

SECTION 3

EMERGING CHALLENGES





CHAPTER 9

GENETICALLY MODIFIED CROPS

Lead Authors: Nathaniel Makoni, Jennifer Mohamed-Katerere

Contributing Authors: Munyaradzi Chenje

“Because biotechnology is such a revolutionary science, and has spawned such a powerful industry, it has great potential to reshape the world around us. It is already changing agriculture and what many of us eat. Any major mistakes could lead to tragic and perhaps permanent changes in the natural world. For these reasons, future generations are likely to look back to our time and either thank us or curse us for what we do – or don’t do – about GMOs and biosafety.

Doing the right thing is not simple.”

CBD AND UNEP 2003

INTRODUCTION

There is growing debate about the potential value of modern biotechnology, and in particular of transgenics, in helping to achieve Africa’s development and food security goals. The challenge facing policymakers is not only to understand what the technology can do, or has done elsewhere, but also to establish what opportunities it presents to Africa.

There are three critical issues. First, whether or not genetically modified organisms (GMOs) offer a sustainable food security option; second, what the implications are of transgenic technologies for biosafety as well as for human health and well-being; and third, the extent of existing African capacity to undertake research, and effectively monitor and evaluate genetically modified (GM) products and their use.

Genetic modification techniques allow novel traits to be introduced into animals, crops and micro-organisms. These techniques can be used to improve livestock, poultry and fish productivity as well as their resistance to disease. Genetic modification is being used in the forest sector to create pest resistance, herbicide tolerance and wood quality traits (FAO 2005). Crops can be genetically engineered to improve appearance, taste, nutritional quality, drought tolerance, and insect and disease resistance. Thus, GM crops are often held up as the solution to yield deficits.

However, achieving food security is about more than just fulfilling yield deficits. Food security is having sufficient physical, social and economic access to safe, nutritious and culturally acceptable food (Witcombe and Sanchez 2004) at the household level, without having to resort to emergency supplies. This demands either adequate food production or food imports. Agricultural choices are as much about food quantity as they are about nutritional needs, livelihoods, culture, poverty, trade and sustainable development. Genetic modification technology may be useful in addressing some of these aspects. However, the potential of such technologies is controversial. There is considerable uncertainty about the impact on human and environmental health, and also whether these products will provide a sustainable solution to food problems. The risks and benefits associated with GM technologies are difficult to quantify.

As resources for public sector research decreases, and the values that promote private sector development and interests become entrenched in global governance instruments, the growth of GM technology and applications seems certain. However, the potential role of GM crops for Africa in promoting food security and improved human well-being is far from clear, and it is uncertain how their adoption will impact on the sustainability of livelihoods and food production systems. This chapter focuses exclusively on

● Food security is having sufficient physical, social and economic access to safe, nutritious and culturally acceptable food.

● Witcombe and Sanchez 2004

Box 1: Genetic modification – just one biotechnology

Genetic manipulation is not new. For millennia, farmers have relied on selective breeding and cross-fertilization to modify plants and animals and encourage desirable traits that improve food production and satisfy other human needs (CBD and UNEP 2003).

Biotechnology includes a wide range of scientific techniques that are used in several fields including agriculture and medicine. The Convention on Biological Diversity (CBD) defines biotechnology as:

“Any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use.”

Agricultural biotechnology includes bio-fertilization, tissue culture, marker assisted breeding and transgenics. For example, artisans have exploited traditional fermentation techniques to transform grains into bread and beer, and milk into cheese. Such intentional modification of the natural world has contributed enormously to human well-being. Transgenic applications involve the modification

of the genetic structure of one organism through the insertion of a gene from another organism and can be used to modify plants, animals and micro-organisms. A gene is a biological unit that determines an organism's inherited characteristics. This process of modification is called genetic recombination – it adds characteristics that the original organism did not have. The resultant organisms are called “genetically modified” or “genetically engineered” or “living modified” organisms (LMOs) – these organisms have been genetically modified in a way that does not occur naturally.

Modified non-living organisms include products such as drugs, vaccines and food additives, canned, processed and preserved foods. Biotechnology techniques and products applicable in the health sector that may be of value in developing countries include molecular diagnostics, recombinant vaccines, vaccine and drug delivery techniques, sequencing pathogens, genomes, microbicides, bioinformatics, recombinant therapeutic proteins and combinatorial chemistry (Millennium Project 2005b). Environmental management techniques that may be useful include bioremediation.

Sources: CBD and UNEP 2003, Mackenzie and others 2003, UN 1992, UN Millennium Project 2005b

the debates around GM and food security; its other possible uses are not discussed.

The challenge for policymakers is how to respond to this uncertainty about the relative opportunities and threats posed by GM technologies: the dilemma is whether to adopt this new technology and face criticism for lack of precaution, or to require thorough study of potential risks and face criticism for failing to act promptly (Young 2004).

GM crop areas was higher in developing countries than in developed ones, developing countries accounting for slightly more than one-third of the world's GM crop area. (James 2004). Land under GM crops is expected to continue increasing as the sector grows in India and China and new countries introduce GM crops (James 2004). In 2004, soybean accounted for 60 per cent of all GM crops, maize for 23 per cent and cotton for 11 per cent. In the near future, GM maize is projected to have the highest growth rate as more beneficial traits become available and are approved (James 2004).

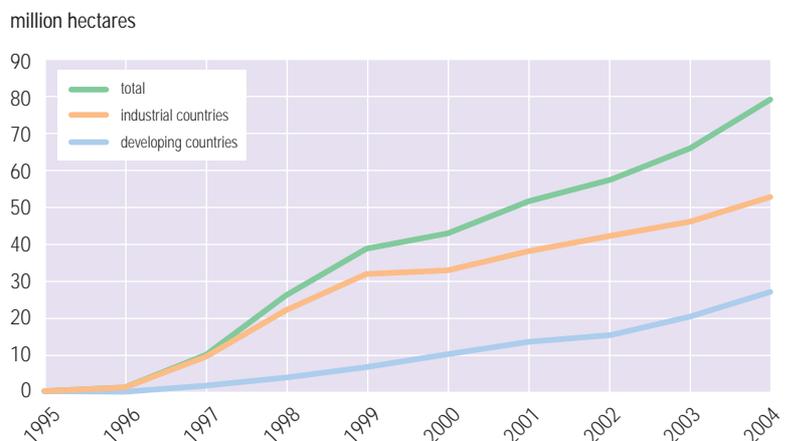
STATE-AND-TRENDS

GLOBAL GROWTH IN COMMERCIALIZATION OF GM CROPS

Despite a steady increase in global plantings of transgenic crops from 1996, when they were first introduced, the global percentage of land under GM crops remains relatively small. Figure 1 shows global plantings. Genetically modified crops account for only 4 per cent of total global cultivation (WHO 2005).

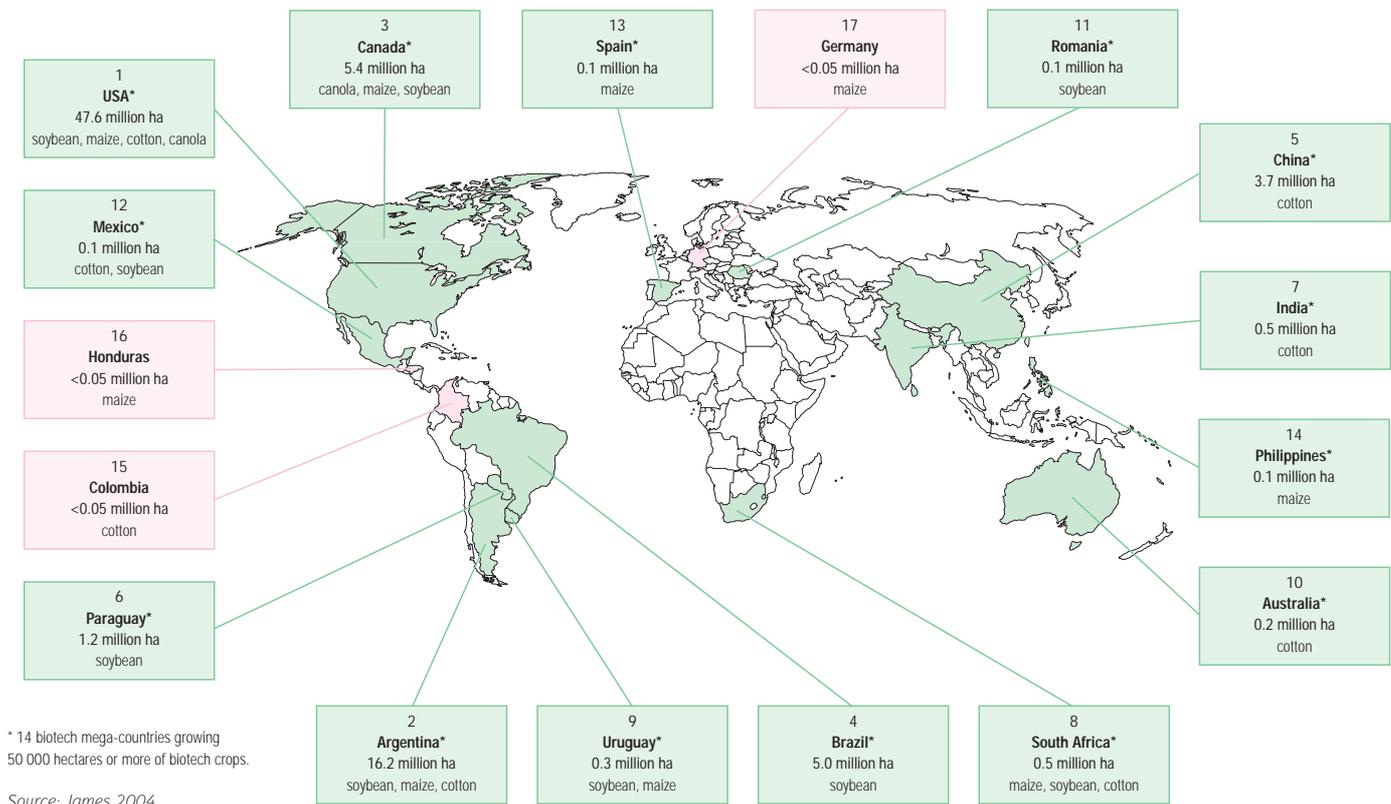
Global plantings of GM crops jumped by 20 per cent in 2004; this was the second largest yearly increase since commercial plantings began in 1996 (James 2004). In that year, land under GM crops rose to 81 million ha. For the first time, the hectareage growth in

Figure 1: Global area of biotech crops



Source: James 2004

Figure 2: Biotech crop countries and mega-countries* 2004



In 2004, there were 8.25 million farmers involved in GM crop production in 17 countries (James 2004). Although 90 per cent of these farmers were from developing countries, only one of these countries, South Africa, was in Africa. The International Service for the Acquisition of Agri-Biotech Applications (ISAAA) predicts that by the end of the decade, up to 15 million farmers will grow GM crops on 150 million ha in up to 30 countries (James 2004). The global biotech crop market was worth US\$4 700 million in 2004, and is projected to rise to US\$5 000 million in 2005 (James 2004).

As shown in Figure 2, there are 14 countries growing over 50 000 ha of GM crops. In 2004, Paraguay, Spain, Mexico and the Philippines joined this group. However, global production is dominated by five countries. The USA with 59 per cent of global sowings has the largest share of total land under GMO production. It is followed by Argentina with 20 per cent, Canada and Brazil with 6 per cent each, and China with 5 per cent of land under GM crops globally.

