrabudgetary funds from the Italian government. This project has focused on pre-clinical research and on the training of African scientists and doctors; it involves collaboration between some of the world's leading AIDS research teams. Professors Luc Montagnier (Paris, France) and Robert Gallo (Baltimore, USA) discovered the AIDS virus in the early 1980s and are now working together with Professor Vittorio Colizzi's team (Rome, Italy) and scientific teams in Burkina Faso, Cameroon, Côte D'Ivoire and Nigeria.

Since UNESCO cannot engage its responsibility in the area of clinical trials, this part of the project to develop a pediatric vaccine would not remain with UNESCO.

For details: www.unesco.org/science/bes

The First Lady of Cameroon, Chantal Biya, cutting the ribbon at the opening ceremony of the newly constructed AIDS centre on 23 February. Also pictured are the First Ladies of Burkina Faso and Comores, Chantal Compaore and Anzali Ambali, as well as Luc Montagnier and, behind him, Noureini Tidjani-Serpos, UNESCO Assistant Director-General for Africa. The First Ladies all belong to African Synergies, a movement they launched in 2002 to link the different initiatives fighting AIDS on the continent and mobilize international resources

Great apes champion receives UNESCO medal

UNESCO's 60th Anniversary Medal was awarded to Jane Goodall, the British-born primatologist, on 17 January at UNESCO in Paris. The medal recognizes Ms Goodall's lifelong dedication to the preservation of Africa's endangered great apes.

'Ms Goodall was one of the first to sound the alarm regarding the serious danger facing the great apes, which provide us with a direct link to humanity's past,' said UNESCO's Director-General in presenting the award. She has been a researcher and champion of chimpanzees and other primates since she first arrived in Africa in 1960 at the age of 26. Fewer than 400 000 great apes survive today, compared to two million 50 years ago. UNESCO and UNEP coordinate the Great Apes Survival Project (GRASP), of which the Jane Goodall Institute – a global NGO – has been a patron since 2001.

For details: www.unesco.org/mab

UNESCO puts ethics within everyone's reach

The Global Ethics Observatory contains all currently available resources on ethics worldwide. It was officially launched on 15 December, at a meeting of the International Bioethics Committee in Tokyo, Japan.

From now on, it will be possible to access directly and free of charge four databases covering the fields of bioethics, environmental ethics, science ethics and technology ethics. In addition to a Who's Who listing contact details of experts in each of these fields, the user will be able to consult ethics-related listings of institutions, teaching programmes and legislation, rules and regulations, all collected from UNESCO's Member States. These databases are the first such resource on ethics activities around the world.

For details: www.unesco.org/shs; geo@unesco.org

9. *The conference's major sponsors were: Global Forum on Oceans, Coast, and Islands; Global Environment Facility; UNESCO's IOC; UNEP Global Programme of Action for the Protection of the Marine Environment from Land-based Activities; Canadian Department of Fisheries and Oceans; US National Oceanic and Atmospheric Administration; Gerard J. Mangone Center for Marine Policy, University of Delaware; World Ocean Network; International Coastal and Ocean Organization*
10. *For the list of MDGs, see* A World of Science*, July 2005; on the Johannesburg outcome, see A World of Science, October 2002*
11. *The* World Water Development Report *is joint effort of 24 UN agencies and entities involved in water resources management. It is produced on their behalf by the UN World Water Assessment Programme, the secretariat of which is based at UNESCO*

Would Einstein have ap

How successful was the International Year of Physics? In celebrating the 100th anniversary of Einstein's *annus mirabilis* in 1905, the Year was intended to serve as a rallying point for the public by recalling the important benefits physics has brought society over the past century.

Four leading physicists speak frankly about their individual experiences of the Year. Prof. Judy Franz from the USA is Secretary-General of the International Union of Pure and Applied Physics (IUPAP) and Executive Officer of the American Physical Society; Prof. Martial Ducloy from France chaired the International Steering Committee for the Year and is former President of the European Physical Society; Prof. Francis Allotey from Ghana is President of the Society of African Physicists and Mathematicians; and Prof. Masno Ginting is President of the Indonesian Physical Society.

What did the physics community you represent hope to gain from the Year and how did it go about achieving this goal?

J.F. We wanted to make non-scientists more excited about physics. We helped organize national events and many local ones and provided a website, which listed over 600 events, so that people across the country could see what was happening in their region. We also organized programs that were carried out in approximately 10 000 school classrooms. Overall, I think the international physics community did an excellent job of promoting the public understanding of physics. Of course, in some countries, physicists achieved much more than in others.

M.D. The goal of the Year was to improve communication between the physics community and society at large, including young people, in order to narrow the gap and recall the importance of physics in solving the societal problems of the 21st century. There was a large mobilization of physicists worldwide.

F.A. The aim was to motivate more young people, including girls, to study physics and choose physics as a career. We hoped to make decision-makers and the general public in our part of the world more aware of the important role physics plays in our daily lives and in industrial development. We informed the Minister for Environment and Science and Minister for Education and Sports about the aims of the Year. A national planning committee with various stakeholders was formed. We received financial support for local activities from the government and from industry. The media was invited to our activities. We organized a series of lectures and physics

pproved?

Judy Franz *Martial Ducloy* *Francis Allotey* *Masno Ginting*

exhibitions for students, teachers and the general public on science in general and physics in particular, including topics such as Physics and Health Care, Physics for Wealth Creation and Physics for Development. A physics outreach programme was started: a Physics Talent Search and Physics Quiz were organized for young people throughout Ghana - the hour-long award ceremony for the winner of the Physics Quiz was televised live nationwide; Ghanaian young scientists participated in the International Junior Science Olympiads in Indonesia in 2004 and 2005, the Year's launch conference in Paris[12] and in the Young Physics Ambassador Symposium in Taipei from 30 December 2005 to 4 January 2006.

M.G. We introduced competitions like the National Olympiad in physics for junior and senior secondary school pupils and the International Junior Science Olympiad, in which pupils and the general public were invited to participate. The Indonesian Physical Society, in cooperation with the Indonesian Institute of Sciences (LIPI), organized a two-day seminar to which Nobel Laureate for Physics Prof. Douglas Dean Osheroff was invited as the keynote speaker. LIPI invited young scientists from all over Indonesia who had received science awards for their work, either in Indonesia or abroad, to attend this event. All of them presented their work during the seminar.

How important was it for UNESCO to lend its support to the Year?

J.F. Very important. For instance, in many countries the local government would not have given any funding without the official declaration by the United Nations and UNESCO. In all countries, this United Nations support helped attract media attention.

M.D. The support of international organizations, and of the United Nations in particular, gave an official seal to the Year and was essential for mobilizing the physics community in many countries. One may regret the absence of financial support.

F.A. UNESCO's support was critical. It showed the Ghanaian public that the Year was an important world event. This enabled us to receive financial support and full participation from the Ministry of Education and the Ministry of Science. Donations were also received from some local private organizations.

M.G. In my opinion, the United Nations/UNESCO support for the Year was very important for scientists all over the world and especially for physicists. The declaration of 2005 as International Year of Physics stressed the importance of young people studying physics.

Wasn't the declining number of young people studying physics one of the issues highlighted by the Year? Are countries taking any policy measures to redress the situation? Is the physics community itself planning to gather data and information to see how the Year has influenced tertiary enrolment in physics?

