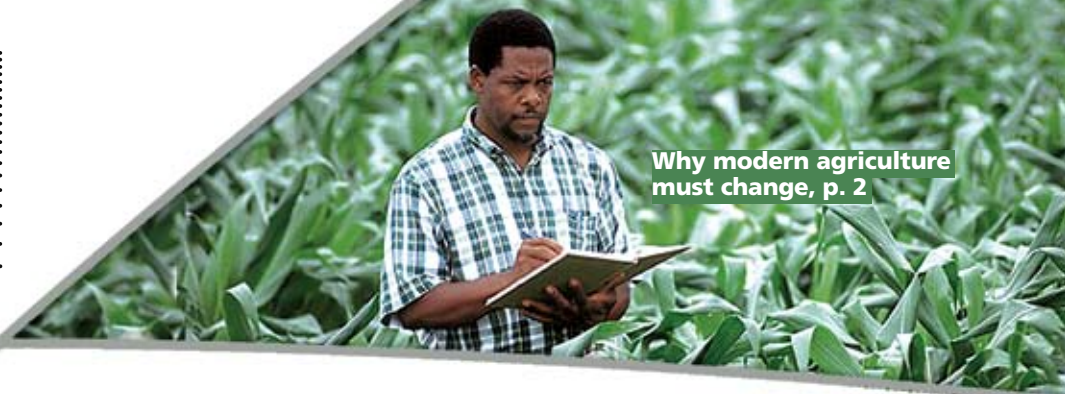




United Nations  
Educational, Scientific and  
Cultural Organization



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# A World of **SCIENCE**

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### Food for thought

**Th**anks to persistent increases in yields from modern crop varieties, the world has never produced as much food. Yet global food stocks have just hit a 25-year low. With the implacable logic of economics, these low stocks have pushed up prices: the cereal import bill of the world's poorest countries is forecast to rise by 56% over last year, according to FAO. Since March last year, soybean and wheat prices have increased by 87% and 130% respectively.

Dozens of countries are being rocked by food riots. In March alone, riots were reported in Burkina Faso, Cameroon, Côte d'Ivoire, Egypt, Ethiopia, Haiti, Indonesia, Madagascar, Morocco, the Philippines and Senegal. In Pakistan and Thailand, army troops were deployed to prevent people from seizing food from fields and warehouses. In Haiti, riots forced the resignation of the Prime Minister.

Among the factors driving up food prices is growing demand, particularly from emerging economies with ever-more mouths to feed. With meat consumption climbing, greater expanses of land are now needed to grow animal feed. But people are not only competing with livestock for food. They are also competing with biofuels, equally land-hungry. Also blamed for the crisis are escalating oil prices pushing up freight costs, financial speculation on international markets and an anomalous climate in many mostly African and Asian countries.

As the FAO food summit highlighted in June when donors pledged US\$5 billion in emergency aid, we must resolve the food crisis swiftly and efficiently. But we also owe it to the countries in need to implement the structural adjustments which will prevent such crises from becoming chronic emergencies in future. That means rethinking the way we practice agriculture and trade.

Yet positions remain divided on how to improve food security. Some developing countries are contemplating a return to food self-sufficiency, a move encouraged by French Minister of Agriculture Michel Barnier, who urges Africa and Latin America to emulate Europe's Common Agricultural Policy by forming regional blocs self-sufficient in food. Others, like US representative to the FAO Gaddi Vasquez, argue that the current mutual reliance on the global market for food is a good thing. There is a consensus that countries will have to grow more food but some seem prepared to sacrifice social well-being and the environment in the process, even though we owe the current predicament largely to this short-sighted approach.

In such a climate, the release of the first global report on the state of agriculture at UNESCO in April could not be more timely. As we shall see overleaf, the *International Assessment of Agricultural Science and Technology for Development* confirms that today's agricultural and trade practices are failing the poor and failing the environment. If we don't overhaul the way we practice agriculture, it warns, many countries may find themselves heading for environmental and social collapse.

W. Erdelen  
Assistant Director-General for Natural Sciences

# Why **modern agriculture** must change

At a time when record prices for agricultural products like rice, maize and wheat are fuelling social tensions in nearly 40 countries, a report released at UNESCO headquarters in Paris on 15 April concludes that the rules of modern agriculture must change. The report is co-sponsored by FAO, the Global Environment Facility, UNDP, UNEP, UNESCO, the World Bank and WHO.

The way the world grows its food will have to change radically to serve the poor and hungry better, if countries are to cope with a growing population and climate change while avoiding social breakdown and environmental collapse. That is the central message of the *International Assessment of Agricultural Science and Technology for Development*. It proposes a series of options for charting a new course, including greater acknowledgement of the role of the small-holder farmer, new trade rules and an 'agro-ecological' approach to farming.

The fruit of three years' work involving 400 scientists and piloted by a Bureau made up of government representatives from developed and developing countries, consumer groups, NGOs, producers, institutions and the private sector, the assessment was approved by 57 governments<sup>1</sup> in Johannesburg on 12 April. The process was first launched in 2002 by the World Bank and FAO at the World Summit on Sustainable Development in Johannesburg.



*Banana plantation in Mozambique. The indiscriminate or inappropriate use of fertilizers and pesticides in most sub-Saharan countries has damaged human health and the environment. Although extremely low in Africa, pesticide misuse is still a big concern in most countries: over 50 000 tonnes of obsolete stocks of chemicals have accumulated over the past four decades. Many of these chemicals and their containers are in poor condition and threaten to contaminate soil, water, food and air. The solution could be to combine basic training on how to use chemicals safely with the promotion of practices which reduce their use, such as the greater utilization of organic and mineral fertilizers and biopesticides, combined with more substantive solutions requiring changes to agricultural policies*

The report was originally intended to cover global food production only. Its purview was later extended to include social justice, traditional knowledge, health, gender issues and the environment. In its analysis of the state of global agriculture, the report covers such major issues as biofuels (*see overleaf Waiting for second-generation biofuels*), genetically modified (GM) crops, shrinking biodiversity, the use of traditional agricultural knowledge, tensions in trade, intellectual property rights, environmental degradation and the impact of climate change. It comes at a time of widespread riots in response to soaring food prices.

## Tensions around the table

Drafting of the report was not without its own tensions. Industry representatives did not always see eye to eye with other sectors represented in the Bureau, particularly on the issue of GM crops. Tensions peaked in October when CropLife International members Monsanto and Syngenta dissociated themselves from the assessment.

In an editorial entitled 'Deserting the hungry?' in January, *Nature* reported the spokesman for CropLife as saying that the decision to leave the table 'was prompted by the inability of its members to get industry perspectives reflected in the draft reports. One of these perspectives is the view that biotechnology is key to reducing poverty and hunger, and it is based in part on high (and rising) levels of demand for biotech crops from farmers across the developing world,' CropLife told *Nature*. But 'the idea that biotechnology cannot by itself reduce hunger and poverty is mainstream opinion among agricultural scientists and policy-makers,' the editorial commented.

Assessment team leader Robert Watson shrugged off this setback. 'I always knew it was a social experiment,' he told *Science* in March. For the former chief scientist at the World Bank, 'if we can stimulate a debate, for instance, about the degree to which agricultural science is meeting the needs of the poor and whether everyone gains from free trade, then it's a success.'

## Countries in crisis must develop self-sufficiency in food

'We are perhaps at a turning point in agriculture,' observes Guillen Calvo from UNESCO. 'After decades of inciting poor countries to develop food crops for export (cash crops) to earn foreign currency for repaying debt and other purposes, all the major development agencies are now advising these same countries to reinvest in subsistence agriculture.'

There is a growing feeling that modern agricultural practices are failing the poor. What has gone wrong? Modern crop varieties were introduced to improve crop yields and thereby reduce hunger and avoid agricultural expansion over much larger tracts of land. Modern varieties of cereals in particular, but also of root, protein and horticultural crops, have since been widely adopted. Asia grows modern cereal varieties on 60–80% of the cultivated area. They are also widely grown in Latin America. Thanks to the application of agricultural knowledge in crop and livestock breeding via genetic improvements, irrigation, improved husbandry, greater use of fertilizers, pesticides and mechanization, modern crop varieties have provided sufficient food to reduce undernourishment by half in Asia–Pacific and Latin America since 1970.

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*Olive trees as far as the eye can see for this monoculture in the semi-arid region of Andalusia in southern Spain. Horticulture, including fruit-growing, expanded by 178% between 1970 and 2004, half of the increase occurring in China (52%), 40% in other developing countries and 8% in developed countries. This makes horticulture the world's fastest-growing agricultural sector. The share of horticultural products in trade has likewise increased*

Yet, although per capita food consumption has increased, with 61% of the world population now eating more than 2730 kilocalories per day, an estimated one-third of humanity has 'not been affected by modern agricultural science.' Not everyone has benefited from the Green Revolution<sup>2</sup>. In much of Africa and East Asia for instance, countries have been slow to adopt modern crop varieties. In sub-Saharan Africa, where agriculture accounts for 32% on average of the region's GDP, overall per capita yields declined from 1970 to 1980 and have stagnated ever since. Some 30% of Africans are chronically hungry.

Yet poverty also remains endemic in countries like India, Mexico and Thailand which have embraced modern crop varieties. How is it that an estimated 43% of the rural population in Thailand – the world's biggest exporter of rice – now lives below the poverty line, even though agricultural exports grew by 65% between 1985 and 1995?

How is that, in Latin America and the Caribbean, which produces one-third of the world's transgenic crops, 37% of the population still lives below the poverty line and 10% is hungry or malnourished, despite higher yields? Why, when the planet's biggest exporter of food is blessed with abundant freshwater and vast tracts of arable land, does Latin America import much of its food, creating dependence on international markets and disrupting local production?

How is that, in India, one of the greatest beneficiaries of the Green Revolution, the number of landless rural farmers rose from 28 million to over 50 million between 1951 and the 1990s? And why does India grapple with one of the world's highest rates of child malnutrition?

The report concludes that current 'international policies promoting economic growth through agriculture do not necessarily resolve the issue of poverty.' One of the consequences of the structural adjustment policies advocated by the World Bank in recent decades, it recalls, has been the abandonment of the land by poor farmers, who can no longer afford farm inputs like the fertilizers, insecticides and pesticides which modern cereal varieties demand. The cost of these inputs is one cause of the high migration from the countryside to urban centres in search of jobs in India and elsewhere, the report observes.

Nor does liberalizing agricultural trade appear to have helped small farmers or rural communities appreciably in much of the world. Kenya for example was self-sufficient in food until the 1980s. It now imports 80% of its food, even though 80% of exports are agricultural. The report concludes that 'opening national agricultural markets to international competition before basic infrastructure and national institutions are in place can undermine agriculture, poverty alleviation, the environment and food security.'

Perhaps the most glaring example of the perverse effects of liberalized trade can be seen in Mexico. The country of origin of corn, Mexico began importing mass quantities of this foodstuff from the USA after signing the North



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*Cattle-breeding in France. The global production and consumption of livestock products have been growing dramatically in recent decades, especially in largely populated countries with fast-growing economies. Argentina and Brazil together accounted for 37% of global exports of beef in 2005, while the economic take-off in Asia, mainly in China and the Republic of Korea, is expected to generate a 22% increase in demand for beef imports over 2005. The four biggest consumers of beef are the USA, Brazil, Japan and China*

## Waiting for second-generation biofuels



First-generation biofuels consist predominantly of bioethanol and biodiesel produced from agricultural crops like maize and sugar cane. Production has been growing rapidly in recent years, primarily due to policies in support of them. The Americas are leaders in the field. Brazil produces 60% of the world total of ethanol from sugar : in 2005, production reached a record 16.5 billion litres, two million of which were destined for export.

Although biofuels hold out 'great hopes' for reducing dependency on fossil fuels, there are concerns that they are pushing up food prices and accelerating deforestation, thereby boosting CO<sub>2</sub> emissions. Research by David Pimentel and Tad Patzek at Cornell University (USA) supports the notion that 'more fossil energy is spent to produce biofuels than they provide' because of current processing methods, which would mean that biofuels actually 'create a negative balance of greenhouse gas emissions, when they were supposed to do the opposite.'

In the long term, the effect on food prices may diminish but environmental effects caused by the land and water requirements of large-scale increases in first-generation biofuels production are likely to persist.

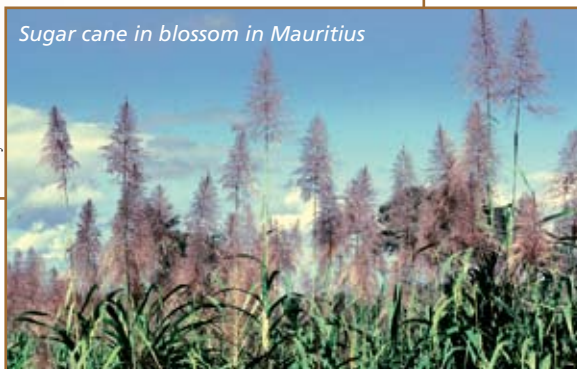
The solution could lie in second-generation biofuels such as cellulosic ethanol and biomass-to-liquids technologies, which allow conversion into biofuels [Ed.: such as the residual parts of cereal crops (husks, stems, leaves, etc) and industrial waste (wood chips, fruit pulp, etc)]. They could potentially reduce agricultural land requirements per unit of energy produced and cut back greenhouse gas emissions.

However, second-generation biofuel technologies are not yet commercially proven and their environmental and social effects are still uncertain. For example, the use of feedstock and farm residues can compete with the need to maintain organic matter in sustainable agro-ecosystems.

Bioelectricity and bioheat are usually more efficient and produce fewer greenhouse gas emissions than liquid biofuels and fossil fuels. Digesters, gasifiers and direct combustion devices can be successfully employed in certain settings, like off-the-grid areas. There is potential for expanding these applications but research is needed to reduce costs and improve operational reliability.

Source: International Assessment of Agricultural Science and Technology for Development (2008)

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Sugar cane in blossom in Mauritius

American Free Trade Agreement with the USA and Canada in the early 1990s. The subsidized US corn was more competitively priced than the Mexican corn produced locally, which created dependence on the imported corn. When the USA decided to use part of its production to produce ethanol, the diversification in markets pushed up the price of corn. As a result, the 'tortilla,' a staple food in Mexico, became unaffordable for most Mexicans, leading to 'tortilla riots' last year which were only calmed when the government imposed a ceiling on corn prices.