In Africa, the use of GMO technology and its products is still in its infancy. South Africa is the only African

Box 2: GM crops in Egypt

Crops under field trials:

- Cucumber
- Maize (*Zea mays*)
- Maize
- Melon
- Musk melon
- Squash
- Potato (*Solanum tuberosum*)
- Cantaloupe

- Sugar cane (*Saccharum officinarum*)
- Tomato (*Lycopersicon esculentum*)
- Wheat

Crops approaching commercialization:

- Potato – Resistance to infestation by potato tuber moth
- Squash – Resistance to a major viral pathogen
- Maize – Resistance to stem borers
- Cotton – Resistance to certain insects

Source: Mansour 2005

Box 3: Bt cotton in South Africa

Bt stands for *Bacillus thuringiensis*, a toxin producing bacterium found naturally in soils. Scientists have isolated genes responsible for the production of this bacterium and inserted it through genetic modification into cotton and maize to increase pest resistance.

Smallholder farmers in the Makitini Flats, South Africa have been growing it since 1997. By 2003 it was estimated that about 75 per cent of South Africa's cotton was Bt cotton (Pschorn-Strauss 2005). In the initial period, smallholder Bt cotton appeared to be very successful. The higher cost of Bt cotton seed was offset by lower chemical use and yield increases of between 20-40 per cent (Glover 2003). However, from

about 2003, there was a rapid decline in the area under Bt cotton. In the period 2003-04, only 35 700 ha of cotton was planted, amounting to an 80 per cent reduction since 2000. This is ascribed to low world prices and droughts: in 2004 -05 the area planted was 21 700 ha, an extraordinary 40 per cent drop in area planted with cotton in one year (Pschorn-Strauss 2005). Reportedly, 90 per cent of smallholders who planted Bt cotton are in debt; the total debt among small-scale cotton farmers in northern KwaZulu-Natal was estimated at over US\$3 million in 2004 (Pschorn-Strauss).

Sources: Glover 2003, Pschorn-Strauss 2005

country that is commercially producing GM crops. However, Egypt is approaching commercialization of four GM crops; these are potatoes, squash, yellow and white maize, and cotton (Mansour 2005).

In South Africa, under the Genetically Modified Organisms Act of 1997, three transgenic crops – insect or herbicide resistant cotton, maize and soybean – have been approved for commercialization (Department of Health undated). GM crop plantings are growing: in 2004 South Africa had 500 000 ha under GM crops (James 2004) and growth continued in white maize used for food and yellow maize used for feed; soybean plantings increased from 35 per cent adoption rate in 2003 to 50 per cent in 2004, whilst *Bacillus thuringiensis* (Bt) cotton stabilized with about 85 per cent of producers adopting it (James 2004).

RESEARCH AND DEVELOPMENT

Globally, GM research and development (R&D) is led by six large multinational life science companies independently or in collaboration with the Advanced Research Institutes (ARIs) in the industrial countries. These companies include Monsanto, Syngenta, Aventis, CropScience and Dupont. A number of developing countries (such as Brazil, Argentina, China, India, Malaysia and the Philippines) have significant R&D programmes in biotechnology and transgenic crops.

An increasing number of African countries have GM R&D capacity. South Africa, Zimbabwe, Kenya, Nigeria, Mali, Egypt and Uganda are widely acknowledged as being the lead countries. As many as 24 other African countries have some GM R&D capacity and at least 20 are actually engaged in such research (African Centre for Biosafety 2005). These countries include Benin, Burkina Faso, Cameroon, Egypt, Ghana, Kenya, Malawi,

Mali, Mauritius, Morocco, Namibia, Niger, Nigeria, Senegal, South Africa, Tanzania, Tunisia, Uganda, Zambia and Zimbabwe (African Centre for Biosafety 2005).

Nine countries – Benin, Burkina Faso, Egypt, Kenya, Morocco, Senegal, Tanzania, Zambia and Zimbabwe – are known to have conducted field trials (African Centre for Biosafety 2005). Supporting legislation and policy to regulate research and commercialization processes have not kept pace with these developments.

Private sector dominance has meant that most agricultural biotechnology research focuses on developed country concerns such as improved crop quality or management rather than drought tolerance or yield enhancement, and innovations that save labour costs (such as herbicide tolerance) rather than those that create employment (Nuffield Council on Bioethics



GM trial potatoes in Makhatini, South Africa.

Source: Biowatch

Table 1: GM crop research in Africa

Country and Project name	Partners and Funders	Research Objective	Additional Information
KENYA Insect-Resistant Maize for Africa	Kenyan Agricultural Research Institute (KARI) in collaboration with the International Maize and Wheat Improvement Centre (CIMMYT). Funded by Syngenta Foundation for Sustainable Agriculture.	Bt maize resistant to the stem borer	Open field trials started in May 2005. Government Authorities destroy crop in August 2005 due to spraying of restricted chemicals.
KENYA	KARI MONSANTO International Service for the Acquisition of Agricultural Applications. Funded by USAID and Monsanto.	Transgenic virus-resistant sweet potato	
BURKINO FASO	In 2003, Monsanto, Syngenta and Burkina Faso's Institut National de l'Environnement et la Recherche Agronomique (INERA).	Field tests of two Bt cotton varieties	Research has taken place without the involvement or consent of the national biosafety committee which is tasked with developing a national regulatory regime for GMOs.
EGYPT	Monsanto and Egypt's Agriculture Genetic Engineering Research Institute (AGERI) currently collaborating in field trials of Bt cotton. Laboratory work is being done on GM potato, tomato, corn, faba bean, wheat, cucurbits and cotton. Field trials are being conducted for insect-resistant potato and virus-resistant cucurbits. GM crops will be available soon on the commercial level.	Multiple crops, insect resistance	Commercial introduction could take place as early as 2006.

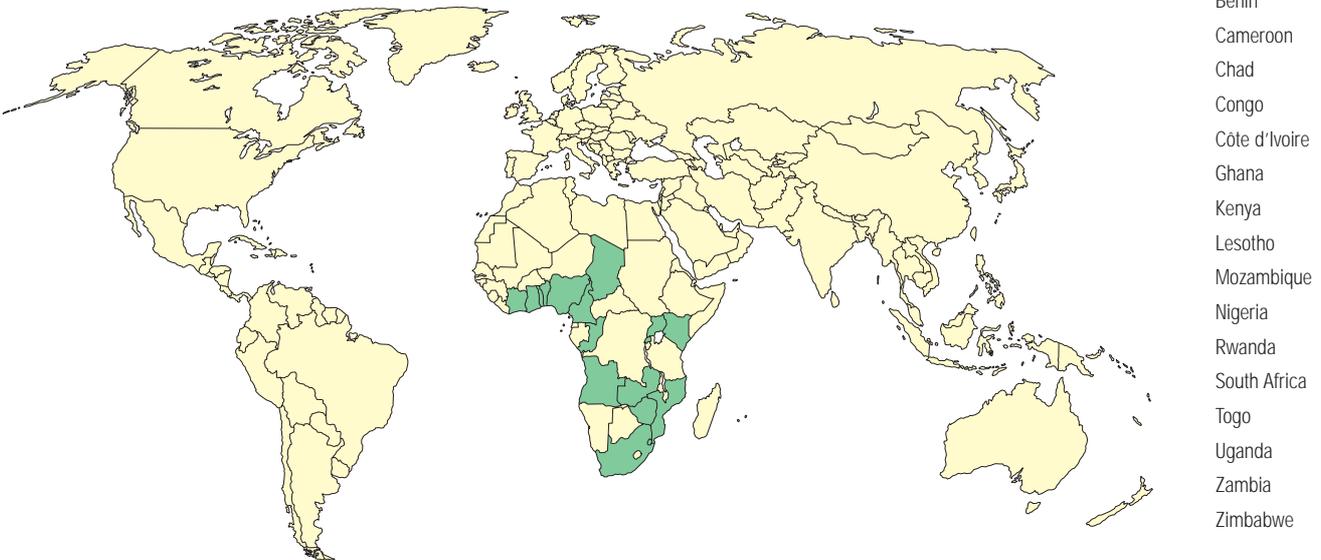
Sources: Odame and others 2003, Glover 2003a, GRAIN 2005, Mansour 2005

1999). With the shift away from public sector research to private sector research, agricultural research has become increasingly profit-driven and less focused on needs fulfilment. There are an increasing number of research initiatives of African interest. In Africa, the main GM crops of research and commercial interest are sweet potato, maize, cotton, soybean, pigeon peas, bananas and tobacco. Much of this research is based on public-private-partnerships (PPPs) as shown, for selected countries, in Table 1. These include projects on vitamin A rice, virus-resistant sweet potato and Insect-

Resistant Maize for Africa (IRMA). Insect-resistant research is seen as particularly important given the losses that are suffered as a result of insect infestations. In Kenya, for example, farmers lose about 15 per cent of the maize crop to stem borers (Glover 2003a).

Research cooperation between developing countries and institutions or companies based in the developed world has been important in promoting transgenic research in Africa. For example, the Swiss Federal Institute of Technology (SFIT) in Zurich plans to collaborate with researchers in Kenya, Nigeria, the UK

Figure 3: Distribution of cassava mosaic virus



Source: University of Arizona/College of Agriculture and Life Sciences 2003

and the USA on the African cassava mosaic virus (Sawahel 2005). This virus is transmitted to cassava by whiteflies when they feed on the plant. In parts of Eastern and Central Africa, epidemics of the disease can lead to total loss of harvests. Researchers at SFIT have used genes from a virus that periodically devastates cassava crops to create cassava plants that can resist the virus. Cassava is an important food crop in many parts of Africa and is strongly affected by genetic erosion, pest infestation and plant disease because it is a vegetatively propagated crop (Aerni 2005). Genetically modified cassava could save African farmers large economic losses. So far, the only way to curb the virus is by intensive use of insecticide to kill whiteflies. But this can be prohibitively expensive for subsistence farmers and can threaten their health and that of surrounding plants and animals (Sawahel 2005).

Given biosafety concerns, some countries are investing in improving their research and monitoring capacity. Zambia, for example, has begun building a modern molecular biology laboratory to detect GMOs entering the country (Ngandwe 2005). The goal of this US\$330 000 laboratory facility is to be accredited as a regional and national referral laboratory that will provide research and training in collaboration with the University of Zambia and the Norwegian Institute of Gene Ecology (Ngandwe 2005). Other countries such as Madagascar have taken a more cautious approach, banning the growing or importing of GM foods due to concerns over their effect on human health and the environment (Apps 2005).

Despite the growing interest in GM crops, non-transgenic agricultural research remains the backbone of agricultural research in most African countries. In Kenya, for example, of the 17 biotechnology research and training projects only 2 use transgenic technologies (Odame and others 2003). Researchers in Côte d'Ivoire and Madagascar are engaged in non-transgenic rice research to improve yield. In Côte d'Ivoire, the Consultative Group on International Agricultural Research's (CGIAR) West African Rice Development Association (WARDA) has used an "embryo rescue" technique to cross-breed African and Asian rice. The new variety has several advantages over conventional African varieties including early maturity, improved pest resistance, drought- and acid soil-tolerance and greater height (which makes it easier to pick by hand) (Glover 2003a). Madagascar has implemented a system of rice cultivation which through improved agronomic practices, and without the use of GM varieties or chemical inputs, has shown improved yields (Glover 2003a).