J.F. In the USA, we ran a very successful programme for secondary-level pupils, in which more than 700 schools participated. In the USA, the American Institute of Physics keeps very good statistics about the number of pupils taking physics at secondary school and the number of undergraduate physics degrees awarded, as well as a great deal of additional data The number of physics degrees awarded to undergraduates has been rising for the past five years or so, so it may be difficult to see the effect of the Year on top of this background increase. We shall nevertheless try to do so.

M.D. Many activities have sought to attract the attention of young people but it is still too early to assess the impact of these. In some countries like France, there has already been an increase in the number of students enrolling in science at university, as observed last September. The need to change teaching methods in science has already been felt in France and has led to the *La main à la pâte* programme in primary schools, which is being extended to a number of European countries and beyond. Similar approaches are now being developed for physics teaching in secondary schools[13].

F.A. Yes, the declining number of physics students was one of the motivations behind the Year. The Ghana Institute of Physics is taking an active part in mobilizing physics teachers and pupils. More female pupils are getting involved in science at school. This is evident in the number of females (40%) who attended the Year launch ceremonies and took part in the Physics Talent Search and physics competitions we organized; over 6000 students and pupils took part in the talent search, which was organized at the district level right through to the regional and national levels. It is too early to talk about policy or to have data to hand but the Ghanaian Minister of Education has indicated in the media that he will be instituting financial incentives to motivate more pupils to take science at secondary school and at university.

M.G. Yes, that was the idea behind the Year. I am convinced that secondary-level physics will be more interesting for pupils from now on. But I am not so sure these same pupils will go on to study physics at university and take up a career in physics. The main problem is that, while they may find physics an interesting subject to study, many bright students think there is no future for them in physics. It may be a good idea to invite physical societies around the world to gather this information. The Indonesian Physical Society has encouraged students to enroll in physics at university. For example, we already have an agreement with the Dean of the Faculty of Mathematics and Science at the University of Indonesia to allow admission without sitting the regular university entrance test for students

taking part in any international physics competitions. We are also exploring support from local governments and private companies for scholarships for bright pupils planning to enroll in physics at university.

Do you think the Year has succeeded in generating a durable interest in physics among the general public and media in your country?

J.F. In the USA, there is no durable interest in almost anything. We shall have to maintain our efforts for the interest to survive. However, we have learned a lot about what efforts are most successful. I believe there were articles in most major newspapers. Science-oriented magazines and newsletters all gave the Year excellent coverage. It would be interesting to learn how many countries had at least one major public outreach event – we know this was the case for about 90 countries and perhaps more – and how many of these organized events they had never tried before. From the enthusiastic responses I have seen, many countries and physical societies will be continuing some of their more successful activities now that the Year is over. I know that the American Physical Society has added a staff person to continue our Physics Quest as an annual activity. This is aimed at middle school students (years 6–9 of schooling), an age group for which the American Physical Society has never had programmes before. Activities during the Year depended heavily on national and international physical organizations and key individuals who volunteered a tremendous amount of their time. In fact, the large portion of volunteer time is a good measure of the importance of the Year for the international physics community. In addition, many organizations and governments contributed funding. Working together, IUPAP, UNESCO and its Abdus Salam International Centre for Theoretical Physics were able to raise almost US$500 000 for the World Conference on Physics and Sustainable Development in Durban last October[14], with contributions from more than 25 different organizations.

M.D. In France, and more generally in Europe, the impact on science communication has been tremendous: more than 500 public events were held in 2005 in France, 700 in Germany, 200 in Poland, etc. Throughout Europe, 37 countries participated actively in the Year, 18 of which received grants from the European Union. Public interest in physics has definitely been raised. Our concern now is the durability of this interest. The tremendous momentum given to science communication should be carried on. On the media side, there has been a noteworthy interest, although this was more focused on Einstein himself than on physics. This has demonstrated that collaboration between science and communication can be done on a large scale.

F.A. The Year was very successful. Five commemorative stamps were issued. A weekly one-hour science programme was initiated by a national radio station. Activities of the Ghana Institute of Physics have increased. Moreover, the Ghana Association of Science Teachers has requested that the outreach programmes of Science on Wheels and the Physics Talent Search continue, which they are doing. Science on Wheels visited various schools and colleges, with financial support from the Ministry of Science and Technology and the Ministry of Education: physicists from the Ghana Institute of Physics arranged science demonstration equipment on a van, both of which were provided by the Ghana Education Service. As for the talent search, it has raised awareness among students, parents, education planners and the government of the importance of physics. As a result, for the first time, Ghanaian media and secondary school pupils are showing great interest in the solar eclipse we shall be able to observe in Ghana on 29 March 2006. On this occasion, the Ghana Institute of Physics and the Society of African Physicists and Mathematicians are organizing a conference at the University of Cape Coast. This will be webcast around the world and will showcase Ghanaian science.

M.G. The media – television, newspapers and radio – gave all the events enthusiastic coverage, making the Year more popular. I was interviewed on a very good radio show along with teachers, parents and others from different islands, among them Aceh, Kalimantan and Bali. The show was broadcast all over Indonesia. There is a programme called *Pesona Fisika*, or Physics Edutainment, which has been broadcast every Sunday evening for two years now on *Televisi Republik Indonesia* to very good viewer ratings. I think the Year was very successful. Pictures of Einstein and of the Year's logo could be seen everywhere. People talked about the Year. Many pupils became more interested in physics than before. In my opinion, the International Physics Young Ambassadors Symposium in Taipei mentioned earlier by Prof. Allotey was one of the Year's biggest achievements because it captured the spirit of solidarity. Many countries participated in this culminating event for the Year's Physics Talent Search, which targeted girls and boys aged 10–18 who were not enrolled in university. The Symposium provided these gifted pupils with an authentic scientific and international experience which enabled them to share their interests, work on experiments together and create lasting friendships.

Minella Alarcon

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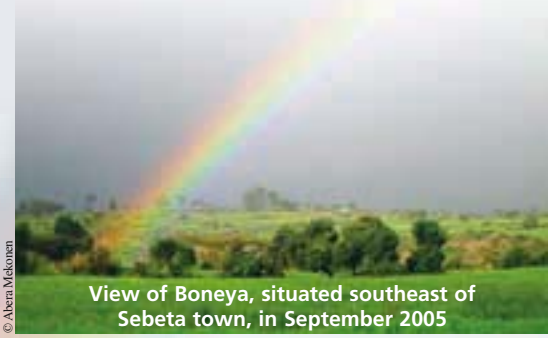
12. UNESCO and partners invited 500 teenagers and their teachers from schools around the world to Paris for a week in January 2005 to listen to lectures given by Nobel Prize laureates and other leading physicists on quantum physics, cosmology, nanotechnology and other topics related to the challenges of the 21st century. This 'open conference' for the general public marked the launch of the Year

*13. See: When learning science becomes child's play (*A World of Science*, July 2005); and Physics without tears (*A World of Science*, January 2005)*

*14. See: Physicists commit to sustainable development (*A World of Science *4(4), October 2005)*

Ethiopia: a pot of blue gold at the end of the rainbow?



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View of Boneya, situated southeast of Sebeta town, in September 2005

Severe drought has struck again in Ethiopia. Some 740 000 pastoralists in the southeastern part of the country are suffering acute food shortages and pre-famine conditions, with widespread migration of people and animals. The plight of these people may sound chillingly familiar. In recent decades, Ethiopia has been stricken by several severe droughts, each of which has exacted a terrible human toll. Is this cycle inevitable?