The Chinese government estimates that 10 million farmers will be displaced by China's implementation of World Trade Organization (WTO) rules, with the livelihoods of a further 200 million small-scale farmers expected to decline as a result of further implementations of trade liberalization and agricultural industrialization.

Even in North America, where the industrial model of agricultural production is most developed, 38 000 small farms went out of business between 1995 and 2000 in the USA and, in Canada, farm debt has nearly doubled since the 1989 Canada-USA Free Trade Agreement.

Despite the fact that some of their own members are adversely affected by current trade rules, many OECD member countries 'are deeply opposed to any changes in trade regimes or subsidy systems. Without reforms here, many poorer countries will have a very hard time...,' remarks one of the assessment co-chairs, Hans Herren.

### Sorghum versus cocoa

'There seems to be a consensus among governments that countries in crisis<sup>3</sup> are going to have to develop self-sufficiency in food,' observes Calvo. 'This is tantamount to admitting that the role of agriculture cannot be solely to earn foreign currency for reinvestment in other sectors. It is important for countries to develop strong local agricultural systems and to make better use of local and regional markets. Modern agricultural practices are based on an industrial approach which neglects the small-holder farmer, who is more and more often a woman.'

'The report observes that intensive agriculture, with its focus on crops like cotton, coffee, soybean and palm for export, has degraded the environment without making a substan-

tial contribution to poverty reduction,' says Calvo. 'We now realize that these policies favouring cash crops over staple food crops have placed countries in a situation of great dependency on imports. The assessment has helped to open our eyes to the failures and errors of the past.'

'There may be a general consensus among governments today of the need to revigorate staple food crops and/or subsistence agriculture,' adds Calvo, 'but opinions diverge on how to achieve this. The assessment proposes that we focus on small-holder agriculture, make better use of local and community knowledge and favour practices which require fewer agricultural inputs like chemical fertilizers, pesticides and insecticides. The overall aim of course is to retrieve self-sufficiency in food while protecting the environment.'

In this context, some emerging concepts and paradigms are attracting wider attention and support. The authors of the chapter on Latin America repeatedly refer to food sovereignty, for example, a term coined in 1996. This well-known, if hotly



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*Post-harvest jasmine rice depot in Thailand, the world's biggest exporter of rice, ahead of Vietnam. In May, the Prime Minister of Thailand proposed creating a cartel of rice-exporting nations to fix prices. The proposal came shortly after Vietnam underbid Thailand on a contract to supply rice to the Philippines, before announcing it would be delaying delivery to guarantee supplies for its own domestic market. The FAO has since forecast a record high for rice production in Asia, Africa and Latin America this year*

debated concept goes beyond self-sufficiency in food. Food sovereignty advocates the right of peoples to define their own food, agriculture, livestock and fisheries systems, as opposed to having food crops imposed on them to a large extent by international market forces. Food sovereignty is supported by indigenous peoples, peasants, some farmer's groups and by environmental organizations but does not find favour with economists who defend liberalized international trade.

### **Why the poor are losing out in agricultural trade**

Developed countries account for about 63% of world agricultural exports. With the exception of Australia and New Zealand, all the OECD countries provide high subsidies and tariffs (border protection) for agricultural products. These protectionist measures accounted for 45% of farm gate prices in 2000–2002. Conversely, 'developing countries as a whole reduced average agricultural tariffs from 30% in 1990 to 18% in 2000,' observes the report.

The WTO Agreement on Agriculture limits the extent to which governments may support their agricultural producers. For developing countries, the ceiling is fixed at 20%. In any event, resource constraints limit the extent to which many governments can actually support their farmers: to 2% for example in Bangladesh and 8–10% in India and Vietnam. Middle-level exporting countries like

*Fishing boats in Ghana. Fish is an important source of protein in sub-Saharan Africa, where about 10 million people make their living as small-scale fishers, processors and traders, more than what many small-scale fisheries can sustain. As climate change causes fish species to disappear from sub-Saharan Africa's 13 rivers, commercial aquaculture will grow, dominated by large producers like Nigeria, South Africa and Madagascar but with countries like Côte d'Ivoire, the Republic of Congo, Ghana and Kenya also expanding their aquaculture rapidly. Aquaculture has been the world's fastest-growing food-producing sector for 20 years and currently represents about 40% of the world's total food fish supply. Global fish production – encompassing both wild harvests and aquaculture – increased by about 230% between 1961 and 2001*

India are trying to obtain 'agreements which will maintain their own existing levels of support while reducing the levels allowed to developed countries.'

This is because small-holder farmers suffer from competition from imports that are cheaper than their own products, owing to the high subsidies on exports in OECD countries, as in the case of the 'tortilla' crisis in Mexico. To cite another example, opening up sections of agricultural markets to liberalized trade led to a 55% fall in cotton prices in India between 1996 and 2003 in the face of competing imports from subsidized producers, like those in the USA. Many destitute cotton farmers in India were driven to suicide.

Yet food price support for domestic producers to help them compete with imports from subsidized producers can have perverse effects. In the 'Green Revolution belt of Punjab Haryana in India, for example, continued minimum price support to wheat and rice continues to stall attempts at diversification,' observes the report, 'as the rates of return from assured grain prices inhibit a shift towards more risky, if higher return, crops.'

'Uniform rules on the nature and measures of support cannot be applied to developed and developing countries alike,' notes the report. 'Least developed countries are unable to match the competitiveness of larger and more complex economies. Differential market access, for given time periods, can help least developed countries benefit from international trade.' The World Bank is currently implementing a project to assess the impact of liberalization and structural adjustment strategies on rural livelihoods.

### **Agriculture severely degrading land and water**

'Although considered by many to be a success story,' Watson observes, 'the benefits of productivity increases in world agriculture are unevenly spread.' Moreover, 'we are putting food that appears cheap on our tables but it is food that is not



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## Issues in agribiotech and genetic engineering



Advances in biotechnology hold great promise for poverty alleviation and environmental protection. Polymerase chain reaction technology, for example, can be used to reduce cattle production of methane, a greenhouse gas. Grain crops can now be utilized to reduce nitrogen and phosphorus levels in animal waste. These tools can also be used to characterize indigenous animal genetic resources to understand key factors in disease resistance and adaptation and thereby further protect local breeds.

'Nevertheless,' observes the assessment, 'the impact on poverty reduction and safety of many of these technologies is currently unknown.'

### Which organisms are genetically engineered and where do they grow?

Currently, most of the commercial application of genetic engineering in agriculture comes through the use of GM crops. The commercial use of other GM organisms, such as mammals, fish or trees, is much more limited.

Genetic engineering (GE) of crops has emerged as a major agricultural technology over the past decade. Herbicide tolerance and insect resistance – the latter based on traits from *Bacillus thuringiensis* (*Bt*) – dominate the market, although GE traits come in other categories, such as pest and disease resistance, tolerance of abiotic stress (like drought), yield, nutrition and vaccines.

The four primary GM crops in terms of global land area are soybean (57%), maize (25%), cotton (13%) and canola/oilseed rape (5%), with the USA (53%), Argentina (18%), Brazil (11%) and Canada (6%) major producers. In Asia, GM cotton production occurs in smaller-scale systems in India (3.7%) and China (3.5%). Sixteen other countries make up the remaining area (4.8%) of GM crop production.

### In what form do GM crops reach the consumer?

GM crops are mostly used for extractive products (oil from soybean, starch from maize) or for processed products such as cornflakes or tortillas. Wholegrain GM maize is only consumed as food aid sent to famine areas, while some parts of GM cotton plants are used for animal feed. A great diversity of novel traits and other crop plants are under development, such as for pharmaceutical and industrial purposes. 'Their impact will need to be evaluated in the future. The main challenge here will be to keep GM pharma and industrial crops separate from crops for food.'

GM crops are only grown commercially in three or four European countries, primarily in Spain. This is because consumer demand for GM foods is 'almost non-existent' and consumers are able to avoid buying GM foods owing to the strict labelling laws in the European Union for food products. This problem does not apply to non-GM foods: 75% of cotton imported into the EU today from the USA and China are GM varieties.

### Have farmers benefited from GE crops on the land?

It is a matter of debate. GE crops have been shown to favour the establishment of large holdings and farms. Some studies indicate a lower use of insecticides, others a significant rise in herbicide use. New evidence of high insecticide use by Chinese growers of GE insecticidal crops (*Bt* cotton) has demonstrated that farmers do not necessarily reduce their insecticide use even when using a technology designed for that purpose.

Field and laboratory studies 'show a great diversity of impacts [of GM crops] on non-target organisms, including arthropods and plants.' In Latin America, for example, where *Bt* crops are grown extensively, scientists are concerned that the *Bt* toxin 'may affect beneficial insects that feed on pests that eat the *Bt* crop. There is also evidence that the pollen from *Bt* crops deposited on the leaves of wild plants around the areas planted in *Bt* crops may kill other lepidopterans that are not pests, such as the Monarch butterfly. And that the *Bt* toxin adheres to soil colloids and lasts up to three months, having a negative impact on the populations of invertebrates that help in the decomposition of organic matter.'

One controversial topic surrounds claims that GM crops reduce pesticide use and thus help to conserve biodiversity. Here again, there is contradictory

evidence. Most field studies were conducted in pesticide-intensive, large-scale monocultures like those in which 90% of GM crops are currently grown. Consequently, these results have limited applicability to low-input, small-scale systems with high biodiversity.

When *Bt* crops were introduced into farming systems which did not use synthetic pesticides, as in the case of organic maize production systems, 'there were no benefits in terms of reduced insecticide use. In fact, in comparison with insecticide-free control fields, certain non-target taxa were less abundant in *Bt*-crop fields.'

Canadian farmers are one casualty of the European aversion for GM foods. After adopting GM varieties themselves, Canadian farmers lost their market for US\$300 million of canola (oilseed rape) to GMO-free markets in Europe. Maize exports from the USA to Europe have also declined from 3.3 million tonnes in 1995 to 23 000 tonnes in 2002 'due to fears about GMOs.' The American Farm Bureau estimates this loss has cost US farmers US\$300 million per year.

### What about the unintentional spread of GM traits?

The consequences of this could be serious. In 2006, unapproved GM traits which had originated in rice field trials in the USA and China were found in commercial rice sold in European supermarkets; when imports were consequently banned, farmers in both countries suffered serious economic losses, later compounded by the cost of certifying that their crops were free from unapproved GM traits. Similar controversy followed the discovery of transgenes in landraces of maize in Mexico.

There is evidence of increased invasiveness or weediness as the result of the unintentional gene flow of GM traits, such as herbicide and insect resistance, into cultivated and wild or weedy relatives. In Canada, organic oilseed rape production in the prairies was largely abandoned because of widespread genetic contamination with transgenes or transgenic oilseed rape.

GE risk analysis has acknowledged the possibility of negative ecological effects from the deliberate or inadvertent release of transgenes into the environment through pollen-mediated gene transfer to weedy relatives of GM crops and through horizontal gene transfer. For most crops grown under regulatory approval, such as maize in the USA, the likelihood is negligible. In other cases, as for canola in Canada, low levels of transgenic DNA have entered non-GM seed supplies.

There have also been cases of the food supply being contaminated, with possible litigation ensuing against farmers for the non-intentional presence of transgenic DNA in their crops. This is likely to emerge as an even bigger issue as pharmaceuticals are introduced into crops.

Despite technical solutions to prevent such gene movement – such as limiting transgenes to the chloroplast genome not carried in pollen or the controversial terminator technology [Ed. which makes the seeds a farmer buys sterile, preventing him or her from replanting them the following season] – and traditional plant variety purity protocols, no method is likely to be completely effective in preventing movement of transgenes.

There are regulations or guidelines for risk assessment in the USA, Canada and the European Union. Some groups feel that pre-market testing for environmental risks of GM crops to non-target organisms need to follow the protocols for chemicals, such as pesticides.

The Cartagena Protocol on Biosafety was adopted under the Convention on Biological Diversity and entered into force in 2003. It is the first international agreement for the control of modern biotechnology. It applies the precautionary principle to the use and transnational movement of transgenic crops.

Source: International Assessment of Agricultural Science and Technology for Development (2008)



Soil scientist measuring maize crop growth in the USA. In North America and Europe, the amount of agricultural research funded by the private sector has grown tremendously, a factor that has largely determined the direction taken by research. Big transnational corporations thus wield considerable influence on agricultural science and its priorities

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always healthy and that costs us dearly in terms of water, soil and the biological diversity on which all our futures depend.' It is estimated that one-third of the Earth's severely degraded land has been damaged by agricultural activities.

agriculture, cereal yields are no longer increasing, despite irrigation. Crop yield increases in East and Central Asia for instance are generally below the world average, leaving most countries net food importers.



## The nitrogen dilemma

Nitrogen is vital for food production because it is an essential constituent of amino acids, proteins, nucleic acids and DNA that are vital for living cells, including plants.

Before the 20<sup>th</sup> century, the fixation of gaseous nitrogen in reactive forms which living organisms can use occurred only naturally, via a small number of micro-organisms in the soil and through lightning.

In 1918, Fritz Haber from Germany was awarded the Nobel Prize in Chemistry for combining gaseous nitrogen (N<sub>2</sub>) with hydrogen (H<sub>2</sub>) to produce reactive ammonia (NH<sub>3</sub>). Thirteen years later, his compatriot Carl Bosch would receive the same prize for devising a way to produce ammonia on a commercial scale as fertilizer. The discovery of how to convert non-reactive gaseous nitrogen into reactive forms for agriculture removed an important barrier to the rapid growth of the human population but it came at a high cost.

In some parts of Europe, North America and Asia, there is now *too much* reactive nitrogen: the excess nitrogen applied in agriculture seeps into soils and groundwater, polluting the environment. Large parts of Africa and Latin America, on the other hand, have *too little* naturally occurring reactive nitrogen and more is used by cropping than is replenished by fertilizers, causing widespread depletion of soil nutrients which hinders attempts to feed the rapidly growing population. The dilemma will be how to optimize the use of nitrogen to sustain human life while minimizing the negative impact on the environment and human health.