GM FOOD AID

Drought, inadequate water resources and poor soils, along with other economic and social pressures, have made food shortages a problem in many parts of Africa.

From 2002, GM crops have been offered as food aid. In Southern Africa, several countries have expressed concern about the use of GM crops as food aid, given the lack of clarity about their potential impacts. During the drought of 2002-03, several countries opted to reject GM food aid. In making their decisions, countries considered not only the immediate issue of food

Box 4: Some approaches to GMO foods and food aid in Africa

ANGOLA – Banned imports of all GMO produce, except for food aid provided it was milled. The United Nations World Food Programme (WFP) reported that the additional cost of milling discouraged some food donors.

ETHIOPIA – Banned import of GMO food, saying it would undermine farmers who already have their own traditional ways of fighting pests and weeds. Debate continues over whether GMO crops could help the country out of years of serious food shortages.

KENYA – Does not permit GMO food imports, but government is in final stages of drafting legislation to govern the process of commercializing GMO products.

LESOTHO – Banned GMO food imports unless they are already processed or milled, citing concerns over environmental contamination.

MADAGASCAR – Banned growing or importing GMO foods due to concerns over the effect on human health and environment.

MALAWI – Banned GMO imports unless already processed or milled, citing concerns over environmental contamination.

MOZAMBIQUE – Banned GMO imports unless already processed or milled, citing concerns over environmental contamination.

SWAZILAND – Has no restrictions on GMO imports.

SUDAN – Has some restrictions on GM food aid.

TANZANIA – Is in the process of drafting legislation to govern the import of GMO foods.

ZAMBIA – Banned import of all GMOs, citing concerns over environmental impact and effect on human health. In response, it is alleged that the WFP moved some non-GM food aid stocks out of the country.

ZIMBABWE – Banned import of all GMO produce, except for food aid, provided it has already been milled.

Source: Apps 2005, ERA 2005

shortages and the overall implications of GM crops for human and environmental health, but also future directions in agriculture, the implications of private sector-led research, livelihood and development options, ethical issues and rights concerns (Mohamed-Katerere 2003). Similarly, public concerns are raised about the relationship between GM crops and

sustainable agriculture. Participatory Ecological Land Use Management (PELUM-Tanzania, PELUM-Kenya, and PELUM-Zimbabwe), Biowatch South Africa, and national consumer councils have all been key players.

Some approaches to GM food aid are identified in Box 4. Mozambique raised concerns about accepting GM maize aid on biosafety and human health grounds and opted to ban its import. Zambia refused to accept GM food aid in any form; Zimbabwe, Malawi and Mozambique refused to accept GM food aid unless it was milled, this being seen as a precaution to avoid any germination of whole grains and to limit impacts on biodiversity; Lesotho and Swaziland authorized the distribution of non-milled GM food, but not before it warned the public that the grain should be used strictly for consumption and not for cultivation; and in 2004, Angola and Sudan introduced restrictions on GM food aid.

Global anti-GM food campaigns have influenced public attitudes to GM foods in Africa. Consumers International (CI), a worldwide federation of consumer organizations with 38 member organizations in about 22 African countries, has played an important role in shaping the debates around GM foods. It advocates a legal regime in which all GM foods are subject to rigorous, independent safety testing, labelling and traceability requirements, and in which producers are held liable for the environmental or health damage which their products may cause (CI 2005). There is growing acceptance of this approach globally.



Vegetable farmers planting coriander to repel insect pests, Sudan.

Source: FAO

The high level of investment needed in GM research and its application has constrained African participation and has led to research that primarily focuses on developed country needs. Transgenic research is very expensive when compared to more traditional biotechnology techniques. For example, the IRMA project is estimated to have cost US\$6 million over 5 years and the transgenic sweet potato research US\$2 million, compared to the average funding of tissue culture and marker technology projects costing on average US\$300 000 (Odamé and others 2003).

The absence of a supportive policy and legal framework is often cited as an inhibiting factor for the development of biotechnology. On the one hand, biotechnology companies may be reluctant to invest in costly research without the legal guarantee that they will be able to commercialize their products (Seshia 2002). Supportive legislative frameworks for research include not only clear rules for risk assessment and commercialization but also intellectual property rights (IPR) (Yamin 2003). Although IPR standards have been developed through the World Trade Organization's (WTO) Agreement on Trade-Related Aspects of

Intellectual Property Rights (TRIPS), domestic IPR legislation in many African countries remains weak. Many countries struggle with how to reconcile IPRs with farmers' rights and other local interests. There are concerns that strong IPRs will entrench global domination of world food production by a few companies and increased dependence on industrialized nations. IPR may place restrictions on farmers, including on their existing rights to store and exchange seed. Some of the challenges regarding IPR are discussed in Box 5. On the other hand, in some instances the absence of a legal framework has encouraged research as biotechnology companies can act with few restraints and responsibilities. For example, in 1998 Monsanto engaged in the planting of GM crops in Zimbabwe as there was no regulation, although these crops were subsequently destroyed when the government established what had happened (Glover 2003a).

At a national and regional level, the lack of adequately inclusive policy processes has contributed to a polarized GM debate. Since the United Nations Conference on Environment and Development (UNCED) in 1992, civil society has been increasingly recognized as an important partner in the development of environmental policy and practice. Civil society organizations, globally and within Africa, have been very active in claiming this space around issues related to genetic modification. A range of concerns has been raised related to the debates around human health and biosafety as well as to the socioeconomic implications, especially as they relate to issues of food security, livelihoods and human well-being. As discussed in Chapter 1: *The Human Dimension*, an increasing number of intergovernmental African agencies, international organizations and national governments are recognizing the value of such approaches. For example, Benin has established a five-year national moratorium on the importation, commercialization and utilization of all GM products or products derived from GMOs to give the country time to effectively debate, develop and implement national biosafety legislation (GRAIN 2004).

Another set of concerns relating to policy-making processes is the growing influence of the scientific and private sector in policy development and how to balance this with public concerns. Issues of public trust, accountability and transparency, as well as farmers' and consumers' rights, underlie much of this.

In many arenas, public objection to and concerns about GMOs are important constraints to GM research and the commercialization of GM products. Globally, these concerns focus on health and environmental

● People accept new technologies because they believe the potential benefits outweigh the potential risks.

● CBD and UNEP 2003

Box 5: Intellectual Property Rights: potential conflicts and opportunities for resolution

Intellectual Property Rights affect how financial benefits are distributed. The approaches of the WTO and the CBD are quite different:

- The Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) asserts IPR on life form, while the Convention on Biological Diversity (CBD) asserts national sovereignty and thus by implication the right to prohibit IPR on life forms.
- The CBD promotes equitably shared benefits from use of biological resources and protection of traditional knowledge; TRIPS promotes the private appropriation of benefits and has no mechanism for acknowledging the role of traditional knowledge in the industrial use of genetic resources.

However there are some opportunities for reconciling these differences:

- Article 1 of TRIPS provides some flexibility, allowing domestic law to exceed minimum protection standards, a provision that could allow member nations to enact legislation to protect traditional knowledge.
- Article 27.2 of TRIPS allows for the exclusion from patent ability based on public order or morality.
- Article 27.3b of TRIPS allows for the development of unique IPR protection systems for plants, animals and essentially biological processes, creating an opportunity to develop alternative IPR regimes appropriate to the needs and conditions of traditional communities.

Source: GBDI and IITA 2000

implications. These concerns stem from the continuing high levels of uncertainty around impacts and risks as well as the poor dissemination and communication of available information. No technology or human activity is completely risk-free; people accept new technologies because they believe the potential benefits outweigh the potential risks (CBD and UNEP 2003). Public mistrust of private sector motives resulting from past private sector behaviour in potentially risky areas such as tobacco, pharmaceuticals and chemicals is also a factor (Mohamed-Katerere 2003). Some are concerned about possible dumping by companies or nations in efforts to dispose of surplus stocks or to recoup the cost of R&D. In Southern Africa, some governments have expressed similar concerns about GM food aid (Mohamed-Katerere 2003). In Africa, public concerns have revolved around ethical issues, food security and livelihood concerns, farmers' and consumer rights, and non-inclusive policy processes. Farmers' organizations in West African countries have, in voicing their objection to the introduction of GM crops, focused on a range of factors that undermine the productive agricultural sector, including European Union (EU) and US cotton subsidies, and are beginning to look more critically at the dominant model of cotton production, questioning the need for chemical inputs and looking for means to reduce their dependence on cotton (GRAIN 2004). Researchers and farmers are successfully rebuilding agricultural practices based on farmer knowledge and local resources that greatly reduce the use of pesticides (GRAIN 2004).

Given the magnitude of what is at stake, these concerns remain, despite the policy and regulatory frameworks on environment and biosafety developed under the CBD in 1992 and its Cartagena Protocol in 2000, which specifically regulates the transboundary movement of living modified organisms.

OPPORTUNITIES AND RISKS

There is much controversy about the opportunities and risks posed by GM technology. This results in part from the lack of information to support policymakers and the public in evaluating the options. Much of the information that is available is oversimplified and may focus on just one aspect of the debate, thus making it an unreliable source. Better scientific information is often inaccessible to non-GM specialists. A key challenge facing African countries is how to deal with this information gap and how to evaluate the contradictory information that is available.



Farmers in Côte d'Ivoire select the NERICA rice varieties to grow during PVS trials. Here they compare panicles of rice varieties during post-harvest evaluation.

Source: World Bank

An IUCN – The World Conservation Union (IUCN) report finds that the controversies are essentially in three areas (Young 2004):

- The interpretation of science and specifically whether GMOs are inherently safe or inherently dangerous from a human and environmental perspective;
- Economic analysis and in particular how to evaluate the cost-and-benefits associated with GMOs; and
- Socio-cultural impacts and biosafety implications revolving around issues of food production and security, livelihoods, and human and environmental health.

MARKETS AND TRADE

The uncertainty about the impact of growing GM crops on markets for other crops is a concern for many countries. The European Union's *de facto* moratorium on new approvals for the production and import of GMOs is particularly important.

Traceability requirements, such as the EU's 2003 initiative on country of origin labelling, have impeded imports from the US where many GM crops are produced. Traceability requirements are designed to address problems of contamination of organic crops by GMO pollen drift, the use of contaminated seeds and

sloppy handling. Such practices have been reported (Riddle 2002) and are a trade concern. Increased commercialization of GMOs in Africa could threaten organic agriculture and agricultural exports to, for example, EU countries where GMO use remains restricted (Pruzin 2004).

An additional issue is the relationship between national safety standards and labelling requirements and global agreements. While the Cartagena Protocol allows members to develop more stringent safety standards than those it provides, there is the risk that such standards could be found to violate provisions of the WTO agreements.

FOOD SECURITY

An important challenge for much of Africa is how one improves food security. Determining appropriate strategies requires a clear understanding of the nature of the food security problem and an understanding of what exactly GM crops can bring to addressing this. Millennium Development Goal (MDG) 1, target 2 seeks to reduce chronic hunger by half from the 1990 baseline by 2015.

Genetic modification technology may contribute to food security goals through increasing crop yields, producing hardier crop varieties that can withstand heat and drought, enhancing nutritional and medicinal value, and improving storability (UN Millennium Project 2005b). Increasing crop resistance to insects and diseases and reducing weeds could help reduce crop losses and reduce dependence on costly fertilizers and herbicides, resulting in valuable savings for resource-poor farmers (Bernsten 2004). For example, the

European corn borer destroys 7-20 per cent of the world's annual maize harvest (Ives and others 2001). If Bt can successfully control the corn borer, maize yields in Africa could increase significantly (Ives and others 2001). However, the potential of such innovations is highly contested.