The answer is no. Ethiopia has sufficient water resources to meet the needs of its growing population. The problem is that these resources are massively underexploited. To harness this potential, the government has begun implementing a 15-year programme to develop the water sector. Full implementation, however, will depend on whether the government can attract sufficient foreign investment. The irony is that, three years into the programme, it is still not certain where this foreign investment will come from, even though the international community is very much present in Ethiopia: it has been providing the country with uninterrupted humanitarian aid now for two decades. Recent developments suggest that a solution could be just around the corner.

Ethiopia being prone to drought and desertification, people tend to picture a country of barren landscapes baked by the sun. The reality is much more nuanced. Ethiopia has three distinct climatic zones: tropical in the south and southwest, cold to temperate in the highlands and arid to semi-arid in the northeastern and southeastern lowlands.

Half of Ethiopia's 71 million inhabitants live 2 200 metres above mean sea level (masl). At this altitude, temperatures are cooler, rainfall is more plentiful and malaria less of a scourge. A further 40% of Ethiopians live between 1 400 and 2 200 masl. Just one in ten Ethiopians, therefore, live in the arid and semi-arid zones covering 60% of the country.

Map prepared for the UN World Water Assessment Programme by AFDEC, 2006

Water running through their fingers

Ethiopia is endowed with nine major rivers, all of which it shares with its neighbours. The nine riparian countries launched the Nile Basin Initiative in 1999 in the hope of coming up with a permanent legal and institutional framework for sharing this precious resource. Negotiations are still in progress. If they succeed, this will be the first comprehensive agreement binding riparian states in the region. Four river basins located in the western part of the country supply 83% of surface water.

The country also has twelve big lakes. Lake Tana in the north, for example, is the source of the Blue Nile. However, apart from these rivers and lakes, there is hardly any perennial flow in areas below 1 500 masl. All but 3% of the country's annual renewable freshwater potential (122 billion m^3) literally flows out of the country. Currently, less than 5% of surface water is used for consumption, even though the country is estimated to have a potential of 54.4 billion m^3 of surface runoff and 2.6 billion m^3 of groundwater.

Why the waste?

Why the waste? It boils down to two words: extreme poverty. National funds are in short supply and current investment is insufficient to break the vicious circle of poverty.

With a per capita GNP of US$100 in 2001[15], Ethiopia is one of the poorest countries in the world, even by Sub-Saharan standards (approx. US$259 per capita). Nearly 52% of Ethiopians live beneath the national poverty line[16], with poverty in urban and rural areas estimated at 58% and 48% respectively.

Economic growth is highly vulnerable to spells of severe drought, like that which plagued Ethiopia in 2001/2002.

A wetland treasure trove

© FAO/17121/M. Marzot

Children cleaning fish in wetlands

Wetlands are areas of saturated ground which are neither fully terrestrial nor fully aquatic. In Ethiopia, they contribute directly to food security by providing vegetables in the early rainy season when the supply of food from the upland fields is running out for many families.

Wetlands also contribute indirectly to food security. Some of the poor make a living from collecting materials which they either sell directly or use to make crafts; these are then sold in turn to buy food. Medicinal plants are also found in wetlands and contribute to the well-being of households through direct use or through sales.

With the exception of coastal and marine-related wetlands and extensive swamp-forest complexes, all forms of wetlands are represented in Ethiopia. These include alpine formations, rivers, lakes, non-tidal and floodplain wetlands. It is estimated that wetlands cover 1.14% of the country. Even though Ethiopia is not signatory to the Ramsar Convention on Wetlands, a significant proportion of its wetlands – 31 sites are important bird areas – qualify as wetlands of international importance.

Ethiopia's wetlands are being degraded, however, due to draining for agriculture, cattle grazing, industrial pollution and unsustainable utilization of resources, among other human causes. Although some policies specifically address wetlands, there is an overall lack of a national wetland policy, despite their value for rural communities.

The figures speak for themselves: whereas real GDP grew by 6.0% in 1998/1999, 5.3% in 1999/2000 and 7.7% in 2000/2001, it fell back to 1.2% in 2001/2002.

The government is also faced with the phenomena of steep population growth and urban migration. Close to 10 million Ethiopians live in urban centres, including 2.5 million in the capital of Addis Ababa alone. Rural exodus is fuelling urban growth of 4.4% per year. In 1984, there were only 124 towns with more than 5 000 inhabitants, today there are 305.

Ethiopian women have one of the highest fertility rates in the world, (6.1 children on average [UNESCO, 2005]), although this rate is gradually declining. Despite an infant mortality rate of 10% and life expectancy at birth in 2001 of just 46 years (UNESCO, 2005), Ethiopia has a rapidly growing population which is expected to reach at least 118 million by 2030.

Sanitation still a luxury

With the exception of Addis Ababa and a few other urban centres, sanitation services are almost non-existent. Just 10% of Ethiopians benefit from proper sanitation facilities and 30% from safe water, according to the Ministry of Water Resources (2002). There is a much better access to water in urban areas (74%) than in rural parts of the country (23%). Moreover, even where water installations do exist in rural areas, nearly one-quarter of these are not functioning at any one time. Central Statistic Authority results (1998) show that 64% of rural dwellers have to fetch water from a source at a distance of up to 1 km. The situation deteriorates during dry periods, as water carriers have to walk longer distances for even smaller quantities of lower quality water. High population growth, low education levels and high rates of illiteracy have also contributed to ill health.

Universal primary education by 2015?

The government's Education and Training policy adopted in 1994 has focused on improving access to education and making it more equitable, relevant and quality-based. The goal is to achieve universal primary education by 2015, one of the Millennium Development Goals. In the three years to 2001, the overall enrolment ratio in Ethiopian primary schools (ages 7–12) rose from 82% to 85%. Girls are still less well-off than their brothers but the gap is gradually closing. Some 66% of girls attended in school in 1998 and 74% three years later.

Water-related diseases a killer

Patients at health facilities are usually treated for respiratory and skin infections, malaria, diarrhoeal diseases and intestinal parasitic infections. About three-quarters of the country is a breeding ground for mosquitoes, the vector of malaria. Malaria is especially endemic in hot lowlands, which prompts many Ethiopians to live in the highlands. Diarrhoea, the most prevalent water-related affliction, is responsible for 46% of child deaths under the age of five. Taken together, the five types of illness mentioned above account for over 63% of all reported child deaths.

© UNESCO/B. Bisson

Famine victims in 1984. Basic food assistance from the international community dates back to this terrible famine, which claimed more than one million lives. Ten years previously, another famine had killed 19% of Ethiopians living in drought-affected areas; the 1974 famine was one of the immediate causes of the popular uprising which led to the downfall of Emperor Haile Selassie I

© UNESCO/Dominique Roger

Women and girls are particularly vulnerable to water-borne and water-related diseases, as they are the ones who most frequently come into contact with contaminated water when fetching water for the family

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Cattle drinking from a river. Traditional livestock production in Ethiopia is economically inefficient, as pastoralists keep a huge population of livestock, either for prestige or as security against drought spells. This has two obvious disadvantages: the huge cattle population puts pressure on the rangelands, affecting the plants and the soil, and a large capital of money is tied up in a standing crop of livestock with an uncertain future

An economy at the mercy of drought

Some 86% of Ethiopians live from farming, which contributes 57% of GDP. Rain-fed crop cultivation is the principal activity and is practiced over an area of 28 million hectares (ha), or approximately 23% of potentially arable land. The rural population is thus extremely vulnerable to the regular spells of severe drought which ravage the country. It is estimated that up to 3.7 million ha could be irrigated, as compared to a mere 300 000 ha today (see box overleaf).