Source: Human alteration of the nitrogen cycle. UNESCO-SCOPE Policy Brief, No 4, April 2007: [www.unesco.org/mab/pub.shtml](http://www.unesco.org/mab/pub.shtml); for further information: [a.persic@unesco.org](mailto:a.persic@unesco.org)



*Tomato harvest. Chemical fertilizers have boosted crop yield enormously but at a high environmental cost. Nitrogen fertilizers are particularly problematic, as plants cannot absorb all the nitrogen they contain. The residue contaminates soil and groundwater, and can be carried to the coast via rivers where it causes algal blooms which deplete oxygen levels in the ocean, creating dead zones*

©Dominique Roger/UNESCO

Irrigation has had a high social and environmental cost. Entire communities have been displaced to make way for large dams and the diversion of water away from rivers, lakes, oases and other wetlands dependent on groundwater has caused salinization, channel erosion, a decline in biodiversity, the introduction of invasive species, problems of poor water quality and genetic isolation through habitat fragmentation. At the same time, it has penalized floodplain and other inland and coastal fisheries.

Salinization and water-logging of soils from inefficient irrigation is a major problem in Central and West Asia and North Africa; it affects more than half the irrigated lands in the Euphrates plains and in Pakistan. Nearly half the region's renewable water resources are below the minimum level necessary for development (500m<sup>3</sup> per person per year).

As the population grows, competition for water will intensify. Agriculture already accounts for 70% of all water consumption. The report warns that, 'under current water-use practices, increases in population and changes in diet are projected to increase water consumption in food and fibre production by 70–90%.' Add to this the anticipated effects of climate change on Africa, Asia and the Pacific and you have an explosive cocktail. Between now and 2020, the amount of water available per person in East and South Asia and the Pacific, for instance, will drop to one-third that in 1950, or even less.

The report observes that, in East and South Asia and the Pacific, the current agricultural development path is increasing pollution, 'notably from nitrogen.' Some 60% of the ecosystems are degraded or used unsustainably and nitrogen pollution from fertilizers and domestic animal waste is expected to rise (see *The nitrogen dilemma*). Without political commitment, 'the downward spiral towards socio-economic turmoil and ecological degradation may be rapid and perhaps even irreversible.'

Irrigation was essential to achieving gains from the new high-yielding, fertilizer-responsive crop varieties. Between 1961 and 2000, the area of irrigated land worldwide doubled to 277 million ha, equivalent to about 18% of farmed land. Today, two-thirds of the world's irrigated land is in Asia, where it accounts for almost 35% of cultivated land. Some 40% of world cereal production comes from irrigated land, including as much as 80% of China's grain harvest. Yet, in several Asian countries practicing intensive

## Biodiversity threatened by agriculture

One of the more insidious causes of the current food crisis is the global homogenization in eating habits. 'Many countries have abandoned their traditional foods in favour of a more Western model with its focus on a handful of cereals and a copious consumption of meat and sugar,' observes Calvo. 'This has created an enormous dependence on overseas markets. We have not yet reached the point of no return but the message is clear: if countries don't maintain a rich agricultural biodiversity, they risk a growing dependence on a shrinking choice of cereals.'

## Natural enemies

The natural enemies of pests – their predators, parasitoids and pathogens – can be used as pest control agents. Globally, the annual economic contribution by natural enemies has been estimated in the hundreds of billions of dollars worldwide.

Biological control provides natural enemies with suitable habitats and resources and limits use of disruptive pesticides. Since these approaches are locally adapted, they rarely produce products that can be widely marketed and have attracted little interest from the private sector. Yet they form the cornerstone of much ecological pest management. Practical applications include the Biologically Integrated Orchard systems of California (USA), vineyard habitat management and rice ecosystem conservation.

The importance of natural enemies is highlighted by the often explosive outbreaks of pests introduced into regions which are devoid of specific natural enemies. Dramatic early successes in the late 19<sup>th</sup> century spurred classical biocontrol efforts around the world but these methods were later displaced by the widespread adoption of cheaper, fast-acting synthetic pesticides. Confidence in biocontrol declined, until problems arising from pesticide use rekindled interest. Initially, work in developing countries focused on large-scale commercial, industrial and export tree crops with less direct impact on small-scale farmers. Subsequent programmes focused on staple food crops and on building indigenous capacity.

Biological pest control has a long history in Africa. Kenya for example managed to control the coffee mealybug (*Phenacoccus kenyae*) biologically countrywide after it appeared in the 1920s. Interestingly, the persistent use of insecticides led to resurgences in the 1950s on the larger estates but not on small-holder coffee plantations. A factory for biological control using *Bt* began production in Nairobi in 2004.



A predatory *Polistes* wasp looking for bollworms or other caterpillars on a cotton plant

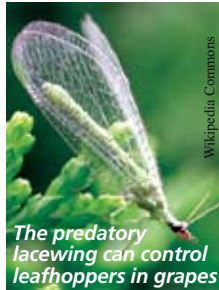
Ecologists have raised concerns about the potential impact on non-target organisms of introduced biocontrol agents. However, the safety record of invertebrate biocontrol is well-established, thanks to a substantial body of research. Moreover, there are now rigorous screening protocols and methodologies for environmental risk assessment of biocontrol agents: FAO, CAB International, BioScience and the International Organization of Biological Control have developed a Code of Conduct for the Import and Release of Biological Control Agents.

Contrary to classic biocontrol, 'augmentation' involves mass production of naturally occurring biocontrol agents to reduce pest pressure. The decentralized artisanal biocontrol centres of Cuba offer one model of low-cost production for local use. Augmentative control in Latin American field crops and throughout the European glasshouse system are other examples. Growing consumer interest has helped to establish a small but thriving biocontrol industry in industrialized countries mostly, with some uses in developing countries where pesticide use is difficult or prone to trigger pest outbreaks, as in the case of sugar cane, cotton and fruit trees.

The costs of producing, storing and distributing living organisms have made these products less attractive to the private sector than chemical pesticides; currently they comprise only 1–2% of global chemical sales. Their relatively limited use also reflects chronic underinvestment in public sector R&D and a regulatory system that disadvantages biological alternatives to chemical pesticides.

Global challenges for biocontrol include a possible growth in exotic pest problems due to globalization and climate change. Natural enemies have previously demonstrated their capacity to adapt to changing climates encountered in expanding their geographic range and to control invasive species in a safe and sustainable manner. These attributes, along with the imperative to reduce pesticide contamination of drinking water supplies, suggest that biocontrol will play a growing role in future pest management practices.

Source: International Assessment of Agricultural Science and Technology for Development (2008)



The predatory lacewing can control leafhoppers in grapes

Loss of genetic diversity represents a serious problem south of the Sahara, for example, because a number of species and crops that represent a very small part of global trade are local food staples, such as tef and yams. It is paradoxical that sub-Saharan Africa lacks micronutrient-rich foods, despite possessing an enormous potential for crop genetic resources. Ethiopia for example has 12 potentially valuable crop plants, including the vegetable okra (*Abelmoschus esculentus*) and the legume crop yeheb (*Cordeauxia edulis*).

If international trade promotes a narrow specialization in a few specific products, the development of improved varieties has similarly focused on a narrow range of cereals and animals, threatening 'discarded' varieties with extinction, despite their valuable contribution to the gene pool and their utility for the local economy.

Harmful agricultural practices, such as the excessive use of nitrogen fertilizers, inefficient irrigation or the unintended contamination of plants and arthropods by GM crops, are having a disastrous effect on biodiversity. Expanding the area covered by agriculture is another threat, as it reduces the size of natural habitats and key migration corridors.

The report cites other reasons for not expanding agricultural land. Both Africa and Latin America, it notes, have 'significant traces of undeveloped land that could be cultivated but estimates suggest that only a small fraction of these areas – 7% of Africa, 12% of Latin America and the Caribbean – are free from the types of severe soil constraints that limit profitable and sustainable production.' In addition, many of the remaining undeveloped areas are of regional and global importance for biodiversity and ecosystem services, such as the continents' tropical forests.

The monopoly control of plant genes is also a biodiversity issue. In a textbook case in May, *The Washington Post* reported that the world's agribusiness giants, BASF (Germany), Monsanto (USA) and Syngenta (Switzerland), had 'filed [about 530] applications to control nearly two-thirds of the climate-related gene families submitted to patent offices worldwide.' These GM crops have been engineered to withstand drought and other environmental stresses. According to the Ottawa-based ETC Group, an activist



body that supports subsistence farmers and whose report was cited by the newspaper, ‘the move could undermine public-sector plant-breeding institutions... which have long made their improved varieties freely available.’

‘Gene patents generally preclude the age-old practice of saving seeds from a harvest for replanting, requiring instead that farmers purchase the high-tech seeds each year,’ recalled the newspaper. It cited one BASF patent claim for a gene tolerant of environmental stress ‘which seeks to preclude competitors from using that gene’ in more than 30 of the most common crops, including maize, rice, soybean, coffee, canola and wheat.

Richard Jefferson, the founder of Cambia, a non-profit institute based in Australia that helps companies work together on patents, occupies the middle ground. ‘I don’t mind Monsanto developing these tools’, he told the *Washington Post*. ‘I mind that we don’t have an economic ecology that lets other companies compete with them.’

### Time to redirect knowledge towards preserving the ‘agro-environment’

The report calls for redirecting the wealth of agricultural knowledge and expertise the world has built up over recent decades towards strategies that combine productivity with protecting natural resources like soils, water, forests and biodiversity.



*Grinding millet in Mali. Soil moisture stress affects more than 80% of Africa’s agricultural land, limiting nutrient uptake and thus productivity. There is ample scope for small-scale irrigation and water harvesting in sub-Saharan Africa, where irrigation is rare: just 4% of arable land, compared to 35% in Asia and 15% in Latin America*

It is recommended that agricultural science place greater emphasis on safeguarding natural resources and on ‘agro-ecological’ practices. These practices include the use of natural fertilizers, biopesticides (see *Natural enemies*) and traditional seeds, the avoidance of monocultures – particularly vulnerable to outbreaks of pests and disease – and reducing the distance between agricultural production and the consumer. With food riots now also breaking out in cities, one option advocated by the report is to foster peri-urban agriculture and vegetable gardens in city suburbs. Among the advantages of peri-urban agriculture: lower transport costs meaning fewer greenhouse gas emissions and cheaper retail prices for foodstuffs, a greater use of local crops, the maintenance of green belts and job creation.

Other policy options include ending subsidies that encourage unsustainable practices like intensive agriculture and using market and other mechanisms to regulate and generate rewards for agro-environmental services. Countries could explore the potential for paying farmers who leave valuable wetlands undrained, for example, or who use forests to reduce carbon emissions. However, if farmers are to adopt sustainable practices, they will also need to be able to count on long-term land and water-use rights and tenure, as well as measures which reduce risk, such as credit and insurance schemes.

The report suggests providing incentives to promote integrated pest management and environmentally resilient germplasm management, as well as for alternative markets like those for green products, certification for sustainable forest and fisheries practices and organic agriculture, and the strengthening of local markets.

There are various interpretations of integrated pest management, from the ‘toolbox’ continuum emphasizing diverse technical and biologically intensive options – but not within an ecological framework – to integrated ‘pesticide’ management focusing on the use of lower dose, less hazardous and more selective pesticides. CropLife mentions non-chemical approaches like biocontrol but presents this option as being ‘generally

## What do we mean by agro-ecology?



Agro-ecology is a science which stems from a blend of scientific and indigenous knowledge (ethnoscience); it sets out to reduce the negative impact of conventional agricultural systems through productive diversification and the use of ecologically friendly technologies.



© S. Schlegel/UNESCO

*Wheat in Spain*

While agro-ecological methods vary and are by definition mostly site-specific, those wishing to embrace agro-ecology should adopt the following criteria:

- Use renewable sources of energy instead of non-renewable sources
- Use biological nitrogen fixation
- Use on-farm resources as much as possible
- Sustain soil nutrients and organic matter stocks
- Conserve water and use efficient irrigation systems
- Conserve genetic resources and maintain local landraces
- Manage ecological relationships and re-establish ecological relationships that can occur naturally on the farm
- Use intercropping, which entails cultivating two or more crops on the same land at the same time, and cover cropping systems. A cover crop is any crop grown to provide soil cover in order to prevent soil erosion by water and wind
- Minimize disturbance and use, for example, reduced tillage or no-till methods, to combat soil erosion from wind and water, and increase rates of water infiltration and groundwater
- Match cropping patterns to the productive potential and physical limitations of the farm landscape
- Use multiple varieties and landraces of crops and animals on farms, avoid dependence on single crops/products (monoculture) and use alternative markets
- Ensure that local people control their development and augment farmer participation
- Promote a multidirectional transfer of knowledge, as opposed to ‘top-down’ knowledge transfer, and use indigenous knowledge.



## Could European companies be starting to see farmers as partners?

As prices for raw materials soar, attitudes towards investing in agriculture may be changing in the business world. In May, the UK *Financial Times* cited Mark Lundy, senior research fellow at the Consultative Group on International Agricultural Research, as saying that 'food producers can no longer afford to ignore farmers. It used to be very much a buyers' market. Now companies have to position themselves as good partners.'

Examples in Europe include Barry Callebaut, a Swiss chocolate manufacturer which bought a 49% stake in Biolands, an exporter of organic cocoa based in Tanzania, in April. 'Biolands runs a smallholder programme involving 20 000 farmers, paying farmers for delivering beans. It also trains them and gives them seeds,' reported the *Financial Times*. Cocoa prices rose by almost 50% between September and February but, by investing in producers, Barry Callebaut gets to control part of its cocoa supply. 'We try to buy more and more cocoa directly from cooperatives or other organizations because it's giving us full control over the quality,' the company told the newspaper, which reported plans by Biolands to extend the Tanzanian project to other countries.

Meanwhile, Cadbury Schweppes plans to invest £30 million (US\$59 million) over the next decade in cocoa farms in Ghana, which provides nearly three-quarters of its cocoa. The company created the Cadbury Cocoa Partnership with UNEP earlier this year.