However, as the Brundtland Report cautioned as early as 1987, the challenge of improving food security is more than just increasing food production. The Brundtland Report noted that globally agriculture does not lack resources but lacks the policy to match need and production (WCED 1987). Food production is closely linked to cultural and livelihood systems. Crucial issues that need to be addressed include (Young 2004):

- The impact of reliance on GMOs to solve social and economic problems;
- The impact of the cost of GM crop production;
- The implications of expensive R&D processes;
- The equitable sharing of benefits arising from the use of genetic materials conserved primarily in the developing countries;
- The impact of GMOs on local livelihood systems; and
- The impact of GMOs on agricultural biodiversity.

The assumption that food shortages stem from a gap in food production and population growth is now widely challenged. The problem of world hunger is not a problem of food production but one of distribution. The world today produces more food per inhabitant than ever before: enough food is available to provide 1.9 kg for every person every day: 1.1 kg of grain, beans and nuts, about 0.4 kg of meat, milk and eggs and the same amount of fruits and vegetables (Altieri and Rosset 1999). The real causes of hunger are poverty, inequality and lack of access to food and land. Too many people are too poor to buy the food that is available (but often poorly distributed) or lack the land and resources to grow it themselves (Lappe and others 1998 in Altieri and Rosset 1999).

Genetically modified crops may be important from a developing country perspective because specific nutritional values can be added (UN Millennium Project 2005b). One of the best known genetic enrichment food crops is vitamin A improved rice, also called "Golden Rice." Insufficient vitamin A intake by children in developing countries is the leading cause of visual impairment and blindness, affecting over three million children in sub-Saharan Africa (SSA) (Muir 2003). Pregnant women with vitamin A deficiency (VAD) face an increased risk of mortality as well as high risk of mother-to-child HIV transmission. Thus, if effective, nutritionally enhanced "Golden Rice" could be one

- The challenge of improving food security is more than just increasing food production.
- WCED 1987)



Cajanus cajan (Pigeon Pea) is a perennial legume. This plant is drought-resistant, nitrogen fixing, and enhances soil fertility. It requires low inputs and can be intercropped with traditional crops.

Box 6: Will the use of Bt cotton result in less pest threats and pesticide use?

In 2002, Bt cotton was planted on 4.6 million ha worldwide, approximately 13 per cent of the global cotton area. Almost all of this Bt cotton acreage was sown to Monsanto's "Bollgard" variety. Bollgard is genetically modified to produce the Cry1Ac toxin of *Bacillus thuringiensis*. Monsanto has developed a second Bt cotton variety, "Bollgard II", which produces two different toxins, Cry1Ac and Cry2Ab. In 2004, Dow Agro-sciences hopes to introduce "Widestrike", another Bt cotton producing two toxins (Cry1Ac and Cry1F), while Syngenta is trying to introduce its Bt cotton, "VIP Cotton".

The Bt toxins expressed by Bt cotton only target lepidopteran pests (caterpillars) and some lepidopteran pests are more susceptible than others. Bt cotton has been shown to be effective against the tobacco budworm (*Heliothis virescens*) and the pink bollworm (*Pectinophora gossypiella*), but less effective in controlling cotton bollworms (*Helicoverpa zea* and *Helicoverpa armigera*), an important cotton pest in West Africa. This is why farmers growing Bt cotton continue to use pesticides against bollworms and continue to experience damage from these pests. In the US, despite the use of supplementary insecticides, farmers growing Bt cotton lost around 7.5 per cent of their crop to cotton bollworms in 2002. During that

year, 36 per cent of the Bt cotton fields in the US were sprayed with insecticides specifically targeting bollworms and other caterpillar pests. Farmers outside the US have had similar experiences. In the Indian state of Andhra Pradesh, where Bt cotton was cultivated for the first time in 2002, Monsanto's Bollgard cotton failed to control cotton bollworms.

There are many important cotton insect pests for which Bt cotton offers no control, such as sucking pests like aphids and jassids. These secondary pests can result in significant crop damage on Bt crops, which helps to explain why insecticide use remains high in Bt cotton fields. In Australia, pesticide use against bollworms has declined, but farmers still spray their Bt cotton fields with insecticides 4.6 times per year. The adoption of Bt cotton may even increase problems with secondary pests. In the Indian state of Andhra Pradesh, farmers growing Bt crops had to spray more against aphids than farmers growing conventional crops. In the US, where insecticide use against bollworms has dropped by half since the introduction of Bt cotton, total insecticide use has remained stable due to the growing importance of secondary pests.

Source: GRAIN 2005

important tool for addressing the MDG 5 on maternal health. While genetically enriched crops can be an important nutritional strategy, the efficacy of this approach is contested. It remains to be seen whether these crops will live up to the nutritional values demonstrated in the laboratory in real life. "Golden Rice" is genetically modified to produce beta-carotene, the precursor of vitamin A. For beta-carotene to be converted to vitamin A, it requires a functional digestive tract, adequate zinc, protein and fat stores, adequate energy, and protein and fat in the diet. However, in populations that suffer from VAD, the overall dietary deficiencies act as barriers to the conversion (Gola 2005). The question also arises as to whether this is the most cost-effective and sustainable way to address nutritional deficits (Muir 2003). An alternative is to promote the use of existing varieties of food crops with high levels of beta-carotene such as sweet potato. One of the main factors constraining the inclusion of adequate fruit and vegetable in rural peoples' diets is the problem of food storage. Research in some

countries, including Zimbabwe, is attempting to address these shortcomings (Muir 2003).

Nutritional diversity may be threatened by GM licensing agreements and production systems which push farmers to monoculture and thus reduce the variety of crops planted for household consumption.

The livelihood implications of adopting GM technologies are still not fully understood. Biotechnology is a technology under corporate control, protected by patents and other forms of IPR, and therefore contrary to farming traditions of saving and exchanging seeds (Altieri 2002); consequently there has been considerable resistance by non-governmental organizations (NGOs) and community organizations to the adoption of GM crops. There are concerns about the impacts of the changing nature of agribusiness and its impact on poor people and their food security. Because hunger is primarily linked to poverty, lack of access to land, and the maldistribution of food, one concern is that biotechnology may exacerbate inequalities underlying the causes of hunger. Leading

GM companies have been rigorous in enforcing contractual agreements around the use, storage and sale of GM seed and products. Small-scale farmers have been prosecuted in developed and developing countries (ERA 2005).

CHEMICAL USE

Modern agriculture has had negative impacts on the environment. The high level of chemical inputs required for improved varieties, developed under the green revolution, which replaced traditional varieties has had a heavy toll.

Transgenic agriculture promises to limit the environmental releases of damaging chemicals (Cullen 2004, Bernsten 2004, and FAO 2002) by reducing the need for pesticides and herbicides, and fertilizers. However, these claims remain contested, as discussed, for example, in relation to Bt cotton, in Box 6. Whether the incorporation of the pesticide into the crop itself rather than application on the soil will be environmentally friendlier is not known (Young 2004). The challenges and opportunities associated with chemical use are considered more fully in Chapter 11: *Chemicals*.

Africa currently uses 3.6 million tonnes of fertilizer, but the potential requirement to maintain average levels of crop production without depleting soil nutrients is 11.7 million tonnes per year (Henao and Baanante 1999). The negative environmental aspects



Farmer fertilizing maize crop in Burkina Faso.

Source: P. Lowrey/FAO

of mineral and organic fertilizers include accumulation of dangerous or even toxic substances in soil. This includes cadmium pollution from mineral phosphate fertilizers or from town or industrial waste products; eutrophication of surface water, with its negative effect on oxygen supply, which threatens fish and other forms of animal life; nitrate accumulation in groundwater, diminishing the quality of drinking water; and unwanted enrichment of the atmosphere with ammonia from organic manures and mineral fertilizers, and with nitrogen oxide (N₂O) from denitrification of excessive or wrongly placed nitrogen fertilizer (Finck 1992).

BIODIVERSITY

It is not known how GM technologies will impact upon biodiversity. The CBD defines biodiversity as:

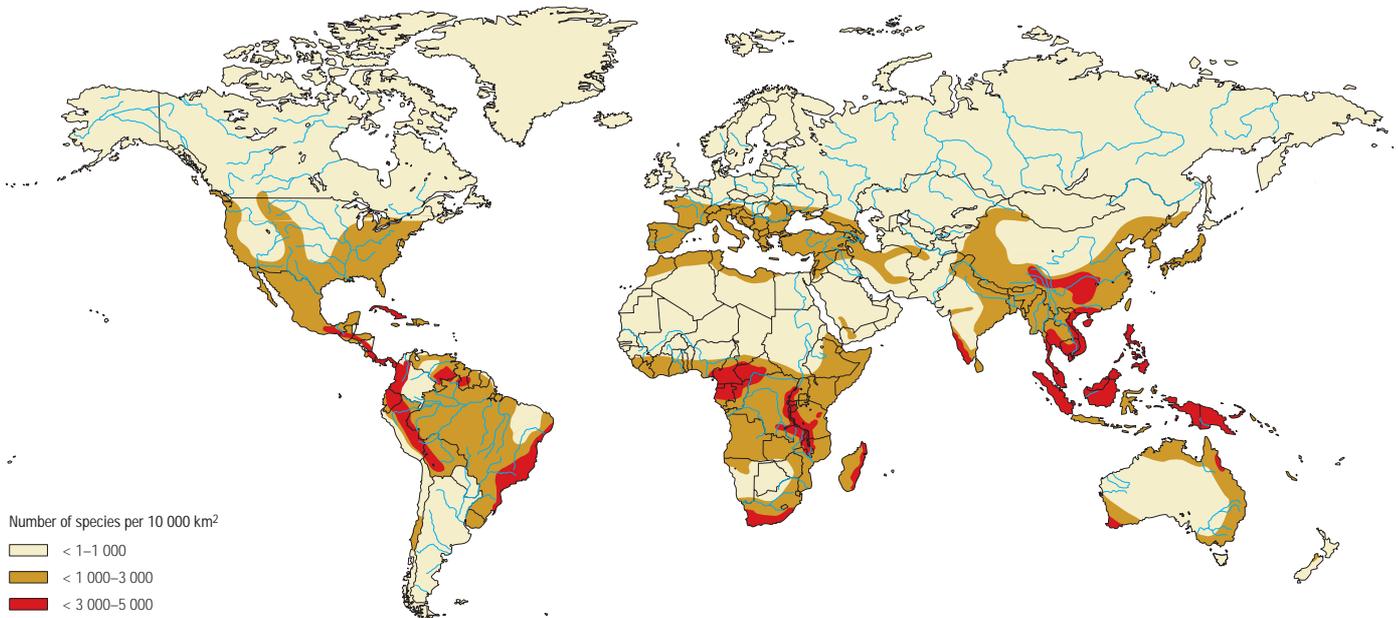
“The variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.”

The introduction of a transgene into a recipient organism is not a precisely controlled process and can result in a variety of outcomes with regard to integration, expression and stability of the transgene in the host (FAO and WHO 2003). The risks associated with modifying the genetic structure of crops are not well understood and there is little agreement on either the severity or likelihood of potential risks. This controversy emanates from a scientific dispute about how “stable” GM crops are. Several concerns can be identified.