A growing appetite for energy

The main source of energy in Ethiopia (about 93%) is biomass: wood, coal, agricultural residues, animal wastes, etc. Wood-burning is rapidly depleting the forests which used to cover 30% of the country and now cover 3%. The removal of vegetation for fuel – but also for cropping, construction, mining, through grazing and the action of the wind – also leaves the soil more susceptible to erosion. It is estimated that some 2 billion tons of soil are being eroded annually.

Currently, hydropower contributes about 1% to annual energy production. It is estimated that 30 000 MW of hydropower can be generated using available water resources. However, merely 670 MW of the hydropower potential has currently been developed.

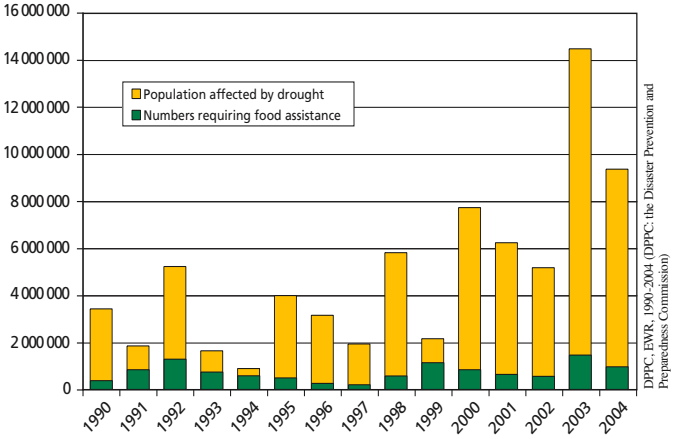
Household consumption accounts for 88% of total energy consumption and industry just 5%. As Ethiopia's economy depends almost entirely on subsistence agriculture, the need for electricity has been fairly low. This situation is now changing, as urbanization and industrialization fuel the demand for energy. The Ethiopian Electric Power Corporation plans to implement a variety of hydroelectric, oil and gas resource development schemes to improve access to electricity from 15% to 20% by 2010.

Drought and flooding on the increase

As most of the rivers in Ethiopia flow in deep gorges, floods have traditionally not been a common occurrence. However, due to massive deforestation and loss of surface vegetation, flooding now occurs annually in some parts of the country, such as on the banks of the Blue Nile River and in the vast plains of the Baro Akobo Basin in the country's southwestern region. Although sometimes associated with economic and social damage, floods provide much-needed water to ensure the fertility of grazing lands. This makes them eagerly anticipated events in Ethiopia, especially for nomads who derive their income from animal husbandry.

Drought used to hit Ethiopia at least once in every ten years. In recent times, however, it has been recurring every two or three years with greater intensity. Areas that only decades ago used to receive enough rainfall to grow crops have become arid zones deserted by the population. There have been about 30 major droughts over the past nine centuries. Of these droughts, 13 were very severe in Ethiopia. Since 1990, 10–50% of the population affected by drought has consistently needed basic food assistance (see figure).

Why is drought becoming more acute in Ethiopia? The worsening situation is the consequence of a chain reaction set off by high population growth. A larger population has placed greater demands on natural resources and this in turn has led to massive deforestation and loss of vegetation. These phenomena have disrupted the replenishment of groundwater and climate regulation, as well as the vital ecological services



Ethiopians affected by drought, 1990–2004

A solution just around the corner?

At the time of finalizing Ethiopia's Water Sector Development Programme in 2002, it was not clear who would finance the projects planned to 2016. Over the past two years, however, both the Ethiopian government and a whole array of external bodies, from the World Bank, European Union and African Development Bank to bilateral agencies, have shown great interest in the programme with the result that pledges are now being made.

In parallel, a highly ambitious plan is being discussed within the European Union's Water Facility for Africa, the Caribbean and the Pacific. The plan would extend coverage of a clean water supply and sanitation to 100% of the population in these regions by 2015, the target year for the relevant Millennium Development Goal.

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The original medium- and large-scale irrigation schemes in Ethiopia's Water Sector Development Programme covered a total of 147 000 ha. The government has since realized that this figure underestimates the huge demand of Ethiopia's growing population and would not secure food security. The government is consequently in the process of revising the scheme and has begun investing on an unprecedented scale in irrigation development (small-, medium- and large-scale). The government is investing in the construction of 90 000 ha of irrigation over and above that originally foreseen in the national programme. Moreover, preparation is under way for a further 100 000 ha of irrigation, 80% of which is to be financed by a World Bank loan and the remainder as a fast-track project using World Bank resources.

For details of the European Union's plan: http://europa.eu.int/comm/europeaid/projects/water/details_en.htm

provided by vegetation cover in controlling run-off and soil erosion. This has led to the drought–flood cycle phenomenon in Ethiopia. The consequence is greater flooding, lesser infiltration of rainfall and the drying-up of local streams and rivers once the rainy season is over.

Today, the contingency plans for water-related natural disasters are prepared by the Disaster Prevention and Preparedness Commission. This Commission brings together all concerned stakeholders to draft a plan of action.

Water is a citizen's right

The fundamental principles of the Federal Water Resource Management Policy issued in 1999 are that water is a natural endowment commonly owned by all Ethiopians and that every citizen is entitled to access to sufficient water of acceptable quality. Water is recognized both as an economic and a social good, the management of which should ensure social equity, economic efficiency, systems reliability and respect for norms of sustainability. The development of water resources is underpinned by rural-centred, decentralized management, an integrated framework and a participatory approach involving all stakeholders and particularly women in user communities.

Water committees are being established locally to run water schemes and to operate and maintain these. The water policy adopted in 1999 dictates that at least two out of five members on these committees must be women. Initially, the water committees were hampered by their lack of legal status but this problem is gradually being resolved. Women are participating fully in planning, implementation, decision-making and training. They are also being empowered to play a leading role in initiatives promoting self-reliance.

An ambitious programme

Within the 1999 water policy, the government has devised a 15-year Water Sector Development Programme to 2016 which came into effect in 2002. The programme has five major components: water supply and sewerage; irrigation and drainage; hydropower development; general water resources; and institutional and human capacity-building. Furthermore, vocational and technical training centres have been established to train technicians on irrigation development schemes and water supply and sanitation services. These centres have been operational since 2003. Many experienced civil engineers, economists, hydraulic engineers, irrigation engineers and other professionals are leaving the water sector however for better pay offered elsewhere in the country by NGOs, the private sector and international organizations, in the main.

With the cost of implementation estimated at US$7.5 billion, the 15-year programmme will rely heavily on foreign investment (60% of the total). Attracting international donors will therefore be a priority (see box).

The Water Sector Development Programme sets specific targets. Rural water supply coverage, for example, is to grow from 23% in 2001 to 71% by 2016. This will be achieved by digging thousands of deep and shallow wells, spring development, the rehabilitation of existing water supply schemes and livestock watering schemes. Six medium hydropower plants are to be constructed by 2016, thereby doubling per capita generation of electricity to 52 KWh/year.

In parallel, the government is establishing basin institutions. With the financial and technical assistance of international donors, an institutional study has been initiated for a "prototype" Blue Nile (Abbay) Basin authority which, if successful, could be followed by others.