In Cameroon, Diageo, the British beverage group that owns the Guinness beer brand, is investing £250,000 in local farms over the next five years to encourage farmers to grow sorghum. This will enable Diageo to reduce its reliance on imported barley, the traditional ingredient in its beer. Nick Blazquez, Managing Director of Diageo's Africa business, told the *Financial Times* that sourcing raw materials locally 'reduces our need for foreign exchange, shortens our supply lines and develops our relationship with the local community.'

In Ecuador, the London-based brewer SABMiller has run into 'a land competition' with the biofuel industry. For Andy Wales, head of sustainable development at SABMiller, the company needs to develop better relationships with farmers, so that they will grow rice for SABMiller rather than maize for biofuel producers. SABMiller uses rice in the brewing process to add starch to beer. SABMiller also has several projects in Africa encouraging farmers to grow sorghum for the brewery, the *Financial Times* reported.

The Fair Trade Movement cited by the assessment could testify to the fact that ensuring poor farmers are adequately rewarded for the crops they produce can also be good business. The British branch claims to have more than 3000 certified retail products in the UK, for a retail value of £493 million in 2007.



Bags of cocoa in São Tome & Príncipe

Source: Wiggins, J. (2008) *Africa's farms reap rewards*. *Financial Times*, 7 May. UK.

too often unreliable or not efficient enough to be commercially used on their own.'

A third type of integrated pest management is based on detailed indigenous technical knowledge (ethnoscience). One example of indigenous pest management is intercropping, a method which entails cultivating two or more crops on the same land at the same time. Indigenous pest management may also tolerate weeds, insect pests and crop pathogens at times, if these provide important foods, medicines, ceremonial materials and soil improvers.

Organic agriculture is one form of integrated pest management. It avoids all use of synthetic fertilizers and pesticides. Consumers – and thus growers – are increasingly turning to organic agricultural systems. The term can be misleading, as organic does not necessarily mean agro-ecological. The production of organic bananas in some parts of Central America and Ecuador, for example, consists of large expanses of monoculture; the reason they obtain organic certification is because they do not use agrochemicals.

It is frequently stated that organic agriculture, because of its lower yields, will not be able to supply enough food to

feed the world. One controversial study<sup>4</sup> cited by the report concluded from examining 300 case studies worldwide that 'organic agriculture could produce enough food on a per capita basis to provide 2540–4380 kilocalories/person/day, depending on the model used. Based at the University of Michigan (USA), the authors also found that, 'in developing countries, organic farms outperformed conventional practices by 57%, demonstrating that intensification using organic methods is possible.'

### Going out to bat for small-holder farmers

The report judges agricultural policies which focus on supporting small farmers as being of higher priority today than technical solutions. It observes for instance that, in developing Asia, the rural–urban divide has been exacerbated both by the displacement of small farmers from land taken over for industrial use and by the emphasis on trade, which 'has led to neglect of rural development and of non-tradable sectors of the economy.'

For FAO Director-General Jacques Diouf, it is urgent to reverse the decline in the level of public resources spent on agriculture and rural development. He believes 'investments

by the private sector in agriculture and related sectors would be forthcoming if appropriate investments in public goods were put in place.' Faced with soaring prices for raw materials, some businesses in Europe seem to be jumping the gun (*see Could European companies be starting to see farmers as partners?*)

'We must produce more food where it is urgently needed,' says Diouf. 'We have to ensure that small-holder farmers have proper access to land and water resources, and essential inputs such as seeds and fertilizers to ... increase their supply response to higher prices, boost their income... and ultimately benefit consumers as well.'

### The current food crisis is a wake-up call

The paradigm shift urged by the report towards more responsible agriculture cannot be realized overnight. It will take sustained, coordinated effort on the part of the world's governments and the willing implication of the private sector. The current food crisis is a wake-up call, a warning that a sporadic food crisis could turn into a chronic crisis if nothing is done to change modern agricultural practices in the months and years to come.

'UNESCO can do its bit,' concludes Calvo, 'by encouraging farmers to diversify production styles and the foodstuffs they grow, to integrate traditional knowledge systems into agricultural practices and to use science, technology and good management practices to protect both agribiodiversity and the environment in general.'

'It is time to look beyond the reductionist image of agriculture as being no different from any other industry,' he urges. 'Perhaps we should speak instead of "agri-cultures",



©Raul Delongano/UNESCO

A farmer with his cows in the Nile Valley in Egypt



©A. Clayson/UNESCO

Taking the pig to market in Zumbahua, Ecuador

in the sense of "agrarian cultures", a term which to my mind better reflects the biological and cultural diversity of farming around the world.'

There will be an opportunity for the world's eight wealthiest countries (G8) to begin making this paradigm shift in July. For the first time in 27 years, the global food crisis will be on the agenda of the G8. Japan's Prime Minister Yasuo Fukuda will be hosting the meeting, which is expected to discuss food trade, biofuels, ways of boosting farming output and how climate change affects agriculture.

Another important rendez-vous on the international agenda will be the conclusion of the Doha round of trade talks by WTO members. However, after more than six years of stop-start negotiations marked by strong disagreements over the rules of agricultural trade, the Doha round is at a standstill. At a time when much of the world is facing an economic recession exacerbated by food and oil crises, this deadlock does not augur well for the future.

Susan Schneegans

Read the assessment: [www.agassessment.org/](http://www.agassessment.org/);  
for details: [s.arico@unesco.org](mailto:s.arico@unesco.org); [g.calvo@unesco.org](mailto:g.calvo@unesco.org)

1. Armenia, Azerbaijan, Bahrain, Bangladesh, Belize, Benin, Bhutan, Botswana, Brazil, Cameroon, China, Costa Rica, Cuba, Dem. Rep Congo, Dominican Republic, El Salvador, Ethiopia, Finland, France, Gambia, Ghana, Honduras, India, Iran, Ireland, Kenya, Kyrgyzstan, Lao PDR, Lebanon, Libyan Arab Jamahiriyah, Maldives, Moldova, Mozambique, Namibia, Nigeria, Pakistan, Panama, Paraguay, Philippines, Poland, Rep. Palau, Romania, Saudi Arabia, Senegal, Solomon Islands, Swaziland, Sweden, Switzerland, Tanzania, Timor-Leste, Togo, Tunisia, Turkey, Uganda, Uruguay, Vietnam, Zambia. Three governments did not fully approve the Executive Summary of the Synthesis Report: Australia, Canada, USA
2. On the Green Revolution, see A World of Science, October 2006
3. **Africa:** Burundi, Central African Republic, Chad, Congo, DRC, Côte d'Ivoire, Eritrea, Ethiopia, Ghana, Guinea, Guinea Bissau, Kenya, Lesotho, Liberia, Mauritania, Sierra Leone, Somalia, Sudan, Swaziland, Uganda, Zimbabwe – **Asia:** Afghanistan, Bangladesh, China, Iraq, Korea (DPR), Nepal, Sri Lanka, Tajikistan, Timor Leste, Viet Nam – **Latin America and Caribbean:** Bolivia, Dominican Republic, Ecuador, Haiti, Nicaragua **Europe:** Moldova (Source: FAO)
4. Badgley<sup>1</sup>, Catherine et. al. (2007) *Organic agriculture and the global food supply*. In *Renewable Agriculture and Food Systems*: 22: 86–108: <http://journals.cambridge.org> (Cambridge University Press)

## Concern for health of Aral Sea's residents

**The Government of Uzbekistan hosted an international conference in Tashkent on 11 and 12 March on the disturbing impact the Aral Sea's ecological problems are having on the gene pool of both the human population and flora and fauna in the region.**

The region has been highly dependent on water for centuries because cattle breeding and crop cultivation are traditional livelihoods. The rapid development of irrigation systems over the past 40 years has overstretched the ecosystem however, driving climate change, desertification, salinization and water-logging.

This has in turn curbed biodiversity and eroded fertile land. With freshwater polluted by cotton fertilizers, pesticides and salt, and with sand and salt storms becoming more frequent, chronic diseases like tuberculosis are on the rise. According to some reports, lung disease, cancers and infant mortality are 30 times higher than in the past.

The conference also explored opportunities for fostering sustainable socio-economic development in the region through joint projects with international partners. In this connection, Olcay Ünver, Director of the Global Water Assessment Unit at UNESCO and Coordinator of the World Water Assessment Programme involving 24 UN agencies, signed a Letter of Cooperation with the Government of Uzbekistan for the preparation of case studies on the Aral Sea.

The German Ministry of Education and Research (Bundesministerium für Bildung und Forschung, BMBF) has been cooperating with UNESCO's Division for Science



©Kristen Kienzler/ZEF

*Woman picking cotton in the Urgench District of Khorezm Province in Uzbekistan. During the Soviet Era, vast tracts of former desert were put under cultivation to produce cotton, a thirsty crop. Farmers were encouraged to use more water and dangerous amounts of pesticide and fertilizer*



©UNESCO

*The Aral Sea, seen here in 1989 (right) and 2003 (far right), was once the world's fourth-largest lake. Today, it is just one-quarter its size half a century ago. In a last-ditch restoration effort, Kazakhstan used World Bank funding in 2003 to build a dam (above) separating the smaller, less polluted, salty northern Aral Sea from the southern part, deemed irretrievable. This construction was recommended by UNESCO consultant Professor Nikolai Aladin from the Institute of Zoology at the Russian Academy of Sciences, within the framework of the UNESCO-BMBF project. Since completion of the dam in mid-2005, the northern Aral Sea has been filling up more rapidly than expected. Once again, people can fish in the Aral Sea*



Source of satellite images: NASA

Policy and Sustainable Development since 1992 on two consecutive projects to help the countries around the Aral Sea assess and mitigate damage to the Sea's ecosystems.

The first project from 1993 to 1999 got under way after BMBF asked UNESCO to manage a scientific research programme to support and network 140 Kazakh, Uzbek, Turkmen and Russian scientists working on 20 sub-projects related to the problems of the Aral Sea. The payment of stipends, coupled with the cost of equipping three existing research centres and setting-up new ones in Kazalinsk and Muniak in the northern and southern deltas of the Aral Sea, called for BMBF funding totaling US\$ 1.2 million.

The second project is ongoing. It was developed by the Centre for Development Research at Bonn University (ZEF) in Germany, in close cooperation with UNESCO and Urgench State University in Uzbekistan. It aims to provide sound, science-based policy recommendations for moving towards sustainable land and water resource management in Khorezm Province in Uzbekistan, while at the same time improving rural livelihoods by making agriculture more efficient.

The idea is to devise a science-based plan for restructuring three interlocking actors in resource management: policies, institutions and technologies. The project blends applied scientific research with the restructuring of management to support the development of informed, consistent agricultural policies at national and regional levels. These policies will then be implemented by the restructured institutions. At the level of technical management, integrated technology packages in land and water use will be introduced.

During the current project phase, which kicked off in 2006, the integrated concept developed by science policy experts for restructuring land use is being tested in real-life situations on farms and at institutions in Khorezm and Tashkent.

BMBF plans to wind up the project in 2010. By this time, it will have invested a total of US\$10 million in the Aral Sea projects over close to two decades.

*On the UNESCO-BMBF project: [v.moustafaev@unesco.org](mailto:v.moustafaev@unesco.org); [www.unesco.org/science/psd/thm\\_innov/aral/aral.shtml](http://www.unesco.org/science/psd/thm_innov/aral/aral.shtml); see also: [www.aralconference2008.uz/](http://www.aralconference2008.uz/) (English and Russian)*

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## A global forum takes to the frontlines of climate change

**In response to the outcry over the continuing absence of vulnerable groups from international debates on climate change, UNESCO's Coasts and Small Islands platform and Local and Indigenous Knowledge Systems programme launched an Internet-based discussion forum on 12 June.**

The forum has been launched in partnership with the Secretariats of the Convention on Biological Diversity and United Nations Permanent Forum on Indigenous Issues, as well as the Office of the High Commissioner for Human Rights.

The Frontlines forum will explore the experiences of rural or indigenous communities living in small islands, the circumpolar Arctic, high-altitude zones, low-lying coastal areas, tropical forests, desert margins and other vulnerable environments. For many people, climate change is a distant threat but, for vulnerable communities, it is already a reality. Effects being felt by small islands, for example, include sea-level rise, storm surges and the consequential salinization of vital freshwater reserves and agricultural lands.

Rural, indigenous or island peoples are also keen observers of the impact of climate change. Confronted over the ages with repeated environmental change, many have built up a rich body of knowledge and skills which allow them to adapt to new situations. This knowledge can be crucial for debates on the impact of climate change and adaptation strategies.

In Sachs Harbour in Canada's western Arctic, Inuit are already using their detailed knowledge of animals and environmental change to modify their hunting and travelling practices in response to climate change. They now hunt polar bears earlier in the year than before and fish through the ice on different lakes and for a shorter duration in spring. Seals are being hunted more often from boats in open water, due to a lack of ice floes. Many Inuit are confident in their ability to cope with climate change, partly due to distinct philosophies which embrace rather than resist uncertainty and change.



*In the Arctic, Inuit have proved adept at adapting to climate change. Coastal sea ice is increasingly preferred to inland routes for travel in the spring, for instance, to avoid bare ground and unreliable snow cover which make progress on snowmobiles laborious. Those travelling overland have forged new trails and routes to avoid slumps, mudslides and erosion caused by permafrost thaw*

Despite their specific vulnerabilities, adaptation strategies and knowledge, indigenous peoples continue to be excluded from debates on climate change. They have voiced their frustration at this, notably through protests on 7 December last year at the United Nations conference in Bali (Indonesia) and at the most recent session of the United Nations Permanent Forum on Indigenous Issues in May 2008 in New York (USA).

On 28 March, small island states delivered a clear message on their plight when the Maldives government tabled a resolution on human rights and climate change to the United Nations Human Rights Council on their behalf. The resolution was adopted by consensus.

The Frontlines forum will explore all of these issues, heightening the profile of vulnerable communities in international debates while providing a platform on which communities can share their experiences. The forum will operate in English, French and Spanish, with possible expansion into other languages in the future. Participants will receive new postings and highlights of discussions via email.