First, GM technology could result in the contamination of crops through gene transfer – “genetic pollution” – and the development of “super weeds” (Altieri 2002, Porter 2005) and therefore have a negative impact on biodiversity. A further concern about GM crops is that the genes could “escape” and, through cross-pollination, mix with non-GM crops or their weedy relatives. For example, an herbicide-tolerant gene could be transferred to weeds in wild habitats, turning them into “super weeds” (ERA 2005). There is evidence of the unintentional spread of genes from GM crops (Monroe 2004).

Second, transgenic crops modified to be resistant to a particular pest or disease may have a negative effect on non-target species that are harmless or beneficial. For example, Bt maize pollen may be toxic to the Monarch butterfly (Losey and others 1999). Although the Monarch butterfly is native to Mexico, the United States

Figure 5: Biodiversity in mountain regions



Mountain eco-regions are exceptionally rich in biodiversity.

Source: Fleury 1999

of America and Canada (Manos-Jones 2004) it is possible that other butterfly species in Africa can be similarly affected. On the other hand, the alternative to transgenic crops could be as harmful to the environment. For instance, the practice of routine spraying of broad-spectrum insecticides is non-selective, and therefore kills all insects regardless of whether they are beneficial or harmful to the crop (Ives and others 2001). A British study on oilseed has recently concluded that it is not the GM crops that harm wildlife but the herbicides sprayed on the crops that significantly reduce the broad leaf weeds such as chickweed, a major bird food (Brown and Gow 2005). The magnitude of these GMO risks to non-target organisms, including beneficial insects, is largely unknown as there have been no comprehensive studies in Africa to date.

Third, pest resistance can occur with frequent use of any pest control product (Soil Association 2003b). Insects can develop resistance to toxins such as the Bt bacterium, reducing the effectiveness of this control method. In Australia, India and China, for example, pests are becoming resistant to some GM cotton crops that have Bt genes inserted (Spinney 1999). Research into the safety of GM crops using genes that produce toxins should precede commercialization and not follow it. Inbred pest resistance might also be toxic to people in the long term. For example, long-term consumption of peas, *Lathyrus sativus*, can cause paralysis if a toxin in the peas accumulates in people, as has happened in Bangladesh and India (Messons cited by Sawahel

2005). Bt crops have proven to be unstable and ineffective; some insects, which survive Bt, transmit genetic resistance to their immediate offspring. If Bt becomes ineffective as an implanted pest control strategy within one insect generation, then organic farmers will be robbed of a valuable biopesticide. Regional cases of Bt resistance have already been reported (Spinney 1999). Insects resistant to the genetically modified Ingard Bt cotton were reported in Australia (Australian Broadcasting Corporation 2001). Indeed, GM plants are not behaving as intended: in 1996, Monsanto's pest-resistant Bt cotton succumbed to a heat wave in the southern US and was destroyed by bollworms and other pests (Spinney 1999). In 1997, farmers who grew Monsanto's herbicide-tolerant cotton saw the cotton balls fall off their crops (Spinney 1999).

Fourth, GM crops engineered to be resistant to specific herbicides enable farmers to spray weeds without damaging crops (Soil Association 2003a). Weeds are developing resistance to these herbicides, and rogue GM plants that grow after a harvest (volunteers) have appeared and spread widely (Altieri 2002, ERA 2005). In particular, GM oilseed rape volunteers have spread quickly, and some plants have become resistant to several herbicides through cross-pollination (Brown and Gow 2005). Elsewhere, GM cotton crops have failed to impart protection from pests resulting in increased use of chemical sprays: farmers are making more frequent applications and reverting to older and more toxic chemicals (Soil Association 2003b).

Fifth, GMOs could impact on genetic diversity. The increased competitiveness of GMOs could cause it to damage biologically-rich ecosystems. Transgenic crops could encourage biodiversity loss through the establishment of monoculture agriculture which replaces traditional crops and other established varieties (Altieri 2002). Currently, the main potential cause of loss of biodiversity is agricultural expansion, which destroys habitats. The needs of a growing global population have largely been met by bringing more land into agricultural production (Ives and others 2001). Proponents of GM crops highlight this and suggest that transgenic crops may be able to help preserve uncultivated habitats by increasing yields on land already under cultivation (Ives and others 2001), reducing the need for conversion.

Sixth, ecological and health hazards are also posed by genetic use restriction technologies (GURT) which are commonly known as terminator technology (McLean 2005). These organisms do not flower and fruit and therefore provide no food for the multitude of insects, birds and mammals that feed on pollen, nectar, seed and fruit, and will inevitably have huge impacts on biodiversity (McLean 2005). Sterile trees can still spread by asexual means and the genes can spread horizontally to soil bacteria, fungi and other organisms in the extensive root system of the trees, with unpredictable impacts on the soil biota and fertility. As transgenic traits tend to be unstable, they could break down and revert to flower-development, spreading transgenes to native trees, or creating pollen that poisons bees and other pollinators as well as causing potential harm to human beings (ISIS

2005b). The sterile monocultures are much more likely to succumb to disease, which could potentially wipe out entire plantations (Spinney 1999). Some companies have developed GM crop seeds that use GURT. As a result, farmers become dependent on large corporations and must purchase new seeds every season (ERA 2005). In addition to social equity issues associated with these monopolistic tendencies, GURT may have environmental risks and thus the technologies require further evaluation. GM crops can be unstable (Hansen 2000, GMWatch 2005) posing risks to other plants.

There are counter claims to all these concerns: the use of herbicide-resistant and pest-resistant crops is believed to have positive implications for biodiversity. With non-herbicide tolerant (non-transgenic) soybean, farmers must clear the weeds before planting their seeds. With herbicide-tolerant soybean, however, the weeds can be better controlled; farmers can plant the seeds by sowing them directly in relatively undisturbed soil. This conserves moisture and soil fauna and flora and also reduces water and wind erosion (Ives and others 2001).

HUMAN HEALTH CONCERNS

Given the uncertainty over the risks associated with GMOs, it is not surprising that strong and often polarized opinions are held around issues of food safety and human health. Consumer and environmental organizations and several governments have adopted cautious approaches to GM-derived foods, preferring to err on the side of safety rather than take unknown risks. Similar concerns have been expressed about the use of GM ingredients in livestock production systems via incorporation of GM-derived oilseeds and cereals in animal feed. The UK, Germany and France have eliminated the use of ingredients derived from GM plants from foods manufactured for direct human consumption or that enter the food supply chain (Soil Association 2003b).

Labelling of GM foods is an important consumer concern. It provides information for consumers and users of the product and allows them to make an informed choice. On this basis the EU, for example, has adopted labelling and traceability regulations (EC 2005). In the late 1990s, Austria, France, Greece, Italy and Luxembourg imposed national bans on a number of GMO products. Poland is the second central European country to ban a GMO maize type after Hungary, which outlawed the planting of Monsanto's MON 810 hybrid seeds in January 2005 (Reuters 2005). In the United States, labelling has not received the same level of attention. In Africa, several countries have prohibited the import of GM foods, as shown in Box 4. Consumer



Genetic diversity in maize.

Source: CIMMYT

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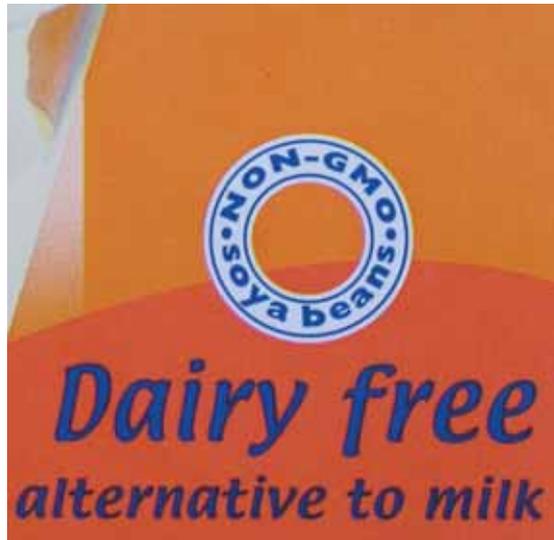
concerns about GM foods include health and ethical considerations (Mohamed-Katerere 2003).

Some human and animal health risks have been identified (Spinney 1999, Cox 1995). Most of the examples are from regions where GMO technology has been in use far longer than it has in Africa. This information provides important lessons for Africa – a region that is now a target for rapid expansion of GMO technology. The limited experience with GMOs indicates some possible risks.

First, increased use of herbicide-tolerant GM crops may pose new risks for environmental and human health. For example, glyphosate is a major formulation of “Roundup Ready” crops and is now the world’s best-selling “total” herbicide. Due to the introduction of GMO-Roundup Ready crops, human and environmental exposure to the herbicide is expected to increase (Brown and Gow 2005). However, there is strong evidence that glyphosate-containing products are acutely toxic to animals and humans (ISIS 2005a).

Second, there are new medical risks from GM technologies. For example, gene therapy involves the use of a virus to carry a modified DNA segment and the virus is potentially pathogenic. The risks of these treatments are largely unknown. There are concerns that medical applications involving genetic engineering may produce cancer-causing genes from normal human genes (Portfolio 21 2005).

Third, the insertion of genes from one crop into another may increase allergic reactions, especially where consumers are not informed about the origins of the transgene. For example, soybean seeds genetically modified to include a gene from Brazil nuts in order to fortify a protein supplement containing soy resulted in people allergic to Brazil nuts reacting to the soy product (Mills 2005). The modified soy product indicated no negative reactions when it was tested on animals, illustrating the difference between the reactions of laboratory animals and humans to GM food products. This warrants further study of this new technology before it is widely embraced. The soil bacterium *Bacillus thuringiensis*, from which endotoxin (Bt) genes are extracted and widely incorporated into GM crops as biopesticide, is a close relative of the anthrax bacterium, *Bacillus anthracis*, and exchanges genes with it. Potentially this can generate more deadly pathogens (Altieri 2002, ISP 2003). Some Bt genes are known to cause toxic or allergic reactions in humans (ISP 2003). However, GM technology can also be used to prevent food allergies by deleting the major allergen, such as the case with soybean developed by Pioneer International (Mills 2005).



The labelling of foods provides important information for consumers.

Source: bounford.com

Fourth, increased antibiotic resistance may result. For example, Novartis’ Bt maize contains a marker gene, which codes for antibiotic resistance in *E.coli*. There is a risk that if animals or humans consume Bt maize-based products such as cattle feed or starch, some antibiotics would be rendered useless (Spinney 1999).

Fifth, vitamin toxicity from nutritionally enhanced crops may be an unintended consequence. When GM crops such as rice and rapeseed with high vitamin A concentrations are planted, there will be no way to distinguish them from normal crops, with the contingent risk of liver damage if too much vitamin A is consumed (Spinney 1999).

ETHICS

GMO and ethics issues centre among other things on patenting, cloning of life forms and biopiracy. These concerns have a direct bearing on achieving sustainable livelihoods and conservation of environmental resources. In Africa, many communities and consumers express ethical concerns about “playing god” as plants are transformed in unnatural ways and about the implications for traditional beliefs and values.

If not properly managed, gene patents could be instrumental in promoting and institutionalizing social inequity (Portfolio 21 2005, ERA 2005). Patenting genetic material traditionally available to a community, without allowing the community free use of the material or providing any return to the community, affects the fair and equitable distribution of resources, a necessity in the development of a sustainable society

(ERA 2005). There is concern that the access and intellectual property issues related to “terminator gene” technologies will lead to increasing dependence on industrialized nations by African countries, and domination of world food production by a few multinational companies.