This article[17] is based on a case study in the United Nations' World Water Development Report 2*,* Water, a Shared Responsibility *(see page 8). The report is freely accessible online at: www.unesco.org/water/wwap*

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15. The equivalent of US$800 in purchasing power parity

16. The national poverty line is that deemed appropriate for a country by its authorities. The national poverty line should not be used to compare countries, as it varies significantly from one country to another (UNDP Human Development *Report, 2005).*

17. The primary reference is the first draft of the Ethiopia National Water Development Report, 2004*. Also cited is the* UNDP Human Development Report 2005: International Cooperation at a Crossroads, Aid, Trade and Security in an Unequal World*. All 2001 socio-economic data are taken from UNESCO's* Education For All Global Monitoring Report 2005*, available online at: www.unesco.org/education*

The **last frontier**

Laboratory photo of one of the newly discovered bone-eating worms, Osedax frankpressi, *which has been removed from a whale bone. Normally only the red and white plumes and the pinkish trunk would be visible. The greenish roots and whitish ovary would be hidden inside the bone.* *See also page 21*

The world's ocean is amazingly rich in life and perhaps nowhere more so than in the deep sea. Here, over millions of years, species have developed unique properties to enable them to cope with extreme living conditions, such as high pressure levels[18]. It is the very uniqueness of these properties which offer exciting potential for the development of new drugs to treat all sorts of human ailments. Products based on marine organisms have already found their way onto the market and are now being prescribed to sufferers of asthma, tuberculosis, cancer, Alzheimer's disease, cystic fibrosis and male sexual impotence, among others. Other industries, such as those for oil or paper, are also bioprospecting the deep sea with promising results.

Today, there are no legal restrictions on exploring the deep sea for the purposes of research or financial gain when it comes to its living resources. In principle, it suffices to have the financial means and the sophisticated technology needed to explore a world that in parts lies as far as 11 km beneath the ocean surface. In practice, deep-sea bioprospecting[19] remains the prerogative of the "lucky few". This raises a number of questions. Firstly, as this newly discovered "blue gold" is mostly located in international waters, making it extra-territorial in international law, it can be argued that the genetic resources[20] living in the deep sea belong to humanity as a whole and therefore ought to be exploited equitably. Secondly, if we are to protect these precious resources and the ecosystems in which these are found, we shall have to exploit them in a sustainable manner.

The need to regulate the use of deep-sea genetic resources was one of the themes dealt with by a global conference last January devoted to Moving the Oceans Agenda Forward (see page 8). It was also the subject of a report published in 2005, upon which the current article is based.

Why bioprospect in the oceans?

The marine habitat is unique for the diversity of its living organisms. Of the main taxonomic groups (phyla), almost all are found in the oceans and half are exclusively marine. If bioprospecting will be crucial to improving human well-being, it is in the oceans that bioprospecting's greatest potential lies.

Examples of compounds derived from marine species or materials

Biological source	*Compound and area of application*
Cyanobacteria	Cryptophycins: anti-cancer; treatment of viral diseases
Sponges and ascidians	Bryostatin-1, ecteinascidin 743, dolastatin-10, halichondrin and spongistatin (anti-tumor); sponge derivate for treating leukemia; sponge steroid contignasterol (asthma drug)
Eleutherobia sp.	Derivatives to treat breast and ovarian cancer
Other marine organisms	Several compounds with properties that are: antioxidant, anti-fungal, anti-HIV, antibiotic, anti-cancer, anti-tuberculosis, immunosuppressant and antimalarial; compounds for the treatment of Alzheimer's disease, cystic fibrosis and impotence

Marine biodiversity is amazingly dense in certain parts of the world. In the Indo-Pacific Ocean, for example, there are as many as 1000 species per square metre. In this highly competitive and sometimes harsh environment, marine species have had to develop strategies for survival, such as resistance to the toxicity, extreme temperature, hyper-salinity and pressure that characterize the deep seabed.

We know from experience that there is a higher probability of selecting active compounds of potential interest to the health and other industries from marine organisms (or parts thereof) than from terrestrial organisms. This means that, statistically, marine organisms are of greater commercial interest than terrestrial ones.

Potentially big business

It is hardly surprising then that many pharmaceutical firms have marine departments. One could cite the examples of Merck, Lilly, Pfizer, Hoffman–Laroche and Bristol–Myers Squibb. Biotechnology companies are also interested in marine products, as the related licenses can be sold not only to pharmaceutical companies but also to industry. Nowadays, it is biotechnology companies, which tend to be small, flexible and adaptive structures, which are responsible for most of the discoveries, whereas 'big pharmaceuticals' tend mostly to license the latter.

Examples of commercial products derived from deep-sea species and materials

Company name	*Product and related properties*
Sederma	Enzymes isolated from deep-sea bacteria used in skin protection products (UV-resistant)
California Tan	*T. thermophilus enzymes* (same type of products as above)
Roche	*T. thermophilus*, *Thermotoga maritime* and other deep-seabed species which thrive at high temperatures Several DNA polymerases (a polymerase is an enzyme that builds new strands of DNA)
Diversa Corporation	Pyrolase™ 160 enzyme, used in industry to reduce viscosity; ThermalAceTM DNA Polymerase
New England BioLabs Inc.	Deep Vent® DNA Polymerase, Therminator[a] DNA Polymerase
Aquaartis	BactoScreen™, a library of extracts of some 1000 marine bacteria isolated from marine organisms and sediments with several potential applications
HyTest Ltd	*Thermus aquaticus* DNA polymerase Taq Red
Promega	Thermostable Tth DNA Polymerase[a]

Marine bioprospecting of the deep seabed is developing rapidly. An analysis of Patent Office databases reveals that several organisms have been used for commercial purposes. These inventions relate to the genomic features of deep seabed species but also encompass techniques developed to determine these features or to isolate active compounds. These techniques are not inventions, *sensu stricto*, but are nevertheless considered as such under the current international property rights regime.

Other patents deal with the isolation of enzymes important for industrial processes, the isolation of cellular compounds that guarantee unique properties (such as resistance to extreme pressure and salinity) and the discovery of mechanisms ensuring resistance to extreme temperatures and toxicity, these extreme properties being of interest for both biomedical and industrial applications.

There is no consensus on the financial benefits derived from worldwide sales of biotechnology-related products taken from all types of marine environments but these are estimated to represent a multibillion dollar market. A marine sponge compound used to treat herpes, for example, generates earnings of US$50–100 million a year; and the value of anti-cancer agents taken from marine organisms is estimated at close to US$1 billion a year.

The oddity of the deep-sea environment

What sources of energy are available to communities living in dark zones? Biochemists have long demonstrated that different forms of energy can sustain life. Light is probably the first to spring to mind, as this serves as the basis for photosynthesis (from *photo* meaning light), but methane, sulphides[21], oil, etc. are also forms of energy. Where there is no light, as in the deep sea, creatures rely on chemical energy (or chemosynthesis). The hydrothermal vents, cold seeps and methane vents we shall shortly discover are all ecosystems which depend on chemical energy.

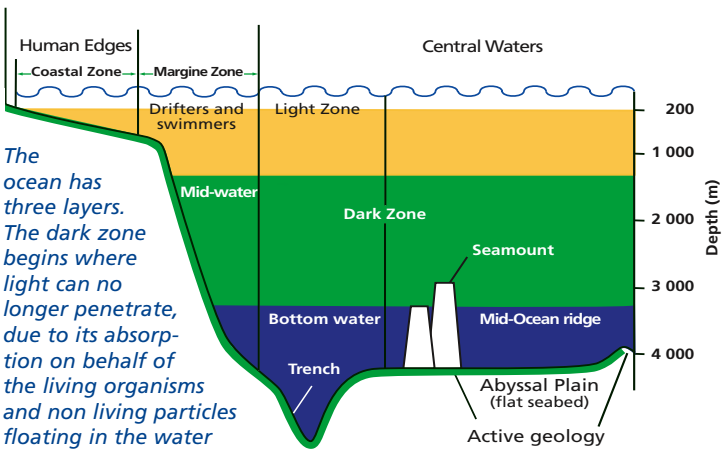
In the absence of light, life in dark waters can also depend on organic substances – dead or alive – reaching the depths of the ocean. Thus, the composition of benthic communities (the term indicates a dependency on the bottom) will rely partly on the availability of organic substances falling all the way down to the seabed. Whale bones for example are known to constitute an excellent surface on which benthic communities deprived of local sources of energy can settle and develop (see photos).