*To participate in the forum: [links@unesco.org](mailto:links@unesco.org); the debates can also be followed at [www.climatefrontlines.org](http://www.climatefrontlines.org)*

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## Better preparation for storm surges is possible

**Nineteen days after tropical cyclone Nargis left more than 100 000 dead or missing in Myanmar, UNESCO's Intergovernmental Oceanographic Commission (IOC) and WMO convened a joint press conference in Geneva (Switzerland) on 21 May to recall the urgency of improving storm surge warning systems in zones threatened by tropical cyclones.**

A tide gauge installed by the IOC in Moulmein had detected a storm surge on 2 May of about 1.5 m. Farther west where the storm made landfall, the Myanmar report of a surge of more than 3 m was corroborated by a WMO mission on 15–18 May. Whipped up by strong winds, storm surges can cause water to pile up above normal levels along the coast and lead to severe inland flooding

Mangrove forests can act as a buffer but, on parts of Myanmar's coast, they have been converted to agricultural land and fish ponds. FAO's Forestry Department estimates the mangrove area in the severely hit Ayeyarwady Delta, the country's rice basket, to be less than half its size in 1975.

The Joint WMO/IOC Committee on Oceanography and Marine Meteorology is currently preparing a *Guide to Storm Surge Forecasting* – for storm surges can be detected hours, even days ahead. But in order to warn populations at risk, the right data have to be available, such as high-resolution topographic and bathymetric charts, in order to model these phenomena and draw up risk maps, notably of flooding. These elements are lacking in a number of coastal states, including Myanmar.

Warning systems like the Indian Ocean Tsunami Warning System, in which Myanmar participates, could serve as a model for reducing the impact of storm surges, as the two phenomena have points in common.

*For details: Tsunami Warning System: [p.koltermann@unesco.org](mailto:p.koltermann@unesco.org); [www.ioc-tsunami.org](http://www.ioc-tsunami.org); on storm surges: [k.alverson@unesco.org](mailto:k.alverson@unesco.org)*

## Network gets **name-change**

**The World Academy of Young Scientists has changed its name to the World Association of Young Scientists (WAYS), after a consultation of members. The decision took effect on 1 April.**

WAYS was launched by UNESCO in 2004 as follow-up to the World Conference on Science (1999). Ever since, it has worked to empower young scientists worldwide under the age of 40. Over time, it has become apparent however that the word 'Academy' can be misleading, as it suggests a more select membership. The change to 'Association' is intended to reflect better the network's social dimension.

Today, WAYS has more than 3000 members originating from more than 120 countries and is growing daily, despite the difficulties in maintaining and developing such a diverse and extended network on a shoe-string budget – WAYS is run by a small team of volunteers.

WAYS has developed a website which serves as a social and professional support network of, and for, young scientists, most of whom struggle to obtain the information and support they need to further their career, regardless of their discipline and geographical location. Many also fail to earn the recognition they deserve for their skills and achievements.

'Such a window on the world seems to be particularly appreciated by our members based in Africa,' comments WAYS President Gaell Mainguy, 'where WAYS is the first network of young scientists across the continent. This no doubt explains why one-third of our members are African.'

After registering online, new members are each given a space in which to display their curriculum vitae and current interests, as well as a personal blog through which to express themselves. Other collaborative tools enable them to share information, post and search for jobs and meetings, seek advice, meet like-minded people and so on.

'WAYS is a social network, a kind of scientific Facebook', smiles Mainguy. 'We help young scientists keep in touch via Internet. In doing so, we are also providing institutions everywhere with a 'catalogue' of fresh faces in science and engineering, at a time when disaffection for careers in science has somewhat inverted the age pyramid.'

Established networks can be hosted freely by the WAYS portal and are attributed their own space. The Permafrost Young Researchers Network was launched during the current International Polar Year, for example, to recruit, retain and promote future generations of permafrost researchers. It is hosted by WAYS.

Other complementary platforms include the Young Professionals' Platform for Agricultural Research for Development, founded by a WAYS member from India, and the World Lecture Project launched by WAYS members in Germany; this online library of more than 700 video lectures in any language and from any scientific field provides scientists and research institutions with an international platform for publicizing their lectures.

But WAYS is much more than a virtual network. 'Through its African regional office, WAYS has expanded from the virtual into the real world', explains Mainguy. 'In March this year, the Scholar Ship Research Institute and WAYS organized a capacity-building workshop for young African scientists in Cape Town (South Africa). Participants from 14 different countries learned about Open Source software applications and Open Access databases to help their wider dissemination in Africa.'

*For details: [www.ways.org](http://www.ways.org); [d.malpede@unesco.org](mailto:d.malpede@unesco.org); [www.world-lecture-project.org](http://www.world-lecture-project.org); <http://pyrn.ways.org/>; [www.ypard.org/](http://www.ypard.org/); on the launch of WAYS, see *A World of Science*, April 2005*

## A fond farewell to a **carbon-based biped**

**Sir Arthur C. Clarke has died at his home in Colombo (Sri Lanka) at the age of 90. The British science fiction writer, who passed away on 19 March, will perhaps be best-remembered for his four-part Space Odyssey saga. The first two novels – 2001: A Space Odyssey and its sequel 2010: Odyssey Two – went on to become blockbuster films.**

Arthur C. Clarke was also an intuitive scientist. As a radar specialist during the Second World War, he advanced the idea in a paper published in 1945 that geostationary satellites would make perfect relays for telecommunications. His idea was realized 25 years later, earning him numerous awards. Yet it was only after the war that he could afford to attend King's College in London, where he earned a first-class degree in mathematics and physics in 1948.

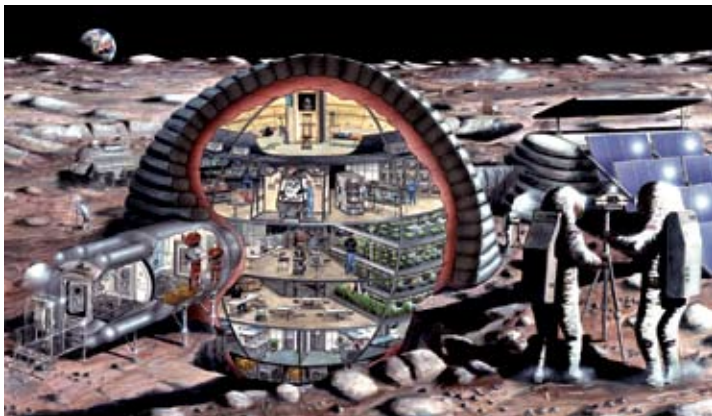
In 1962, Arthur C. Clarke won UNESCO's Kalinga Prize for the Popularization of Science. In his acceptance speech, entitled *Greetings, carbon-based bipeds!*, he regretted that 'many scientists, I am sorry to say, still look down on science fiction and lose no opportunity of criticizing it.' Yet Clarke opined that the 'chief value [of science fiction] is inspirational rather than educational... A careful survey would, I believe, reveal that science fiction is a major factor in launching many youngsters on a scientific career... Perhaps we science fiction writers sometimes show foresight without wisdom, but at least we undoubtedly do have foresight, which may rub off onto the community at large.'

Today, several American inventors would agree with him. They freely admit to having been inspired by a futuristic

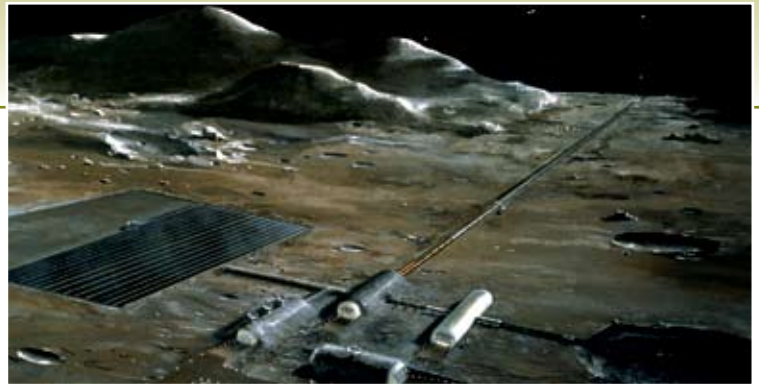
television series, *Star Trek*, which aired from 1966 to 1969. The series followed the adventures of the crew of the starship Enterprise, whose mission was ‘to explore strange new worlds, to seek out new life and new civilizations.’ Marty Cooper, a chief engineer at Motorola who invented the first mobile cellular ‘phone, admits to having been inspired as a child by one of the gadgets used by the crew, a cordless ‘communicator’ capable of voice recognition. There was also a doctor aboard the Enterprise, who specialized in non-invasive diagnostics and scalpel-free surgery. Non-invasive body scans like Magnetic Resonance Imaging and Computerized Axial Tomography are common features now in hospitals. More recently, former *Star Trek* fan John Adler, a brain surgeon, invented the Cyberknife, a computer-controlled robotic device that uses a laser beam to remove cancers without the slightest incision<sup>5</sup>.

Clarke’s most famous novel, *2001: A Space Odyssey*, published in 1968, was itself a case of scientific fact following science fiction. ‘In the novel,’ he said, ‘the spaceship Discovery flew on to Saturn using Jupiter’s gravitational field to boost it on its way. Precisely this “perturbation manoeuvre” was used by the Voyager spacecraft<sup>6</sup> eleven years later.’

The first Space Odyssey novel was published a year before the first human set foot on the Moon, at a time when ‘argument was still raging about the nature of the lunar surface.’ The story begins shortly after the discovery of a mysterious crafted black monolith buried deep in a lunar crater. The monolith has been dated at 3 million years by scientists working at the international Clavius research base on the Moon. ‘What you are now looking at is the first evidence of life beyond the Earth,’ one character tells another.



*This is not an illustration from one of Arthur C. Clarke's novels but rather the pictorial representation of one of several NASA studies in preparation for a possible lunar expedition by 2020. 'A 16-m diameter inflatable habitat like the one depicted here could accommodate the needs of a dozen astronauts living and working on the surface of the Moon', explains NASA. 'Depicted are astronauts, a base operations centre, a pressurized lunar rover, a small clean room, a fully equipped life sciences lab, hydroponic gardens (not needing soil), a wardroom, private crew quarters, dust-removing devices for lunar surface work and an airlock'. In 2001: A Space Odyssey, Arthur C. Clarke had imagined his own team of 1700 male and female scientists living on the Moon. At Clavius base, 'the atmosphere was purified in a ...large, circular room buried just below the lunar surface. Under blazing lamps by night, and filtered sunlight by day, acres of stubby green plants grew in a warm, moist atmosphere. They were special mutations, designed for the express purpose of replenishing the air with oxygen and providing food as a by-product'*



*This painting illustrates another NASA-funded study worthy of an Arthur C. Clarke novel. 'One possible approach to developing industry in space is to use Moon soil as a source of raw materials,' observes NASA. 'Lunar soil contains many major elements which provide the basis for industry and life on Earth. A base being constructed to supply lunar materials to chemical plants in space is depicted here during the second day of construction. These four large horizontal cylinders contain the base habitat, maintenance facility, soil-packaging plant and loading facility for the lunar mass driver, which is in effect an electromagnetic cannon designed in this particular scheme to eject 4-kg packages of lunar soil from the Moon to a point in deep space where the packages will be collected then transferred to a chemical plant nearer the Earth. The solar cell array being deployed will be used to power the base and mass driver. Some 25 persons would work four months to put the large base in place. An operating crew of 10 persons would stay on the lunar surface to provide necessary maintenance'*

Clarke wrote a sequel in 1982. ‘For more than a decade... I indignantly denied that any sequel was possible’, he said later, ‘but the brilliant success of the Voyager missions changed my mind; distant worlds about which absolutely nothing was known when Stanley [Kubrick, the film-maker] and I started our collaboration [in 1964] suddenly became real places, with fantastic surface conditions. Science fiction could now be made far more convincing by scientific fact.’

Clarke also wrote non-fiction books on the technical aspects and implications for society of space flight. He worked with scientists and engineers in the USA to develop spacecraft and addressed the United Nations during its deliberations on the Peaceful Uses of Outer Space. Today, the geostationary orbit 36 000 km above the equator is named The Clarke Orbit by the International Astronomical Union. NASA has dubbed the robotic spacecraft orbiting planet Mars *2001 Mars Odyssey*, in tribute to Clarke.

Just weeks before his death, Sir Arthur – he was knighted in 1998 – delivered a poignant audio message from Colombo to those attending the Global Launch of the International Year of Planet Earth at UNESCO in Paris on 12 and 13 February. Recalling that space science has given us a new perspective on our planet and its beauty, he evoked the need for us to restore our strained relationship with the Earth and expressed his great wish that the world would ‘kick its current addiction to oil’ and instead adopt clean energy sources.

For details: [clarkefoundation.org](http://clarkefoundation.org); Greetings, Carbon-based Biped!: [www.unesco.org/science/psd/news/news08/main08.shtm](http://www.unesco.org/science/psd/news/news08/main08.shtm)

5. From How William Shatner changed the World. History Channel, USA
6. NASA launched the two Voyager spacecraft in 1977 to tour the outer Solar System. About every 175 years, Jupiter, Saturn, Uranus and Neptune are aligned geometrically in such a way as to minimize the trip time and energy required to tour all four; a factor which defined the launch date. The gravity-assist technique then reduced the flight time from Earth to Neptune from 30 to 12 years: Voyager 2 encountered Uranus in January 1986 and made its closest approach to Neptune in August 1989. Contrary to initial expectations, the spacecraft are still out there and may ‘last’ until 2020. The Voyagers owe their longevity to three radioisotope thermoelectric generators which produce electricity from the heat generated by the natural decay of plutonium dioxide. Source: University of California Riverside/NASA

# Andrea Mantesso

## Teeth will help to shape the future of stem cell research



**L'ORÉAL–UNESCO Fellow Andrea Mantesso has just returned to her post as lecturer in the School of Dentistry at the University of São Paulo in Brazil, after spending two years in the Department of Craniofacial Development at King's College in London (UK), under the supervision of Prof. Paul Sharpe. She has used her fellowship to investigate the origins and locations of stem cells on adult and baby teeth. Her ultimate goal is to be able to manipulate these cells one day to treat oral diseases like tooth decay and to engineer new tissues with a broad range of applications. These include the treatment of craniofacial deformities like cleft palate and syndromes which cause disabilities, such as Oral–Facial–Digital syndrome. These conditions can cause sufferers much distress and discomfort; they may also affect their ability to eat, breathe and communicate, depending on the severity of the condition.**

### What are stem cells?

Stem cells are non-differentiated, immature cells that, under certain conditions, can develop into specialized types of cells with specific functions. Stem cells can be found in most multicellular organisms and have two special properties: they are able to renew themselves and can form other tissues.