Biopiracy is also of growing concern, particularly as many African countries lack the legislative and enforcement systems to control illegal extraction of genetic resources. Additionally, the benefit sharing systems for the use of these assets and of traditional knowledge are poorly developed.

The issues of proprietary science have complicated the ethical and safety issues of GM technology. In particular there are challenges around reconciling the rights of product developers with those of consumers. Many public protests have centred on ethical or ecological grounds, the uncertainty about the impacts of the technology, and the public right-to-know and to have access to information, including through labelling.

In several countries, concerns have been raised as to whether “the technology is tantamount to playing god, interfering with nature, contrary to local ethics and also whether gene insertion would play havoc with the totem system that lies at the heart of local cultural association” (Mohamed-Katerere 2003).

RESPONSES

There are a wide range of responses, at multiple levels, to the growing challenges posed by the development of GM technologies and products. These include global and regional intergovernmental responses, science-based responses and civil society initiatives. As a whole, the overall approach of African governments has been to encourage a range of biotechnology research (both transgenic and non-transgenic) while recognizing biosafety concerns and establishing systems to limit its impact.

Biosafety approaches have been shaped by the worldwide acknowledgement of the growing threats which ecosystems and biodiversity face from human activity, and the long-term implications this has for development and human well-being. The CBD secretariat along with UNEP for example notes:

“The stakes are high: although some 40% of the world economy is derived directly from biological diversity, humanity is pushing ecosystems, species and gene pools to extinction faster than at any time since the dinosaurs died out 65 million years ago. At present, natural habitats

and ecosystems are being destroyed at the rate of over 100 million ha every year. More than 31 000 plant and animal species are threatened with extinction; according to the Food and Agriculture Organization of the UN, at least one breed of livestock dies out every week. Band-aids are not enough: only a fundamental and far-reaching solution can ensure a biologically rich world for future generations” (CBD and UNEP 2003).

The range of actors involved in policy development has increased dramatically. Governments, scientists, the private sector and civil society have all become active players. The extent to which the concerns and interests of these respective groups are acknowledged varies between countries and across issues. However, as Box 7 shows, given the complexity of the issues and the risks associated with them, a growing number of policymakers, at the national, regional and global levels, are acknowledging the importance of inclusive policy processes. Box 8 looks at one initiative that

Box 7: Doing the right thing is not simple

Governments cannot achieve biosafety on their own; they need the active involvement and cooperation of other stakeholders:

- Agricultural and health-care research institutes and the biotechnology industry can play a particularly important role. Biotechnology researchers and companies have the expertise, the resources and the incentive for keeping biotechnology and its products safe and beneficial.
- Civil society, individual citizens and non-governmental organizations need to understand the issues and make their views clear to both policymakers and industry.
- The media have a vital watchdog role to play.

Because biotechnology is such a revolutionary science, and has spawned such a powerful industry, it has great potential to reshape the world around us. It is already changing agriculture and what many of us eat. Any major mistakes could lead to tragic and perhaps permanent changes in the natural world. For these reasons, future generations are likely to look back to our time and either thank us or curse us for what we do – or don't do – about GMOs and biosafety.

Doing the right thing is not simple.

Source: CBD and UNEP 2003

Box 8: The African Biotechnology Stakeholders Forum

The African Biotechnology Stakeholders Forum (ABSF) is a not-for-profit and non-sectarian organization funded by the United States Agency for International Development (USAID). It provides a platform for sharing, debating, and understanding issues pertaining to biotechnology in agriculture, health, industry and the environment. The African Biotechnology Stakeholders Forum represents stakeholders in biotechnology in Africa. It currently has individual members in Kenya, Uganda, Tanzania, Ethiopia, South Africa, Ghana and Nigeria; small and medium sized enterprises involved in research, development, testing and commercialization of biotechnology in Tanzania, Ethiopia, Uganda and Ghana. Through its membership and linkages, ABSF is a voice for many biotechnology stakeholders, including farmers, scientists, consumers, politicians and government bodies.

The ABSF objectives are to:

- Provide a forum for sharing and exchanging experiences and practices in biotechnology with a view to

strengthening its application for increased food security, health improvement, poverty alleviation, industrialization and environmental conservation in Africa.

- Improve public understanding of biotechnology through provision of accurate and balanced information to consumers, media and policymakers to ensure that biotechnology is accurately represented at all levels of society.
- Explore innovative and appropriate biotechnology applications and facilitate their adoption and use in sustainable development and poverty alleviation in Africa.
- Build capacity for information generation, dissemination and wise use of biotechnology.
- Facilitate research, development, education and training on biotechnology as well as policy and infrastructure development for meeting Africa's needs in biotechnology.

Source: ABSF undated

brings together stakeholders at the regional level. Annex 3, Table 1 shows some of the national, sub-regional and regional organizations active in biotechnology issues.

SCIENCE-BASED RISK ANALYSIS

Risk analysis is concerned with how to evaluate, contain or avoid negative impacts resulting from the uncertain behaviour of GM products and processes. To be effective, such assessments need to address all costs-and-benefits, and not be restricted to financial expenditures and profits (Young 2004). It needs to address direct and indirect costs-and-benefits, as well as opportunity costs, such as the impact on environmental goods-and-services as well as on agricultural and social systems. Field trials and how crops behave in conditions similar to those following actual release are a critical step in the assessment process, allowing product developers to address problems arising. They play an important role in identifying risks and creating an opportunity for mitigation and adaptation prior to full release.

However, the standardized approach to risk assessment does not allow for such levels of complexity. Most national risk analysis frameworks focus on risk-benefit assessments that are derived

from economic cost-benefit type analysis. In general, they adopt narrow technical approaches, which focus on the characteristics of the host organism and the resulting GMO, the expression and properties of the gene product and the biophysical features of the recipient environment (Mohamed-Katerere 2003). These approaches and their general principles have been developed over several decades in response to technological development in the chemical and pharmaceutical industries. These standardized approaches are particularly attractive to companies and governments as they are simplified and avoid the costs of case-by-case analysis.

Two factors underlie the analysis of risk (Young 2004):

- The magnitude of each potential harm or benefit that might occur; and
- The likelihood of its occurrence.

Magnitude is particularly important from a human and environmental perspective; certain kinds of changes, such as biodiversity loss, may be irreversible. Magnitude is difficult to ascertain where there is insufficient experience with a product or activity. Likelihood is based on comparison with similar situations in the past.

SUBSTANTIAL EQUIVALENCE AND FAMILIARITY

In the area of GM crops, many national assessment systems are based on the concepts of “substantial equivalence” and “familiarity” to determine the likelihood of potential harm (Scoones 2002) and to decide on further product testing and development as well as commercial release. In general, it neglects the socioeconomic aspects.

The concept of familiarity has been used in the chemical industry to determine safety levels on the assumption that closely related chemicals will behave in the same way. This approach is now used in GM risk assessment. Such models have a high level of appeal because they do not require regulators to deal with complex and case-specific factors. This framework neglects the issue of magnitude and rare but significant impacts. It may not be as well suited to LMO as these can behave in unpredictable ways.

Substantive equivalence between organisms is used as an indication of how they will behave. The concept was originally developed as a way for determining food safety (Scoones 2002). If a new GM product is substantially equivalent in chemical composition to its natural antecedent then it is assumed to be safe. This approach neglects the uncertainties around the actual modification of DNA.

INTEGRATIVE APPROACHES

Risk is different from cost because, on the one hand, a certain level of risk is necessary for social, political and economic advancement and, on the other, risk is by its nature uncertain. The challenge in the area of GM is that

risks posed by this technology are fundamentally different from those posed by earlier agricultural technologies. The range of uncertainties is greater than ever before and includes fundamental scientific uncertainties and ignorance about the potential environmental and health risks, as well as wider uncertainties about the impact on agricultural systems and rural livelihoods (Scoones 2002). The importance of recognizing uncertainties and ignorance is evident from the Bovine Spongiform Encephalopathy (BSE) crisis, or mad cow disease, which resulted in major economic and health costs in the UK and Europe. Classical assessment approaches which treat scientific aspects separately from ethical, moral, social and economic considerations may be inappropriate and have been widely criticized over many years (Scoones 2002). In this context of uncertainty, other approaches, including the precautionary approach, can be a valuable part of risk assessment. Taking a precautionary approach requires acknowledging the potential for unforeseen consequences, complex effects and ignorance (Scoones 2002). The precautionary approach offers the opportunity to address normative values of justice, fairness and responsibility which classical risk assessment does not do (Mohamed-Katerere 2003).

A further challenge for risk assessment processes is that the range of actors in the development of new policy making and the negotiation process of regulatory and policy frameworks is wider than ever before: it includes global institutions, multinational companies, NGOs, governments and intergovernmental bodies, scientists

25-29 January 2006. A “citizens’ jury” – 43 small and medium-size farmers – meets in Mali to hear evidence from 14 international witnesses, representing a broad range of views on GM crops. Witnesses included biotech scientists, FAO, and GM farmers from South Africa and India. The jury decided against introducing GM crops and instead made recommendations to strengthen traditional agricultural practice and support local farmers.



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and farmers acting at and across national, regional and global levels. This highlights the need for deliberative participatory processes over simple consultation. Participation is successful when it promotes responsiveness to local and national needs, legitimacy and “ownership” of policy and law. Thus, the processes for participation need to be appropriate and relevant to the country concerned (Glover 2003b). Many African countries have recognized this: participatory approaches have been used in policy development in relation to national law and policy development.

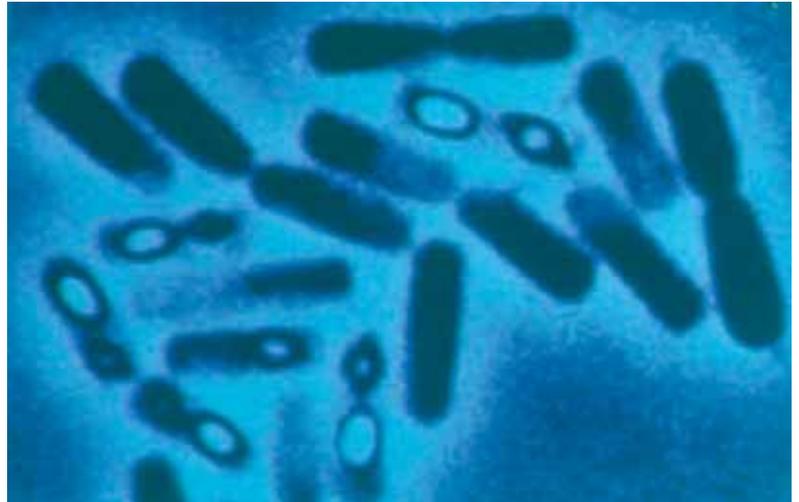
Current risk assessment processes are closely allied to globalization in which individual (R&D, economic and propriety) rights trump social and cultural rights and concerns; these issues are assumed to be adequately addressed through the market and consumer choice (Mohamed-Katerere 2003).

A range of approaches that deal with such complex decision making have been developed which recognize the plurality of views as well as a level of uncertainty and ignorance. These include quantitative approaches designed to examine the multicriteria important in decision making, scenario approaches which systematically analyse future options, and deliberative participatory approaches; these approaches introduce rigour not by limiting the issues under consideration but by being transparent and addressing the full complexity of the issues (Scoones 2002).

LEGAL AND POLICY RESPONSES

The introduction of GMOs has brought new challenges for authorities and policymakers who have to consider impacts on human health, poverty and hunger, livelihoods and food security, free trade and international markets, and the environment, particularly biodiversity. Laws and institutions need to ensure that an acceptable trade-off between competing and often conflicting interests is maintained. As GMO technology is relatively new, governance systems are also in their infancy and have not been able to take all these challenges on board.