Hot vents and black smokers

Hydrothermal vents develop next to seawater which has penetrated the Earth's crust at the bottom of the ocean and been heated by magma. The seawater then flows back into the ocean through a hot vent, bringing with it mineral substances. Hydrothermal vents are thus home to communities capable of withstanding extremely high temperatures; at their source, these temperatures can be nearly as hot as 400°C, in immediately adjacent waters, they can be as hot as 120°C or more. The hottest of these vents are normally referred to as 'black smokers' but vents can also be characterized by lower temperatures (40–75°C).

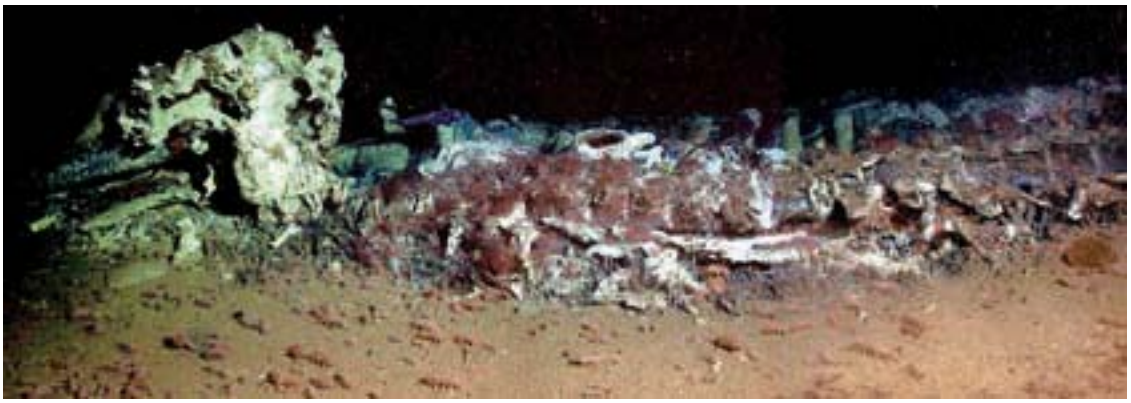
Vents are ubiquitous. They have been spotted along the Southwest Indian ridge, in the Mid-Atlantic Ridge, the East Pacific Ridge, in the Arctic Ocean, etc.

Vents are typically inhabited by a well-developed microbial community. Deep clams, worms, crabs and other macro-



The ocean has three layers. The dark zone begins where light can no longer penetrate, due to its absorption on behalf of the living organisms and non living particles floating in the water column. The light zone normally extends for a few hundred metres, depending on how 'rich' that particular part of the ocean is in 'nutrients' (mainly phosphorus and nitrogen), which form the basis for photosynthesis by marine plants, algae, dinoflagellates, etc. Thus, for example, the Sargasso Sea located off the costs of the southeastern part of North America and the Bahamas – a sea very poor in nutrients – is characterized by a deeper light zone than costal areas adjacent to large urban settings or river deltas, where organic particles and sediments hamper the diffusion of the light beyond shallower waters. Given the average thinness of the light zone in comparison with the dark zone, the ocean is essentially a dark environment

Source: Adapted from Baseline Report of the Census of Marine Life



Photomontage of the whale fall in Monterey Canyon, as it appeared in February 2002, soon after its discovery. Note the large numbers of red worms carpeting its body. The small pink animals in the foreground are scavenging sea cucumbers

organisms feed on this community, which comes at the bottom of the food chain. Both micro- and macro-organisms at vent locations can withstand extreme toxicity and pressure.

Cold seeps

Along the continental margins, other equally remarkable ecosystems can be observed. In deep soft-bottom areas, oil or gases seep out of the sediments, or water combined with lipids (fats) and other organic compounds. These complex chemical substances serve as a source of energy for the local community of micro- and macro-organisms that feed on them.

Seamounts

The deep ocean also inhabits areas that tend to be currently geologically inactive but biologically very active, namely seamounts. These impressive formations, which are millions of years old, create dynamic water circulation phenomena, as they break deep ocean currents and participate in the development of water upwelling. Seamounts form the basis of a typical community of organisms made up of cold corals, sponges and the like. They also provide a habitat for fish and other species of ecological and commercial interest, such as orange roughy, swordfish, tuna, sharks, turtles and whales. Seamounts are home to a particularly high number of endemic species.

If exploitation has only just begun of life forms found in hydrothermal vents, cold seeps and similar deep-sea formations like mud volcanoes and brine pools, the same cannot be said for seamounts. Destructive fishing methods have been used on the rich fauna of seamounts for several years now, including bottom trawling.

Marine scientific research in the deep sea

Submersibles are manned or remote-operated vehicles that can rove the deep seas for long periods. In 1977, hydrothermal vents were discovered by the submersible Alvin during an expedition along the Galapagos Rift in the eastern Pacific Ocean at depths of more than 1000 m (see photo overleaf).

Nowadays, many scientific programmes focusing on the deep seabed, its processes and the life therein are being implemented. One of these is the very ambitious Census of Marine Life Programme, whose mission is to assess and

Close-up view of a whale bone covered with O. frankpressi *worms at the whale fall in Monterey Canyon, showing their red and white plumes, which are believed to function as gills*

explain the diversity, distribution and abundance of marine life and whose efforts are in a large part devoted to studying the deep-sea environment.

A host of research-driven expeditions are taking place in the deepest parts of the world's oceans on a regular basis. Scientists have set up facilities for managing information related to deep-sea research and for exchanging this information. One example is InterRidge, a voluntary scientific initiative which seeks to facilitate cooperation among deep-sea scientists through knowledge networking, the identification of problem issues and research questions, representation of the scientific community in policy discussions and the promotion of education on deep-sea research.

In the early days of deep-sea exploration, the main motivation for marine scientific research was probably the quest for knowledge, with scientists reasoning that, on a human-dominated planet, those areas out of visual reach must hold the promise of new discoveries. Although marine scientists are not bioprospectors, it is difficult – and often impossible – to distinguish 'pure' from 'applied' marine scientific research in the deep sea.

It is probably fair to say that deep-sea research today is equally important to both pure and applied research, since the discovery of new species not only nurtures basic knowledge but is also likely to lead to the identification of new chemicals, which in turn tend to lead to new applications and new economic markets.

The blurring of the borders between pure and applied research – and public and private interests – would normally

Deep-sea scientific cruises

Many scientific monitoring programmes with at least a deep-sea component have seen the light in the last few years. Examples are:

- the European Science Foundation-sponsored EUROMARGINS Programme to improve understanding of deep-sea ecosystems like cold seeps in European seas;
- the US National Oceanic and Atmospheric Administration (NOAA) Vents Programme;
- the activities of the Japan Agency for Marine–Earth Science and Technology's (JAMSTEC) Extremobiosphere Research Center;
- the educational Black Smokers Expedition organized by the American Museum of Natural History; and
- the REVEL expedition, a teacher development programme sponsored by the US National Science Foundation and the University of Washington; this enabled scientists and teachers to conduct joint observations in the Juan de Fuca Ridge deep sea in the northeast Pacific.