This means that they can be grown and transformed into specific cell types, such as muscle, bone or skin. Stem cells taken from the patient's or another person's bone marrow, for example, can be stored in a stem cell bank before being transplanted into a patient whose chemotherapy treatment for cancer has destroyed his or her own bone marrow. After transplantation, the bone marrow stem cells will start to proliferate, forming new bone marrow in the patient and, in many cases, saving his or her life. Bone marrow is composed of many different types of cell and the transplanted stem cells are capable of forming all of these.

There are two broad types of mammalian stem cells: embryonic stem cells, found in the blastocyst of an embryo 4–5 days after fertilization, and adult stem cells, found in many different adult tissues. Whereas embryonic stem cells can form all 220 cell types found in the adult human body, adult stem cells exist in low numbers and form fewer tissues.

After 20 years of research, there are still no approved treatments or human trials using embryonic stem cells because these cells need to receive very specific signals to form the right kind of tissue, a highly complex process that is still not totally understood. Moreover, when injected into animals, embryonic cells can form tumours. Consequently, despite their potential, embryonic stem cells still require further research.

Adult stem cells are rare and less potent than embryonic stem cells but they have been used successfully for many years to treat bone cancer and blood cancers like leukemia, through the bone marrow transplants I mentioned earlier. In addition, the use of adult stem cells in research and therapy is less controversial than embryonic stem cells, since isolating adult stem cells does not involve the destruction of an embryo.

In recent years, many researchers have admitted that stem cell therapy can dramatically change the way we treat human diseases. In future, stem cells will be able to treat many conditions that are extremely expensive for the health-care systems of countries around the world. These conditions include paralysis caused by a spinal chord injury, different types of cancer, diabetes, muscle diseases and degenerative neurological diseases like Parkinson's.

### Where do you find adult stem cells in the human body?

The two main known sources are bone marrow and the umbilical cord through which a mother nourishes her unborn child. The umbilical chord produces only rare stem cells and these can only be obtained once in a lifetime, when the umbilical cord is severed after the baby's delivery. As for the stem cells from bone marrow, isolating these is an intricate procedure.

Recently, it was discovered that adult stem cells also reside in many different tissues in our body and that they are related to the normal reparative and regenerative process after an injury. They may also trigger some human diseases, including cancer.

### Is donor–host rejection of stem cells not also a danger?

A patient's immune system perceives transplanted tissue as a foreign body. It will consequently attack and eventually destroy the transplanted cells, causing the death of the patient in some cases. The only way to overcome immune rejection is to find a perfect match but this often exists only between identical twins.

All other patients in need of a transplant will have to take immuno-suppressive medication daily for the rest of their lives to avoid rejection of the graft. This medication can cause many side-effects, including a predisposition to infection. However, when stem cells are taken from the patient's bone marrow prior to the start of therapy then later transplanted back into the body, the problem of immune rejection does not arise.

Another possibility is the use of embryonic stem cells. In this case, scientists can replace the DNA of embryonic cells with the



DNA of the patient's cells, making them a perfect match. Known as therapeutic cloning, this process is technically very complex and expensive.

**On 29 May, Brazil's Supreme Federal Court voted by a narrow margin to uphold the country's biosafety legislation dating from 2005, which allows research on embryonic stem cells. Which other countries allow this kind of research?**

Embryonic stem cell research has divided the international community. Part of the European Union permits it for example, including Denmark, Finland, Greece, the Netherlands, Sweden and the UK, whereas other members prohibit it, among them Austria, Germany, Ireland, Italy and Portugal. In the USA, federal funding of embryonic stem cell research is restricted but private donations are allowed and some of the country's 50 state governments also support it. In South America, all but Brazil have banned embryonic stem cell research. The same is true of Africa, where this time South Africa is the exception to the rule. In Asia and Australia, only some procedures are permitted.

In Brazil, researchers may only use embryos created by *in vitro* fertilization, in other words embryos which have been cultured outside the human body in a laboratory. The embryos used in research have already been frozen for three years and would be discarded if not used for this purpose.

Although Brazilian legislation is still restrictive compared to that of other countries, the Supreme Court's decision nevertheless opens up many possibilities for research.

*Oral-facial-digital syndrome is a generic name for a variety of genetic disorders resulting in malformations of the mouth, teeth, jaw, facial bones, hands and feet. This patient is undergoing dental treatment at the Special Care Dentistry Centre at the University of São Paulo in Brazil, under the supervision of Prof. Marina Magalhaes*



**What is the link between adult stem cells and teeth?**

A few years ago, scientists discovered that potent cells reside in teeth and could provide a convenient source of adult stem cells. We all naturally lose our baby teeth in childhood. Similarly, our permanent dentition is incredibly easy to access – it suffices to make a routine visit to the dentist.

These cells have been isolated from the dental pulp of both baby teeth and permanent teeth, from the tissues around the teeth which fix them to the jawbone – known collectively as the periodontium, these tissues include the gums and cementum – and from a small area outside the root.

Many studies have since shown that dental stem cells can form new tissues to repair damaged tooth structures and that they can even form bone, cartilage, fat and neural tissue. This raises hopes for other applications for dental stem cells, including bone regeneration, treatments for injuries to neural tissue and degenerative disorders.

**Why is it so hard to turn stem cells into other cell types?**

It is true that the differentiation of a stem cell into a different cell type is a complicated process requiring specific cell-culture conditions. To use a metaphor, it can take a long time to find a recipe which works; we have to identify the right 'ingredients' and the right 'dose' of each in order to tell our cells that they need to form another cell type. To complicate matters, there is not one recipe but several: the ingredients and dosage vary from one cell type to another. To simplify, if we want to form bone, we need to add ingredients A, B and C to our stem cell cultures but, if we want to form nerves, we need to add ingredients D, E and F.

Of course, research is still necessary to perfect the recipe for inducing dental stem cells to form the tissue we want in a controlled manner. This was why I focused my research at King's College in London on identifying the origins and locations of stem cells on teeth. Once we know exactly where these cells are to be found and where they come from, we shall be able to isolate them from the bulk of cells that form a tooth. This will facilitate the manipulation of these cells without interfering with the others, making our results more reliable and consistent.

**Which applications are looking the most promising?**

Although it is early days yet, some promising results have already been published in specialized journals about the uses of dental stem cells in conjunction with other stem cell types. A few craniofacial structures have been engineered which have the potential to correct craniofacial deformities caused, for example, by the removal of a tumour, or which are associated with a genetic condition like cleft palate. Examples of craniofacial structures which have been engineered so far include the upper part of the lower jawbone (mandibular condyle), the calvarial bone in our head and parts of the upper jawbone (maxilla).

Experiments have shown that some populations of dental stem cells are capable of regenerating the structures that form the crown and root of a tooth. In addition, various elements of the periodontium have been engineered, including the periodontal ligament and cementum. This represents a new paradigm for the future treatment of two of the most prevalent diseases in the world: dental decay and periodontal disease.

Adipose tissue – more commonly known as fat – has been engineered *in vivo* from adult stem cells. The tissue engineered from these stem cells has potential applications in facial plastic and reconstructive surgeries.

In an animal model, a biotooth was constructed by an international team of scientists in 2006, using a root as a scaffold on which to grow (plate) different populations of dental stem cells in the lab. The tooth was then implanted in the bone of a mini-pig's mouth. After a few weeks, the cells formed a normal tooth. This experiment has opened up a whole new perspective for dental implants using cells instead of metal.

Interview by Susan Schneegans

See: [www.forwomeninscience.com](http://www.forwomeninscience.com); [www.unesco.org/fellowships](http://www.unesco.org/fellowships)

# A last call to arms

The editorial in the previous issue of *A World of Science* recalled the deadline of 13 May 2009 for countries wishing to submit information on the outer limits of their legal continental shelf, under Article 76 of the United Nations Convention on the Law of the Sea (UNCLOS<sup>7</sup>). The editorial stated that, in order for the submission to be endorsed by UNCLOS, the position of the outer limits of the continental shelf needed to be accompanied by geoscientific proof of the natural extension of territorial land into the sea.

Given the economic potential of offshore oil and gas and the tremendous resource which bioactive natural products from the deep sea represent, it is hardly surprising that most coastal states around the world are doing everything they can to meet this deadline. This article is for those coastal states which have yet to submit the requested information. It may be a departure from the standard fare the journal serves to readers but the imminence of the deadline — and the riches at stake — amply justify it. The strategy that follows for making a submission has been drafted by UNESCO's Intergovernmental Oceanographic Commission and UNEP/GRID-Arendal, a Norwegian NGO established in the town of Arendal by the Norwegian Ministry of Environment, as a 'last call to arms.'



Photo: Chad Teer/Wikipedia Commons

Offshore oilrig in the Gulf of Mexico

This latest extension in the jurisdiction of member states advanced by Article 76 of UNCLOS is unique in human history. It provides for the largest transfer of sovereign rights of the greatest store of planetary resources to States Parties of UNCLOS without recourse to conflict.

The Convention provides State Parties with the right to explore and exploit natural resources on the seabed beyond 200 nautical miles from defined baselines, as long as certain physiographical and geological criteria are met.

As an example, studies of offshore regions around Africa by marine experts estimate that the seabed area passing the test of appurtenance (*see box for definition*) varies between 750 000 km<sup>2</sup> and 1 000 000 km<sup>2</sup>. Since we are entering an era of diminishing natural resources on land and looking increasingly towards the oceans to provide us with these

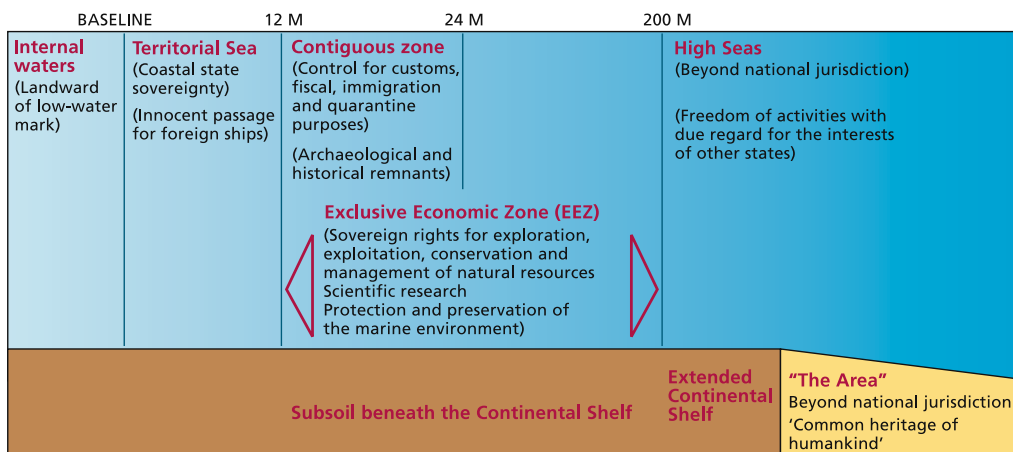
same resources, it is important that current administrations ensure that the rights of future generations are not lost because of a lack of initiative today.

## What are the advantages for a state in defining the extent of its offshore jurisdiction?

According to UNCLOS, there are two distinct coastal rights in relation to the seabed: the Exclusive Economic Zone (EEZ), which refers to the area beyond and adjacent to the territorial sea, from 12 to 200 nautical miles from the coast, and the Continental Shelf covering the seabed and the subsoil of the submarine areas.

It may happen that the same geographical area has two different legal regimes. As Professors R. Churchill and A. Lowe put it, 'while a continental shelf exists *ipso facto* and *ab initio* and therefore need not be claimed, an EEZ must always be claimed.' It is essential for coastal states wishing to exercise their rights and jurisdiction over natural resources to define baselines and their EEZ.

Having maritime spaces and boundaries that are well-defined and internationally accepted is a pre-requisite for global and regional peace and security that is the overriding goal of the United Nations



This figure illustrates the different legal regimes for the various maritime zones adjacent to coastal states (M = nautical mile)

Charter. This privilege carries with it a responsibility to conserve and sustainably utilize the living and non-living resources within the EEZ and to protect and preserve the marine environment from pollution. The regulations governing the EEZ also give other member states the right to safe navigation and the opportunity to conduct marine scientific research in these waters.

The main motivation for extending a country's offshore jurisdiction to 350 nautical miles, or beyond under certain circumstances, from the baselines from which the territorial sea is measured, is the potential resources contained therein. While the continental margin possesses both living and non-living resources, it is at present the potential for

finding non-living resources that is the main stimulus for governments to determine these outer limits properly in accordance with Article 76 provisions.

Although some states might earn more revenue from harvesting sedentary species, such as crabs and oysters, from the seabed than from mining, in global terms the value of hydrocarbons and minerals far exceeds the value of sedentary species. Moreover, it is important to mention that sovereign fishing rights in the water column are limited to the EEZ. Future advances in extraction methods are expected to put many of the currently inaccessible seabed resources within reach. Also, there may be resources (living and non-living) out there that

## How to get started

The basic flowchart for a coastal state preparing a submission to the Commission on the Limits of the Continental Shelf (CLCS<sup>8</sup>) is described in various documents of the Commission. The process can be summarized in three steps; the first two are described in detail, as these are the relevant ones for member states struggling to get the process started.

### Step 1: test of appurtenance

On receipt of an official request from a member state, via a letter or e-mail to [Morten.Sorensen@grida.no](mailto:Morten.Sorensen@grida.no), UNEP/GRID-Arendal can provide access to public marine geoscientific data and technical support that may allow the state to determine whether it is eligible to extend its seabed territory beyond the 200 nautical mile limit in accordance with Article 76 criteria. This test of appurtenance is a crucial first step in a state's decision whether or not to pursue the required technical work for completing a submission.