Africa is responding to these challenges at multiple levels. It has supported initiatives at the global level such as the CBD and its Cartagena Protocol. It has developed cutting-edge solutions at the regional level such as the African Union’s (AU) Model Law on Safety in Biotechnology (African Biosafety Model Law) and has begun to develop national frameworks for GMO development and biosafety. The AU has also adopted a Model Law for the Protection of the Rights of Local Communities, Farmers, Breeders and Regulation of Access to Biological Resources.



Bacillus thuringiensis.

Source: University of Georgia

The AU’s Comprehensive Africa Agriculture Development Programme (CAADP) promotes an integrated multilevel response to the challenges of agriculture. This framework should serve as the basis for developing agricultural strategies. As the Millennium Task Force on Science and Technology cautions, technology cannot of itself determine social change but it can be a useful tool when aligned with development goals and when supporting governance structures are created (UN Millennium Project 2005b).

CARTAGENA PROTOCOL

At a global level, the key response to concerns about biosafety is the Cartagena Protocol on Biosafety adopted in 2000 under the CBD of 1992. The Protocol is primarily concerned with transboundary movement of LMOs; it provides a framework for countries to assess risks associated with LMO prior to authorizing importation. It seeks to ensure:

“An adequate level of protection in the field of the safe transfer, handling and use of living modified organisms resulting from modern biotechnology that may have adverse effects on the conservation and sustainable use of biological diversity, taking also into account risks to human health, and specifically focusing on transboundary movements” (Secretariat of the CBD 2000).

Two key concepts, biosafety and precaution, form the basis for the framework developed in the Protocol. Biosafety is based on the concept of precaution and

Box 9: Precaution

Principle 15 of the Rio Declaration provides that:

"Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."

The Cartagena Protocol applies precaution not just to biodiversity, but to potential risks to human health as well. Additionally it gives importing countries the right to take into account socioeconomic concerns (provided their actions are "consistent with their international obligations"). Such concerns could include the risk that imports of genetically engineered foods may replace traditional crops, undermine local cultures and traditions or reduce the value of biodiversity to indigenous communities.

Source: Secretariat of the CBD 2000, UN 1992, CBD and UNEP 2003

implies minimizing the risk to human, animal and environment health (see Box 9). It includes a range of measures, policies and procedures to minimize potential risks. The precautionary approach has been specifically incorporated in the Protocol.

Although there remains much controversy about what exactly constitutes a precautionary approach, there is evidence of wide support for it as reflected in

Box 10. The Cartagena Protocol applies the precautionary approach to biodiversity and to human risks. It gives importing countries the right to take socioeconomic considerations into account, as long as these are consistent with their international obligations. The Protocol allows governments on the basis of precaution to prohibit the import of a GMO, even where there is insufficient scientific evidence about potential adverse effects (CBD and UNEP 2003).

The Protocol entered into force in July 2003. Although the Protocol has been signed by 37 African countries, many of these have not yet ratified it or developed laws to incorporate it into their legal framework (CBD 2006): Algeria, Benin, Botswana, Burkina Faso, Cameroon, Cape Verde, Democratic Republic of the Congo, Djibouti, Egypt, Eritrea, Ethiopia, Gambia, Ghana, Kenya, Lesotho, Liberia, Libya, Madagascar, Mali, Mauritania, Mauritius, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, Seychelles, South Africa, Sudan, Swaziland, Togo, Tunisia, Uganda, Tanzania, Zambia, and Zimbabwe. Table 2 shows the status of the Cartagena Protocol in African countries.

African countries are faced with the challenge of dealing with transboundary movement of GMOs and illegal use or research activities. Some African country borders are porous, difficult to police and at times subject to bribery (GMWatch 2005). GM maize and rice

Box 10: IUCN-The World Conservation Union calls for precaution

IUCN is a global union of governments, civil society organizations (CSOs) and experts; it brings together 82 state members, 112 government agencies, 784 national NGOs, 33 affiliate members and 84 international NGOs. Consequently it is an important global voice.

In 2002, IUCN adopted a resolution on GMOs, which noted the lack of knowledge of the effects on biodiversity and on the potential role of GMOs in "achieving global food security." which it notes "has not been adequately demonstrated so far." It focuses on the need to adopt a precautionary approach to GMO as set out in Principle 15 of the Rio Declaration and the Cartagena Protocol on Biosafety. To this end it calls "upon key private sector companies to integrate biodiversity into their corporate social responsibilities and actions."

In 2004, IUCN, at its 3rd World Conservation Congress held in Bangkok, Thailand, passed a resolution, which calls

for "a moratorium on further environmental releases of GMOs until they can be demonstrated to be safe beyond reasonable doubt." It also requests the IUCN Council to:

- Prepare policy guidance for sustainable GMOs through a multifaceted approach;
- Promote and support initiatives to ratify the Cartagena Protocol on Biodiversity; and
- Encourage public awareness and promote access to information.

While the resolution was sponsored by most state and NGO-members, state members such as Japan, The Netherlands and Sweden were against the resolution. The US government and agency members refrained from the deliberations.

Source: IUCN 2004

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Table 2: African countries status on Cartagena Protocol on Biosafety

Country	Signature	Ratification/accession	Entry into force
Algeria	25 May 2000	5 August 2004	3 November 2004
Angola			
Benin	24 May 2000	2 March 2005	31 May 2005
Botswana	1 June 2001	11 June 2002	11 September 2003
Burkina Faso	24 May 2000	4 August 2003	2 November 2003
Burundi			
Cameroon	9 February 2001	20 February 2003	11 September 2003
Cape Verde		1 November 2005	30 January 2006
Central African Republic	24 May 2000		
Chad	24 May 2000		
Comoros			
Congo	21 November 2000		
Côte d'Ivoire			
Democratic Republic of the Congo		23 March 2005	21 June 2005
Djibouti		8 April 2002	11 September 2003
Egypt	20 December 2000	23 December 2003	21 March 2004
Equatorial Guinea			
Eritrea		10 March 2005	8 June 2005
Ethiopia	24 May 2000	9 October 2003	7 January 2004
Gabon			
Gambia	24 May 2000	9 June 2004	7 September 2004
Ghana		30 May 2003	11 September 2003
Guinea	24 May 2000		
Guinea-Bissau			
Kenya	15 May 2000	24 January 2002	11 September 2003
Lesotho		20 September 2001	11 September 2003
Liberia		15 February 2002	11 September 2003
Libya		14 June 2005	12 September 2005
Madagascar	14 September 2000	24 November 2003	22 February 2004
Malawi	24 May 2000		
Mali	4 April 2001	28 August 2002	11 September 2003
Mauritania		22 July 2005	20 October 2005
Mauritius		11 April 2002	11 September 2003
Morocco	25 May 2000		
Mozambique	24 May 2000	21 October 2002	11 September 2003
Namibia	24 May 2000	10 February 2005	11 May 2005
Niger	24 May 2000	30 September 2004	29 December 2004
Nigeria	24 May 2000	15 July 2003	13 October 2003
Rwanda	24 May 2000	22 July 2004	20 October 2004
São Tomé and Príncipe			
Senegal	31 October 2000	8 October 2003	6 January 2004
Seychelles	23 January 2001	13 May 2004	11 August 2004
Sierra Leone			
Somalia			
South Africa		14 August 2003	12 November 2003
Sudan		13 June 2005	11 September 2005
Swaziland		13 January 2006	13 April 2006
Tanzania		24 April 2003	11 September 2003
Togo	24 May 2000	2 July 2004	30 September 2004
Tunisia	19 April 2001	22 January 2003	11 September 2003
Uganda	24 May 2000	30 November 2001	11 September 2003
Zambia		27 April 2004	25 July 2004
Zimbabwe	4 June 2001	25 February 2005	26 May 2005

Source: CBD 2006

are already being planted illegally in various regions of Tanzania (Balile 2005). Adoption and ratification of the Protocol could be a useful option. In the absence of effective monitoring and enforcement, bans on the import of GM seeds are of no effect (Balile 2005). The shipment of grain requires leak-proof containers to avoid unintended GMO product contamination. Therefore, responsible deployment of GM crops needs to encompass the whole technology development process, from the pre-release risk assessment, to biosafety considerations, to post-release monitoring (FAO 2005). Monitoring GM crops will provide information for policies and regulations; it will give producers and policymakers better information to help them develop safer adoption processes.

REGIONAL RESPONSES

The African Biosafety Model Law was adopted by the AU at its 74th Ordinary Session in Lusaka, Zambia, in July 2001, and urged member states to use the African Biosafety Model Law to draft their own national legal instruments.



The seed bank at the KwaNgwanase Farmers' Association nursery in northern KwaZulu-Natal.

Source: Biowatch

This model law emanated from a highly participatory process which included researchers, governments, and civil society groups. It reflects a broad consensus on issues of biotechnology development. The regulatory framework utilizes the discretion given by the Cartagena Protocol on Biosafety for countries to adopt more stringent protective measures than the agreed minimum set out in the Protocol. The African Biosafety Model Law recognizes the importance of Africa as a centre of origin and a centre of diversity with regard to food and other crops. It makes provision for considering socioeconomic factors in assessing risks and opportunities. Key legal principles and approaches incorporated include:

- Precautionary;
- The sovereign right of every country to require a rigorous risk assessment of any GMO for any use before any decision regarding the GMO is made; and
- A liability and redress regime.

The African Biosafety Model Law provides a holistic and comprehensive set of biosafety rules including issues that are not dealt with by the Biosafety Protocol. These include mandatory labelling and identification or traceability requirements for GMOs and GM food, and liability and redress for harm caused by GMOs to human health and the environment, and for resultant economic loss (Mayet 2003).

SUB-REGIONAL APPROACHES

Six regional economic communities in Africa, namely the Economic Commission of West African States (ECOWAS), the East African Community (EAC), the Economic Community of Central African States (ECCAS), the Intergovernmental Authority on Development (IGAD), the Southern African Development Community (SADC) and the Arab Maghreb Union (AMU) have taken the lead in developing policy guidance on GMO research, production and marketing in their respective regions.

In Kampala, in November 2002, agricultural ministers of the Common Market for Eastern and Southern Africa (COMESA), agreed to create a regional policy on GMOs. Similarly, the SADC established an advisory committee on GMOs to develop guidelines and to assist member states in guarding against potential risks in food safety, contamination of genetic resources, ethical issues, trade-related issues and consumer concerns. These are set out in Box 11. The EAC has recommended reviewing and developing a common policy on GMOs. The IGAD members formed a Verification and Monitoring Team (VMT) to ensure that food assistance be certified as free

Box 11: SADC recommendations on genetically modified organisms

The following recommendations were formulated by the SADC Advisory Committee on Biotechnology and Biosafety and were approved by the SADC in August 2003 as interim measures aimed at guiding the region on issues relating to biotechnology and biosafety.

Handling of food aid

- The Southern African Development Community should develop and adopt a harmonized transit information and management system for GM food aid designed to facilitate transboundary movement in a safe and expeditious manner.
- The Southern African Development Community is encouraged to source food aid preferably from within the region, and advise all cooperating partners accordingly.
- Donors providing GM food aid should comply with the Prior Informed Consent principle and with the notification requirements in accordance with Article 11 of the Cartagena Protocol on Biosafety.
- Food aid consignments involving grain or any propagative plant material that may contain GMOs should be milled or sterilized prior to distribution to the beneficiary population.
- Food aid in transit that may contain GMOs should be clearly identified and labelled in accordance with national legislation.
- Southern African Development Community countries managing or handling food aid in transit that may contain GMOs are encouraged in the absence of national legislation to make use of the requirements under the African Biosafety Model Law and/or the South African Guidelines on the handling of transit material which may be GM.