Since 1992, more than 400 scientific deep-sea cruises have been undertaken by the USA, France, Japan, Germany, Canada, Russia and Portugal. From interviews with scientists active in deep-sea exploration, it would seem that scientists from other countries have participated in these expeditions.

Plans for the future include:

- an international programme on Monitoring the Mid-Atlantic Ridge (MOMAR), sponsored by the European Commission;
- the North-East Pacific Time-series Undersea Networked Experiments (NEPTUNE), which foresees the establishment of a permanent system of deep seabed multidisciplinary observations on the entire Juan de Fuca plate;
- the European Sea Floor Observatory Network (ESONET), which will undertake repeated observations in the seabed on the Atlantic and Mediterranean coasts;
- Japan's Advanced Real-time Earth Monitoring Network in the Area (ARENA) in the Japan Trench; and
- the New Millennium Observatory (NEMO), which will monitor the impact of volcanic activity on hydrothermal vents.

not be an issue, if the technology used to explore the deep sea were accessible to the majority or if the legal and policy framework regulating access to deep seabed genetic resources, and the use of these, were clear and equitable. But this is not the case.

Deep-sea technology: the prerogative of the lucky few?

Specialized research institutions in a handful of developed countries have come up with unique technologies and techniques based in part on post-war efforts from the 1950s onwards to find peaceful applications for military-based technology.

One example is JAMSTEC, located in the Tokyo Bay area in Japan. JAMSTEC has developed impressive capabilities for descending to extreme depths and operating there on a regular basis. Its fleet is composed of both manned and remotely operated vehicles that allow many deep-sea features

A remotely operated NOAA vehicle is seen here in position for hot fluid sampling at this black smoker vent. Known as ROPOS, this vehicle descends to the seafloor on a fibre optic cable from a ship. ROPOS is equipped with two manipulator arms, video cameras and lights

to be assessed from a physical, chemical and biological viewpoint. JAMSTEC has developed a device known as the Deep Bath[22] for sampling deep-sea sediments and microorganisms and maintaining them at the same levels of pressure and temperature as in their original environment, so that they can be subsequently cultivated. This is important, as creatures from the deep tend to lose their shape and functions once brought to the surface, causing them to die.

The US-based Woods Hole Oceanographic Institution has embarked on ambitious plans to develop the first unmanned vehicle to be deployed without cables. The vehicle is being designed to attain the deepest oceanic point on Earth and should be operational within the next few years.

The French Research Institute for Exploitation of the Sea (Ifremer) is studying the features of deep seabed ecosystems to understand better how to use them in oil-drilling operations. It is also studying the specific functions of deep-sea organisms.

Deep-sea research is a costly business. From interviews with deep-sea scientists and administrators, it would seem that the cost of sampling operations by a manned deep-sea vehicle down to a depth of a few thousand metres and back to the surface can be as high as US$1 million per day, excluding maintenance costs.

Although costs are steadily decreasing due to greater efficiency, reliability and simplicity in operating deep-sea equipment, they remain relatively high. If it is true that scientific collaboration has involved a non-trivial number of scientists from developing countries, these are normally visiting scientists. Moreover, developing countries lack the necessary capabilities, including in terms of knowledge and skills, to handle land-based deep-sea research, with the notable exception of molecular biology techniques, which have become increasingly available worldwide. Deep-sea research therefore remains an 'extravagance' only a handful of countries and companies can afford.

No-man's land

For the time being, living resources found in the deep seabed in international waters are in a kind of 'no man's land'.

This is because the current legal and policy regimes under relevant international legal instruments, and especially the United Nations Convention on the Law of the Sea (UNCLOS) and the Convention on Biological Diversity, do not specifically deal with the conservation and sustainable and equitable use of the biodiversity of the deep seabed.

Non-living resources – commonly known as polymetallic nodules – were thought to represent an important economic stake for the international community at the time UNCLOS was adopted in 1982 and up until recently. The International Seabed Authority was set up in 1994 to regulate these resources in the deep seabed in areas beyond national jurisdiction, a portion of the ocean bottom otherwise known as 'the Area.' The utilization of non-living resources, including in intellectual proprietary terms, adheres to the principle of 'common heritage', according to which these resources belong to all and must be regulated as such.

The same cannot be said for living resources in the deep seabed in areas beyond national jurisdiction, for which there is a clear legal and policy gap. Neither UNCLOS nor the Convention on Biological Diversity regulates the use of living resources found beyond continental shelves or Exclusive Economic Zones. (Within these Zones, the related provisions of UNCLOS, which favour essentially national interests, would apply.) Living resources in the deep seabed were unknown when UNCLOS was being negotiated. Today, the living resources present in the international water column are regulated under UNCLOS' high seas regime, which is quite liberal and permissive overall, with the exception of the adverse impact of activities carried out under State flags[23], for which countries are deemed responsible.

Alvin (pictured) has made over 4000 dives since it was built in 1964. The US Navy-owned submersible is operated by the Woods Hole Oceanographic Institution. A typical eight-hour dive takes two scientists and a pilot as deep as 4500 m. When working at maximum depth, it takes about two hours for the submersible to reach the seabed and another two to return to the surface. Alvin can hover, manoeuvre in rugged topography or rest on the bottom. Alvin's most famous exploits include locating a hydrogen bomb accidentally dropped into the Mediterranean Sea in 1966, exploring deep-sea hydrothermal vents discovered two decades ago and surveying the sunken ocean liner Titanic

The Convention on Biological Diversity adopted in 1992 applies solely to territories falling under national legislation, although the Convention does have the power to regulate activities taking place in territories beyond national jurisdiction whenever these have an adverse impact on biodiversity.

The way forward

The time has come to fill in the important legal and policy gaps described above. Some would argue that this is premature, as long as our scientific knowledge remains incomplete. That is not a valid argument. Once a serious risk of harm to the environment has been identified on the basis of the best scientific evidence available, we must act, even if this evidence is not yet exhaustive. This is known as the precautionary approach.

The United Nations General Assembly offers hope in this regard. The General Assembly has taken the responsible step of setting up an Open-Ended Informal Working Group on Marine Biodiversity in Areas beyond National Jurisdiction. The Group met for the first time last February. Let us hope that the process set up by the General Assembly will be effective and its deliberations wise, for the sake of these resources, humanity and the planet as a whole.