### Step 2: desktop study and project planning

The member state has now determined that it needs to submit information on the outer limits of the continental shelf to the CLCS. It is time to conduct a desktop study and plan the project. Upon request from a member state, UNEP/GRID-Arendal can provide technical training and mentoring through in-country workshops for decision-makers. It can also provide the national geoscientific experts with technical support and play an advisory role for the desktop study. For its part, the UNESCO-IOC can provide important support by identifying, where possible, the relevant heads of organizations in advanced leadership programmes.

The following tasks, outlined in collaboration with the programme on implementing UNCLOS of the German Federal Institute for Geosciences and Natural Resources (BGR) should be part of a thorough desktop study leading to a sound submission.

#### Task 1

Compile all relevant existing data, including that on bathymetry, reflection and refraction seismic data for sediment thickness interpretation, sound velocity in the seabed sediments for sediment thickness calculation, magnetics, gravimetry, seafloor samples and drillings. This should include an assessment of the quality and relevancy of these data for the submission. Copies of the data should be acquired, where possible, as opposed to a simple search.

#### Task 2

Describe relevant framework conditions, including legislation and disputes. Answer the following queries in detail:

- ✓ Have maritime zones and baselines/points already been officially declared?
- ✓ Are these in accordance with UNCLOS regulations or do they need to be revised?
- ✓ Evaluate current baselines/points: should they be revised in order to gain sovereignty over larger maritime areas, such as via defining 'archipelagic baselines'?
- ✓ Which maritime borders with neighbouring states have already been defined and which have still to be negotiated? What is the status of any negotiations and/or disputes?

#### Task 3

Conduct a geoscientific review providing an overview of the geology and geophysics of the continental margin and the implications for submission.

#### Task 4

Elaborate a strategy for the submission based on existing data and having passed the test of appurtenance.

#### Task 5

Identify the need for additional data based on the gaps in data coverage, in order to meet the conditions for submission to the CLCS. Elaborate a survey plan and assess costs for additional data acquisition.

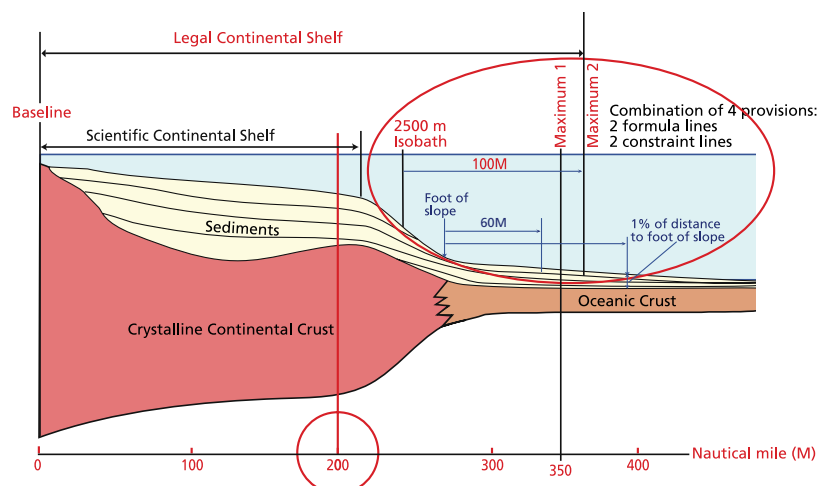
#### Task 6

If necessary, describe needs in terms of the hardware, software and personnel capacities required to carry out the pending tasks that will wind up the submission. Examples are geophysical data that may still need to be acquired then interpreted, or the submission documents that may need to be elaborated further.

### Step 3: preparation of the submission

The tasks included in the desktop study and the preparation of the submission may require the services of a consultant if all the required expertise is not available in the state's different administrations and public services. Member states preparing to make a submission will be in a position to approach the CLCS independently for clarifications and advice.

This example of the outer limit of the continental shelf is based on a combination of the 1% sediment thickness formula and the 100 nautical miles from the 2500 m isobath constraint. Here, an isobath can be defined as an imaginary line connecting all points which are the same depth on the seafloor. The figure also illustrates an example of the relationship between the legal continental shelf, defined through the use of the rules and constraints defined by Article 76, and the geologic configuration of a passive margin



do not seem important now but which might become very valuable in the future. All these marine resources are limited and therefore need to be managed in an effective and sustainable manner.

### The tools for defining a state's offshore jurisdiction

Article 76 entitles coastal states to extend their jurisdiction to 'the seabed and subsoil of the submarine areas that extend beyond its territorial sea throughout the natural prolongation of its land territory to the outer edge of the continental margin.' This is the definition of the legal continental shelf; it extends either to the outer edge of the continental margin or to 200 nautical miles in cases where the continental margin does not extend that far.

Paragraphs 4–6 of Article 76 provide the practical tools for delineating the outer limits of the continental shelf through two formulae: an extension either to a point 60 nautical miles beyond the foot of the slope or to the point where the sediment thickness equals 1% of the distance to the foot of the slope, whichever is further offshore. These distances are constrained by two lines: either (i) a distance of 350 nautical miles from the baseline, or (ii) 100 nautical miles seaward from the 2500 m isobath, whichever is larger but always within the region defined by the formulae for extension. Special cases are land masses (including islands) from which submarine elevations and ridges extend offshore. Provisions exist under Article 76 for these land masses in terms of constraints.

### There must be the necessary commitment

This article is intended to raise awareness of the steps to follow to ensure a submission is delivered on time. However, preparing the submission will require good coordination, quick decision-making and the commitment of resources from member states in terms of funding and/or experienced, skilled personnel, to make sure that the submission contains accurate, complete information. Where such expertise does not exist within a member state, it will have to build this up internally and use the services of suitable consultants.

## The member state's role

The establishment of the outer limits of the continental shelf has profound implications for the sovereignty of the coastal state and therefore needs to be driven and controlled by the state. In this sense, the country team tasked with preparing the submission can reserve the right to call upon additional national or foreign expertise, including from the UNEP shelf programme, BGR and UNESCO-IOC. The country team may offer counsel, such as by assisting in the preparation of the Terms of Reference, and participate or review the desktop study.

Once the desktop study is finished, the team of national technical experts should sit down with the political team – which normally oversees its work –, together with the consultants involved in preparing the desktop study and decision-makers at the highest level. The meeting should review the implications of pursuing the different lines of evidence in terms of planning and budget and decide on the state's strategy for the definitive preparation of the submission.

Ehrlich Desa<sup>9</sup>, Morten Sørensen<sup>10</sup>, Joan Fabres<sup>10</sup>, Yannick Beaudoin<sup>10</sup>, Joannes Berque<sup>9</sup>, Patricio Bernal<sup>9</sup>, Tina Schoolmeester<sup>10</sup> and Aurora Mateos<sup>9</sup>

7. Unless a new resolution is adopted by the 18th meeting of States Parties to UNCLOS on 13–20 June 2008

8. See for example [www.un.org/depts/los/clcs\\_new/commission\\_documents.htm#Documents](http://www.un.org/depts/los/clcs_new/commission_documents.htm#Documents)

9. UNESCO-IOC

10. UNEP/GRID-Arendal

# A city making the **switch to healthy sanitation**

Ghana's capital has a fluctuating migrant population of about 2 million, two-thirds of whom live in slums. With the population growing at the rapid rate of 4.3% a year, the city's services are being stretched to the limit, including those for water and sanitation.

With the world currently not on track to meet the Millennium Development Goal of halving the proportion of those without access to proper sanitation by 2015, the United Nations has sounded the alarm by declaring 2008 International Year of Sanitation.

Meanwhile, the UNESCO-IHE Institute for Water Education in Delft (Netherlands) has made sanitation the focus of a research project called Sustainable Water for Tomorrow's Cities (SWITCH) involving a consortium of partners from 15 countries. Funded by the European Commission and coordinated by the Institute, the project is designing sustainable urban water management systems for 10 cities around the world. One of these cities is Accra.<sup>11</sup>

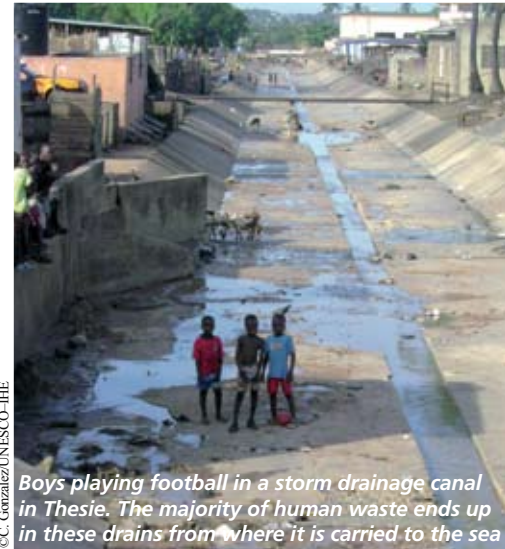
Currently, just half of Accra's population is connected to the regular water supply network. This forces people to rely on secondary sources like water tank operators. 'The urban population's poor access to a proper water supply and sanitation, high losses in the distribution network, polluted water resources and the low rate of cost recovery for water supply services are major problems', explains Frederick Tettey, a Ghanaian student doing research at Kwame Nkrumah University of Science and Technology (KNUST) on the financial and social feasibility of various strategies to improve sanitation. 'But the most burdensome is poor sanitation in slum areas.'

Fewer than 5% of households are connected to the city sewerage network and only 18% of the population has access to basic sanitation. According to the 2000 population

census, one in three households in Ghana uses public conveniences, owing to the absence of toilet facilities in their homes. Most city drains are uncovered and frequently become clogged with human waste. These open drains are supposed to serve as storm drains but have instead become receptacles for solid, liquid and human waste, exacerbating health problems and large-scale pollution of the environment. Cases of cholera (*Vibrio cholerae*) and other diarrhoeal diseases are not uncommon.<sup>12</sup>

## Providing every citizen with flowing water

The government has put together a multistakeholder platform to improve living conditions in Accra. Today, the platform involves more than 20 key partners in Accra:



Boys playing football in a storm drainage canal in Thesie. The majority of human waste ends up in these drains from where it is carried to the sea

©C. Gonzalez/UNESCO-IHE



©C. Gonzalez/UNESCO-IHE



Thesie is one of the oldest neighbourhoods in Accra. It is home to 200 000 people, most of whom live on less than one dollar per day. Their homes have no toilets or piped water supply. Tanks deliver water to the homes and the inhabitants relieve themselves either in the public toilet or in the storm water drainage system. This public toilet in Thesie (right) is used by around 700 people per day who pay a small fee for maintenance

research institutes, city councils and several ministries, NGOs and water organizations and utilities. The poor also participate in the platform through the NGOs, which have an extensive network in poor neighbourhoods and on city councils. The platform will facilitate the scaling-up of successful experiences, including those devised by SWITCH.

The platform has already come up with an integrated plan for the city which fixes some ambitious targets to 2030. These include providing every inhabitant with an uninterrupted water supply, recycling 50–80% of waste, ensuring that 80% of citizens pay for waste collection and other sanitation services, a 70% reduction in the incidence of water-borne diseases and providing sanitation facilities that 100% safe.

The strategy for meeting these targets is still being developed. Although financing the plan will pose a problem, the British, Dutch and German governments have been supporting the Ghanaian water sector for years and are likely to be willing to continue. Ghana should also be able to count on extra revenue from soaring oil and gold prices.<sup>13</sup>

**Waste not, want not**

One of the projects contributing to Accra’s plan to 2030 is SWITCH. It is testing eco-sanitation principles, natural systems for wastewater treatment and improved irrigation practices. In Accra, the UNESCO-IHE Institute for Water



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*This eco-san toilet separates faeces (back) and urine (front) into two distinct compartments, making the treatment of waste easier and less costly. Studies have shown that the nutrients from human urine can be used to grow enough food to feed a person for a day*

Education is working with Wageningen University, also based in the Netherlands, KNUST and the International Water Management Institute in Ghana.

The concept of eco-sanitation considers urine, faeces and waste water as being resources which contain valuable nutrients such as phosphorus and nitrogen, as well as humus, that can be returned to the soil as a low-cost natural fertilizer. Separating urine and faeces in the toilet and avoiding mixing them with water also prevents water sources from being contaminated with pathogens and undesirable nutrients.

SWITCH is studying the feasibility of installing eco-toilets in Accra. Six eco-toilets have been tested on a small scale at Valley View University for the past two years and have come through with shining colours. If they now prove to be economically efficient and are accepted

by the population, they will be installed in public toilets in Thesie, one of the oldest neighbourhoods in Accra. The city is in contact with a Dutch organization for the provision and funding of at least 20 eco-toilets for Thesie. This would reduce the pressure on the sewerage system and the cost of wastewater treatment.

Another line of research being followed by SWITCH uses natural wetlands for wastewater treatment. There is a large modern biological treatment plant in Accra but it is unable

*An Accra farmer in his field. This particular plot is situated between a high voltage power station and a polluted river. Farmers use water from the river to irrigate their crops. In order to reduce the levels of pathogens and bacteria, they let the recovered water decant for two days in simple sedimentation ponds. The hot sun kills the pathogens, which then sink to the bottom of the pond. Most small farmers in Accra do not own the land they till. As they can be evicted at any time, they are loath to invest in irrigation systems. Those who are evicted look for another spot in the city close to a source of water and recommence farming*



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*An estimated 60 000 street food vendors ply their trade in Accra, selling fruit and vegetables or providing ready-made meals of banku, fufu and rice at the unbeatable price of US\$0.02 a serving. They generate a combined annual turnover of US\$100 million but also offer a valuable service to the poor. The meals are usually safe for consumption but are still vulnerable to contamination either directly from dirty water or indirectly, if the vegetables have been grown in fields irrigated with dirty water and fertilized with animal faeces (Source: Mawusi Afele, WHO Bulletin, October 2006)*



A truck discharging wastewater into the overloaded compost and landfill station in Thesie. The water which arrives here doesn't receive any further treatment

to cope with the high demand and there are no funds available for building new wastewater treatment plants in the short term. The existing plant can only handle about 8–10% of Accra's inner city wastewater from domestic and industrial sources. A further 10% of Accra's wastewater is collected for some form of treatment. The remainder (80%) is discharged untreated into open drains, wetlands and natural channels where it finds its way to the sea.

Ongoing research at the Kpeshie Lagoon – a natural catchment west of the city limits – shows that the lagoon may be able to purify grey water. Grey water refers to water used in the home, with the exception of toilets. 'Both natural and constructed wetlands are able to purify water because of their ability to filter suspended solids, degrade organic substances and take up nutrients from the water', explains Professor Esi Awuah from KNUST. In wetlands, the right combination of soil and plants can transform or remove pollutants or micro-organisms through biological or chemical processes. Wetlands can be less expensive to build than other water treatment options and the operating and maintenance costs are low.



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### Taking the risk out of eating vegetables

According to university studies, nearly 200 000 Accra residents consume a portion of raw vegetables watered from polluted sources every day. As the city's vegetable plots rely on wastewater from streams and drains for year-round cultivation of exotic vegetables, many of the vegetables sold at market are contaminated with pathogens.

Within SWITCH, a number of techniques are being tested in the suburb of Djorwulu to reduce health risks, in collaboration with the farmers concerned and the Ministry of Food and Agriculture. These methods include drip

irrigation, sedimentation ponds and the filtration of solids. Drip irrigation minimizes the use of water and fertilizer by allowing water to drip slowly to the roots of plants or onto the soil through a network of valves, pipes and tubing. 'If these methods prove as effective as we expect, they will be extended to the 1000 farms operating in Accra,' explains Liqa Rashid, Senior Researcher at the International Water Management Institute. 'In five years' time, the food consumed in the city will be much safer.'

### Confidence in the future

Two years into the SWITCH project, the focus has steadily 'switched' from research to expanding the activities described above in order to involve a greater number of players in the government's multistakeholder platform for Accra.

Future items on the city's agenda include an advocacy campaign to raise public awareness of the need to pay for water services and avoid polluting open water or wasting water. The population will also be advised on personal hygiene, such as hand-washing after using the toilet and before handling food, or on why it is important to wash vegetables in clean water. The city also plans to provide training in sanitation practices and water management via workshops and seminars to ensure that it is able to call upon skilled labour.

'In 2030, the scenario is for a city facing serious water and sanitation-related challenges but with confidence in its ability to meet them,' explains Bertha Darteh, the SWITCH city facilitator who is responsible for coordinating the project in Accra. 'Citizens can be confident that their urban water system is managed in a holistic manner, with the participation of all parties, including the poor.'

Cristina Gonzalez<sup>14</sup>

For details of SWITCH: [www.switchurbanwater.eu](http://www.switchurbanwater.eu);  
[k.vairavamoorthy@unesco-ihe.org](mailto:k.vairavamoorthy@unesco-ihe.org);  
[c.howe@unesco-ihe.org](mailto:c.howe@unesco-ihe.org)

On the International Year of Sanitation:  
[www.unsgab.org](http://www.unsgab.org); <http://esa.un.org/iys/>;  
[www.worldwaterweek.org](http://www.worldwaterweek.org)

11. The other cities are: Belo Horizonte (Brazil), Alexandria (Egypt), Beijing (China), Chong Qing (China), Hamburg (Germany), Tel Aviv (Israel), Lodz (Poland), Zaragoza (Spain), Birmingham (UK). SWITCH involves 32 partners in all, some of whom come from Colombia, Peru, Greece, the Palestinian Territories and Switzerland
12. Ghana reported 1650 cases of cholera to WHO in Accra and other parts of the country in 2005 and twice the number a year later
13. In 2006, Ghana's gross national income (PPP) amounted to US\$28.4 billion. External debt represented US\$3.2 billion and official development assistance US\$1.2 billion. Total debt amounted to 63% of GDP (2005)
14. Communication Officer at the UNESCO-IHE Institute for Water Education : [c.gonzalez@unesco-ihe.org](mailto:c.gonzalez@unesco-ihe.org)

## Diary

## 1 July

**Science, technology and innovation policy: a key to sustainable development**

Ministerial roundtable 8:30-9:50 am organized by UNESCO at UN Economic and Social Council (ECOSOC) meeting 30 June-3 July. UNESCO Director-General to chair. New York (USA): [m.el-tayeb@unesco.org](mailto:m.el-tayeb@unesco.org); [www.unesco.org/science/psd](http://www.unesco.org/science/psd)

## 1-4 July

**Science, higher education and innovation policy**

Policy forum organized by UNESCO's Regional Bureau for Science and Culture in Europe. For ministers, parliamentarians, academics, universities, research funding bodies from Southeast Europe. The focus will be the Lisbon Strategy. Budva (Montenegro) [veniceoffice@unesco.org](mailto:veniceoffice@unesco.org); <http://portal.unesco.org/venice>

## 8-10 July

**International Platform for Reducing Earthquake Disaster**

2<sup>nd</sup> session of platform involving UNESCO etc to share lessons learned from recent massive earthquakes and discuss action plans.

Paris (France). [t.imamura@unesco.org](mailto:t.imamura@unesco.org)

## 8-11 July

**International Polar Year**

Open Science conf. co-sponsored by SCAR and IASC. Global Ocean Observing System to co-convene session on Polar Observing Systems. St Petersburg (Russian Fed.): [k.alverson@unesco.org](mailto:k.alverson@unesco.org); [www.scar-iasc-ipy2008.org/](http://www.scar-iasc-ipy2008.org/)

## 17 July

**ODINAFRICA**

3<sup>rd</sup> symposium and exhibition of Ocean Data and Information Network for Africa. Open attendance. Mombasa (Kenya): [m.odido@unesco.org](mailto:m.odido@unesco.org)

## 6-14 August

**International Geological Congress**

Themes include: early life and survival of the fittest; climate change: past, present and future; geohazards and human behaviour; mineral resources in a fast-growing economy; the energy race: what will be the future energy mix? Oslo (Norway): [www.33igc.org](http://www.33igc.org); [secretariat@33igc.org](mailto:secretariat@33igc.org); [r.missotten@unesco.org](mailto:r.missotten@unesco.org); [m.patzak@unesco.org](mailto:m.patzak@unesco.org)

## 18-31 August

**Summer school**

To assess biodiversity and growth behaviour of Amazonian floodplain forests. Contribution to UNESCO's Ecohydrology Programme by Institute for National Amazonian Research (INPA, Brazil)-Max Planck Project (Germany) with Institute of Sustainable Development (Tefé, Brazil): [wittman@mpch-mainz.mpg.de](mailto:wittman@mpch-mainz.mpg.de)

## 25-29 August

**Disaster and risk**

Intl Conf. under UNESCO patronage. Davos (Switzerland): [www.idrc.info](http://www.idrc.info)

## 15-18 September

**Hydro predict '2008**

Intl conf. on predictions for hydrology, ecology and water resource management: using data and models to benefit society. Prague (Czech Republic): [a.szollosi-nagy@unesco.org](mailto:a.szollosi-nagy@unesco.org); [karel.kovar@mnp.nl](mailto:karel.kovar@mnp.nl); [www.natur.cuni.cz/hydropredict2008/](http://www.natur.cuni.cz/hydropredict2008/)

## 15-19 September

**Marine information management**

IODE Group of Experts. 10th session. Oostende (Belgium): [p.pissiersens@unesco.org](mailto:p.pissiersens@unesco.org)

## 30 September

**Deadline for nominations**

for biosphere reserves, MAB Young Scientists Awards and Michel Batisse Award for Biosphere Reserve Management. MAB National Committees to submit. Download nomination form for biosphere reserves: [www.unesco.org/mab/BRs/off/Doc.shtml](http://www.unesco.org/mab/BRs/off/Doc.shtml); for awards: [www.unesco.org/mab/bursaries/home.shtml](http://www.unesco.org/mab/bursaries/home.shtml); queries: [mab@unesco.org](mailto:mab@unesco.org)

## New Releases

**Livestock in a Changing Landscape**

UNESCO-SCOPE-UNEP Policy Brief n°6. Exists in English, 6 pp. Nearly 30% of the Earth's terrestrial ice-free surface is devoted to livestock production, while 8% is devoted to the production of crops directly consumed by people. Global meat production tripled from 47 million to 139 million tons per year between 1980 and 2002. Current meat production is expected to double by 2050 to meet rising demand. As livestock production shifts to more intensive systems, it will place more pressure on arable land for the production of feed. Download: <http://unesdoc.unesco.org/images/0015/001591/159194e.pdf>

**Man and Nature. Making the Relationship last**

L. Garnier (ed.). UNESCO-MAB. Technical Notes 3-2008. English and French, 140 pp. Put together by specialists working with the French MAB national Committee. Examines new trends in biodiversity conservation in a world where nature and humankind cohabit. Themes explored via short case studies, debates and articles include biodiversity and business, green corridors and the development of artificial ecosystems, such as the recreation of wetlands in Camargue in France. Download: <http://unesdoc.unesco.org/images/0015/001584/158417e.pdf>

**Dialogue in Biosphere Reserves****References, practices and experiences**

M. Bouamrane (ed). UNESCO-MAB. Technical Notes 2-2007. English and French, 80 pp. Provides guidance on the implementation of the recommendations contained in the Seville Strategy and the Statutory Framework adopted by the UNESCO General Conference in 1995, on dialogue and concertation with a view to encouraging the exchange of knowledge and experience among biosphere reserves in the World Network for mutual benefit. Request a copy from [m.bouamrane@unesco.org](mailto:m.bouamrane@unesco.org); or download : [www.unesco.org/mab/pub.shtml](http://www.unesco.org/mab/pub.shtml)

**Links between Biological and Cultural Diversity**

Report of the international workshop organized by UNESCO with support from The Christensen Fund in September 2007. English only. The myriad links between cultural and biological diversity are increasingly viewed as key elements in achieving sustainable development and the Millennium Development Goals. Download: <http://unesdoc.unesco.org/images/0015/001592/159255E.pdf>

**Policy Document on the Impact of Climate Change on World Heritage Properties**

UNESCO World Heritage Centre. Bilingual English/French, 32 pp. Targets principally World Heritage decision- and policy-makers. Offers guidance on synergies with other international conventions and organizations, research needs, legal issues and mitigation of emissions by the World Heritage Community. Download: <http://unesdoc.unesco.org/images/0015/001598/159881m.pdf>

**Enhancing Science Policy and Management in South Eastern Europe - Science and Technology Statistics and Indicators Systems**

By Tiago Santos Pereira. Science Policy Studies Series. UNESCO's Regional Bureau for Science and Culture in Europe (Venice). English only, 86 pp. Presents the results of a pilot study which consists of two main deliverables: an analytical report on the state of the art of production of science and technology statistics and indicators in Albania, Bosnia & Herzegovina, Bulgaria, Croatia, FYR of Macedonia, Montenegro, Romania and Serbia; and a project proposal for future activities. Based on a series of fact-finding missions to countries of South east Europe by the author in 2005 and 2006 on behalf of UNESCO. For details: [i.nechifor@unesco.org](mailto:i.nechifor@unesco.org). Download: [www.unesco.org/science/psd/publications/s-p\\_series.shtml](http://www.unesco.org/science/psd/publications/s-p_series.shtml)

**Energy Bulletin**

N° 1, June 2008. First edition, prepared by Moscow International Centre for Sustainable Energy Development established in November 2007 under the auspices of UNESCO, 66 pp. Available also in Russian. The new centre will define proposals for Russian cooperation with energy-poor countries, monitor potential for transition to the energy of the future, analyse progress in global energy security policy and prospects for offshore hydrocarbons development and transportation, and for the market of alternative engine fuels. Download: [www.icsed.com](http://www.icsed.com); for details: [a.benchikh@unesco.org](mailto:a.benchikh@unesco.org)

**Protecting the Gulf's Marine Environment from Pollution**

Abuzinada, A., H.-J. Barth, F. Krupp, B. Boer and Al Abdessalaam, T. (eds). Birkhauser Publishers (Switzerland). English only, 285p. The first comprehensive, science-based volume dealing with various types of marine and coastal pollution in the Gulf. Researchers, environmental managers and other experts working in the field of marine pollution in the Gulf may request a copy while stocks last from UNESCO's Doha office: [b.boer@unesco.org](mailto:b.boer@unesco.org)

**Asian Multilingual Thesaurus of Geosciences**

Compiled by Coordinating Committee for Geoscience Programmes in East and Southeast Asia (CCOP) and International Centre for Training and Exchanges in Geosciences (CIFEG). Sponsored by UNESCO's Regional Bureau for Science in Asia (Jakarta) and by the French Ministry of Foreign Affairs. Multilingual: Chinese, English, French, Indonesian, Japanese, Khmer, Korean, Lao, Malaysian, Thai, Vietnamese, 363 pp. Published in 2006, nine years after UNESCO's Division of Earth Sciences began developing a regional geoscience information network in East and Southeast Asia (SANGIS) to facilitate the exchange of geoinformation and data. As a contribution to the current International Years of Planet Earth and Languages, geoscientists, geoscientific institutions and universities in Asia are invited to request a complimentary copy from UNESCO's Jakarta office while stocks last: [g.arduino@unesco.org](mailto:g.arduino@unesco.org). Or consult at the SANGIS website: <http://203.148.160.165/amtg/>

**Real-time Coastal Observing Systems for Marine Ecosystem Dynamics and Harmful Algal Blooms Theory, Instrumentation and Modelling**

M. Babin, C. Roesler and J. Cullen (eds). HABWatch Programme. UNESCO Monographs on Oceanographic Methodology. UNESCO Publishing, € 56.00, ISBN: 978-92-3-104042-9, English only, 830 pp. Offers guidance for developing real-time and near real-time sensing systems for observing and predicting plankton dynamics, including harmful algal blooms, in coastal waters.

**Open Access to Knowledge and Information Scholarly Literature and Digital Library Initiatives - the South Asian Scenario**

By Anup Kumar Dam. Edited by Bimal Kanti Sen and Jocelyne Josaih. UNESCO New Delhi Office. ISBN 978-81-89218-21-8, English only, 137 pp. Describes successful digital library and open access initiatives in South Asia that are available in the form of open courseware, open access journals, metadata harvesting services, national-level open access repositories and institutional repositories. An authoritative source-book on open access development in South Asia. Download: <http://unesdoc.unesco.org/images/0015/001585/158585e.pdf>