Salvatore Arico[24]

This article is based on a report co-authored by Salvatore Arico and Charlotte Salpin and published in 2005 by the Institute of Advanced Study of the United Nations University, entitled Bioprospecting of Genetic Resources in the Deep Seabed.
Read the report: www.ias.unu.edu/binaries2/DeepSeabed.pdf

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18. Atmospheric pressure is caused by the force of gravity. Normal atmospheric pressure is defined as 1 atmosphere (atm) at the level of the sea. In the sea, the pressure caused by the weight of the water column overhead is known as hydrostatic. This pressure increases by 1 atm with each 10 m of depth. The highest pressure is found in the Challenger Deep of the Mariana Trench in the western Pacific. It is about 11 000 m deep with almost 1100 atm of pressure

19. Bioprospecting is loosely defined as the search for compounds contained in living organisms that hold potential or actual commercial value for applications based on such compounds

20. Marine genetic resources can be defined as marine plants, animals and micro-organisms, and parts thereof, containing functional units of heredity that are of actual or potential value

21. Compounds containing sulphur but no oxygen

22. For Deep sea Baro/Thermophiles Collecting and Cultivating System (thermophiles are creatures which thrive at high temperatures)

23. Often, States use flags of convenience to register their ships in other countries and thereby benefit from the latter's fishing quotas, etc. This problem is at the heart of the issue of illegal unreported and unregulated fishing (see page 8 for details)

24. UNESCO Programme Specialist in the ecological sciences. The author wishes to thank Ms Salpin and the IAS-UNU for their indirect contribution to this article, the responsibility for which remains solely with the author

Diary

1 April
White water to blue water
Meeting of Type 2 partnership from Jo'burg Summit (2002), involving UNESCO, NGOs, industry, academia, etc., to integrate watershed, coastal and ocean management. Initial focus on wider Caribbean region. Washington DC: *www.ww2bw.org*; *c.toro@unesco.org* (in Colombia)

18–20 April
Great ape priority populations and habitats
Scientific workshop to determine criteria for list of priority populations and sites within taxa and to compile initial list across taxa. UNESCO will subsequently publish this list. Organized by UNESCO and GRASP Scientific Commission. UNESCO Paris: *kahlenb@fas.harvard.edu*

24–26 April
Boosting innovation by bridging the knowledge gap
2nd General Assembly and intl conf. of Intl Network for Small and Medium Enterprises (INSME), of which UNESCO, UNIDO, WIPO et al. are members. UNESCO University Industry Science Partnership (UNISPAR) Programme. Montevideo (Uruguay): *www.annualmeeting2006.insme.org/*

24–26 April
Ocean Data and Information Network for Africa (ODINAFRICA)
2nd seminar at IODE Project Office to review project implementation and workplans for 2006–2007. Ostend, Belgium: *m.odido@unesco.org* (in Nairobi)

24–27 April
Seismicity and earthquake engineering in the extended Mediterranean region
Workshop jointly organized by UNESCO and US Geological survey to discuss regional approaches to improving seismic data and earthquake risk mitigation. Valletta (Rep. of Malta): *www.unesco.org/disasters*

17–19 May
Strategic role of renewable energy for sustainable development of Central Asia
Regional conf. to focus intl attention on energy problems facing the rural population in Central Asia, with emphasis on Aral Sea zone (mainly Kazakhstan, Kyrgyzstan, Uzbekistan, Tajikistan, Turkmenistan and Mongolia). Co-organized by UNESCO and Govt of Kazakhstan. Almaty: *o.benchikh@unesco.org*

17–19 May
3rd Sheikh Bahai Entrepreneurship Festival
Organized by Isfahan Science and Technology Town, with support from UNESCO Tehran Office. Isfahan, Iran: *n.sadeghi@unesco.org*

5–23 June
Three marine atlases for Africa
Project launch workshop for development of atlases for coastal regions of Eastern, Western and Northern Africa. IODE Project Office in Ostend, Belgium: *m.odido@unesco.org* (in Nairobi)

19–21 June
The future of drylands (see Editorial)
Intl conf. marking 50 years of drylands research within UN. Co-organized by UNESCO, CMS, FAO, UNDP, UNEP, UNCCD, UNU, IFAD, ICSU, OSS, Govt of Tunisia.Tunis: *c.lee@unesco.org*

New **Releases**

Community-based Disaster Risk Management Toolkit for Indonesia
Developed by Yayasan IDEP (Indonesian NGO) with support from UNESCO Jakarta and UNESCO's Coastal Regions and Small Islands Platform
UNESCO and Yayasan IDEP have begun distributing this Toolkit to villages across Indonesia, after pilot testing in Bali and West Aceh. UNESCO's Jakarta office was among those which reviewed the kit and has printed 1000 kits. The programme was launched last October with government support in response to the earthquake and tsunami which devastated Sumatra on 26 December 2004. Designed for use by trainers, the kit comprises a manual, over 50 practical self-help forms, two colour posters, eight disaster comics and a community awareness leaflet. These materials cover in detail the community-based planning process to mitigate future hazards and what steps to take within a community when disaster strikes. Over the years, the Indonesian experience has shown that every dollar spent on disaster mitigation helps to save seven dollars in later disaster response and recovery. To access the kit for free: *www.idepfoundation.org/cbdm.html*; for details: *j.steffen@unesco.org*

Agora (see page 10)
Interactive, online newsletter launched on World Day for Women on 8 March by the L'ORÉAL-UNESCO For Women in Science programme. Four issues per year. The site is accessible to the general public but only community members can post comments (laureates and fellows, National Commissions for UNESCO, etc.). The first issue focuses on the access of girls and women to scientific education: *www.agora.forwomeninscience.com/agora/index.php;* To apply to join the community: *r.clair@unesco.org; egavard@dgc.loreal.com*

Technology Business Incubation
A Toolkit on Innovation in Engineering Science and Technology
By Rustam Lalkaka. UNESCO Publishing. UNESCO's Science and Technology for Development series. English only, €20.00, ISBN: 92-3-104009-X, 123 pp.
Begins by explaining what a technology business incubator is (i.e. a facility which helps selected start-ups and entrepreneurial groups to scale-up laboratory research results or their own innovations and to develop viable businesses), followed by detailed chapters on planning, implementing and operating an incubator, using concrete examples and practical information: from the initial feasibility study and business plan, through choosing a location, planning the layout and finding sponsors, to selecting managers and tenants and monitoring incubator performance. For details: *t.marjoram@unesco.org*

Water: A Shared Responsibility (see page 8)
2nd World Water Development Report, *UNESCO Publishing and Berghahn Books. Published within World Water Assessment Programme hosted by UNESCO and involving 24 UN agencies. English only, ISBN: 92-3-104006-5 and €56.00 in paperback, 600 pp. Exists also as CD-ROM for €36.00, ISBN 92-3-104007-3.*
Request a free copy of the Executive Summary in English, French or Spanish from *i.brugnon@unesco.org* (other languages pending). Download full report: *www.unesco.org/water/wwap*

Water and Indigenous Peoples
Edited by R. Boelens, M. Chiba and D. Nakashima. Knowledges of Nature 2, UNESCO Paris, 177 pp, English only.
The absence of indigenous peoples from global development processes has a dual drawback: firstly, indigenous peoples risk being left by the wayside; secondly, their impoverishment and hardship may be exacerbated by the worldwide push to fulfil the MDGs – in response to international pressure, governments may heighten their exploitation of indigenous lands and territories. Advocates a revision of international development efforts to fully embrace indigenous peoples' knowledge, values, land tenure, customary management, social arrangements and rights pertaining to water. Presented to 4th World Water Forum on 22 March. Request a copy: *sc_links@unesco.org*

For the **young**

Rashid and Dana, the Recyclers
Educational guide to resources recycling, based on the motto Reduce, Reuse, Recycle; provides statistics, relevant addresses and country-specific information. In the interests of gender balance, a younger sister has now joined Rashid, the hero of the original guide, *Rashid the Recycler*, launched in 2003 by UNESCO Doha in cooperation with Qatar's Ministry of Education. Based on the Qatari experience, Rashid and Dana plan to promote recycling in Algeria, Bahrain, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Mauritania, Morocco, Oman, Palestinian Territories, Qatar, Saudi Arabia, Sudan, Syria, Tunisia, United Arab Emirates and Yemen. UNICEF and UNEP are joining UNESCO in this Pan-Arab project. For details: *b.boer@unesco.org*

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