Policy and regulations

- Each member state should develop national biotechnology policies and strategies and expedite the process of establishing national biosafety regulatory systems.

- All member states should sign and ratify the Cartagena Protocol on Biosafety to the CBD.
- The region should develop a harmonised policy and regulatory systems based on the African Biosafety Model Law and the Cartagena Protocol on Biosafety and other relevant international processes.
- Member states without a regulatory framework for GM crops should use approved guidelines and should not import genetically modified grain for seed before approved guidelines are in place.
- Risk assessments should be done on a case-by-case basis and every genetic modification should be tested in the environment under which it will be released.

Capacity-building

- Member states should develop capacities at national and regional levels in order to develop and exploit the benefits of biotechnology.
- The Southern African Development Community should allocate resources for capacity-building in management of biotechnology and biosafety.
- The Southern African Development Community should encourage member states to commission studies on the implications of biotechnology and biosafety on agriculture, environment, health and socioeconomics as part of an integrated monitoring and evaluation system.

Public awareness and participation

- Member states should develop public awareness and participatory programmes on biotechnology and biosafety that involve all stakeholders.

Sources: SADC 2004

of GMOs. Fifteen members of ECOWAS attended a meeting to better understand and discuss the benefits and threats of GMOs.

NATIONAL POLICY AND LAW

The need for adequate national policies and laws to regulate biotechnology research and establish effective assessment processes which safeguard human and environmental health is widely acknowledged. There is a need to develop harmonized approaches to biotechnology and the African Biosafety Model Law provides a good basis for this, as does the Model Law for the Protection of the Rights of Local Communities, Farmers, Breeders and Regulation of Access to

Biological Resources. Other region-wide organizations such as New Partnership for Africa's Development (NEPAD), and its Science and Technology Secretariat could have an important role.

At least nine countries have biosafety legislation or guidelines including Benin, Cameroon, Malawi, Mauritius, South Africa, Tanzania, Uganda, Zambia, and Zimbabwe. Ghana, Kenya, Lesotho and Swaziland all have draft legislation that addresses the issue of biosafety, the commercialization of GM crops and the importation of GM foods.

Developed country aid agencies and international organizations have had a keen interest in supporting the development of an enabling legal environment for

transgenic research and biosafety. Some of these initiatives appear in Annex 3 Table 2. The United States Agency for International Development is the most active in this area. The US has been a keen supporter of GM crop development, offering it as food aid, and the US is also the largest producer of GM crops. Several African countries have or are in the process of developing biosafety policies and law through a United Nations Environment Programme (UNEP) – Global Environmental Facility (GEF) initiative. This capacity-building project supported 100 developing countries to prepare national biosafety frameworks. Thirty-six African countries have or are participating in this project. An AU biosafety capacity-building project designed to spearhead the harmonization of biosafety legislation between member states based on the African Biosafety Model Law has been developed.

THE WAY FORWARD: OPPORTUNITIES AND CONSTRAINTS

Africa's experience with GM technologies is still relatively new compared to other regions and it is faced with many challenges on how best to proceed. Knowledge, transparency, fairness and containment are four key points in formulating a sound African policy on GMOs.



Cotton weaving in Essaouira, Morocco. Cotton is an important part of livelihoods in many African countries.

Source: J.C. Mohamed-Katerere

INCLUSIVE POLICY PROCESSES

Inclusive policy processes, based on adequate information, are essential to developing appropriate national and regional responses. The potential risks and opportunities posed by GM technologies are immense.

Decision making is a process of accountability – to one's constituency, one's country and the world – and as such it must necessarily be based on a weighing of evidence, not only evidence that a decision might pose a particular risk or benefit, but also evidence about the potential dimensions of that risk or benefit, about the likelihood of harm or advantage, about the efficacy of available measures to prevent or mitigate risks, and about other factors and situations within and outside the decision-maker's jurisdiction that affect the decision (Young 2004). Thus it is crucial for decision-makers, legislators, governments and the civil society, to have access to adequate supporting information.

Given the complexity of the issues at stake from biosafety considerations, human health concerns and socioeconomic implications, it is essential that policy processes use a range of techniques that are able to support effective valuation in these areas.

In it is also important, given the range of interests at stake, that policy processes become more deliberative, transparent and accountable.

WEIGHING THE CHOICE OF AGRICULTURAL OPTIONS

A crucial issue facing African governments is determining what kind of development and agricultural strategies can best meet long-term objectives and medium- to short-term goals. A viable agricultural strategy should contribute to the realization of the MDGs and targets including:

- Eradicating extreme poverty and hunger;
- Ensuring environmental sustainability;
- Reducing child mortality;
- Improving maternal health; and
- Combating HIV/AIDS, malaria and other diseases.

Defining such a strategy and identifying appropriate solutions is dependent on research that accurately understands the nature of the problem. Declining African agricultural research has meant that, increasingly, research priorities are often externally driven on the basis of assumptions that are not shared. Much global agricultural research is based on models which focus on production deficits and fails to take into account the multiple factors that are driving food crises including globalization, environmental degradation and HIV/AIDS. The opportunities of and challenges faced by agricultural

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production systems are discussed in Chapter 3: *Land* and Chapter 4: *Freshwater*. The problems of food security are complex and can probably not be resolved through a “technological fix.” Instead they require multisectoral and multilevel (local, national, international) interventions. Nevertheless, GM technologies offer promise for meeting some areas of greatest challenge in Africa. Benefits to the environment can be summarized to include: “friendly” bioherbicides and bio-insecticides, and conservation of soil, water, and energy. Increased food security for the growing populations may result from GM enhanced crop and livestock productivity.

New GM technological advances may create ethical controversies around tampering with nature, from, for example, mixing genes among species and related objections to consuming animal genes in plants and vice versa.

Like all new technologies, they also pose some risks, both known and unknown. Potential environmental impacts include: unintended transfer of transgenes through cross-pollination, unknown effects on other organisms (eg soil microbes) and loss of flora and fauna biodiversity. Traditional agricultural systems have played an important role in maintaining crop diversity. Certain human health impacts have been identified. The impacts on livelihoods, food security and rural options are not well understood.

Although genetic engineering may offer important opportunities for development and achieving the MDGs, it is important to strengthen existing local production systems and not compromise the existing systems. Clear cost-benefit analysis about the efficacy of different kinds of technological options need to be undertaken alongside locally-driven priority-setting exercises. The question remains as to whether development of genetic engineering is a priority for African governments at this point in time.

The value of existing agricultural approaches and non-transgenic approaches for Africa need to be considered. Achievements that have been made, including improving yields, better management of insects, pests, plant diseases and weeds without the use of synthetic pesticides, and the maintenance of soil fertility without chemical fertilizers (ERA 2005), should be consolidated. The value and productivity of traditional agriculture in development and its genetic diversity should not be underestimated. Africa has more than 2 000 native grains, roots, fruits and other food plants (National Research Council 1996).

The issue of IPRs will need to be addressed to ensure that there are no adverse consequences for food productivity, through, for example, the weakening of

Box 12: Developing sustainable agricultural production systems

The Millennium Project Task Force on the Environment identified the following as critical to enhancing sustainable agriculture techniques to preserve natural assets:

- Protect and improve soils, including enhanced carbon sequestration.
- Use water sustainably.
- Maintain crop genetic diversity.
- Mobilize local knowledge and experience.
- Improve crop research, management storage, and use.
- Restore and manage desertified lands.
- Adopt prevention strategies to protect arid ecosystems.
- Mobilize information and technology.
- Protect surrounding natural habitat.
- Rationalize land-use planning.
- Set up systems of communal ownership and management rights.

Source: UN Millennium Project 2005a

farmers’ rights. In addition to directly protecting farmers’ rights, measures to protect genetic resources and ensure benefit sharing may be valuable. These may include:

- Fair and equitable allocation of profits to local communities from which genetic material was obtained;
- Adhering to local law and respecting and protecting local cultures and resources; and
- Adhering to the CBD, particularly Article 8J, and the International Labour Organization (ILO) Convention No. 169 Concerning Indigenous and Tribal Peoples in Independent Countries.

In 1998, the Council of Ministers of the AU adopted the Model Law for the Protection of the Rights of Local Communities, Farmers, Breeders and Regulation of Access to Biological Resources. This serves as a basis for African countries to develop national law which fulfils their obligations to TRIPS and to the CBD, while protecting the collective social process of knowledge and technology generation.

BIOSAFETY AND RISK ASSESSMENT

A biosafety approach would include taking measures to minimize risks to human and environmental health. This could include:

- Ensuring that thorough information is available and that risks are understood and mitigated;
- Products containing GMOs must be clearly labelled and information readily available;
- Clear and fair liability laws and producer responsibility; and

- Genetic and biological material should be managed and contained to high standards.

Evidence-based GMO risk assessments to assure transparent decision making based on human health and ecological data need to be developed. Risk assessments should be on a case-by-case basis as results obtained from other countries might not be replicable. Deliberative approaches should be considered.

The controversy around risks and opportunities demonstrates the need for effective multilevel assessment procedures that incorporate a precautionary approach as envisaged under the Cartagena Protocol. This policy and legislative approach needs to be complemented by capacity development. Countries need to have the capacity to identify GMOs and also to evaluate the risks associated with them.

RISK MANAGEMENT

Possible mitigation plans should be in place in case undesirable outcomes are experienced. This requires that African countries should establish efficient traceability systems as part of their mitigation measures.

RESEARCH PRIORITY-SETTING

Agricultural research, including transgenic research, needs to focus on African realities and needs. African agriculture is largely small-scale and relies on polycultures, which consists of many crops being grown on the same plot with possibilities of symbiotic leguminous relationships providing nitrogen fixation (Makanya 2004). In addition to intercropping, trees and shrubs (agroforestry) are the anchor perennial species, providing *mycorrhiza* for mobilizing phosphorus and other nutrients, and these trees and shrubs promote soil protection against erosion by wind and water. Also, each of Africa's main staples and about 300 leafy vegetables have perennial cultivars and provide a starting point for the genetic selection and breeding of the best cultivars to incorporate into the traditional tree-and-shrub polyculture in farming households (Odhiambo 2001). Development of GMOs should aim to tap these special qualities of Africa's native flora and fauna in the efforts to improve food security and make genetic engineering beneficial to Africa's environment and development.

Research will need to be based on meaningful partnerships between users and researchers if it is to be more responsive to local needs (Jones 2005). Given



Genetic engineering, Egypt. Agriculture project researching into GM foods.

Source: J. Schytte/Still Pictures

Box 13: Biotechnology for smallholder farmers

Biotechnology research that is appropriate for smallholder farming includes biotechnologies which:

- are affordable;
- do not restrict or prohibit farmers from saving and exchanging seed;
- are responsive to local livelihood contexts;
- are appropriate to patterns of labour availability;
- are suitable for use in a multicrop system;
- have traits such as increased drought tolerance, nutrient-use efficiency and disease resistance;
- are suitable and safe for the local ecosystem; and
- are backed by appropriate support, including access to credit, markets and extension services.

Source: Glover 2003a

the multiplicity of CSOs and other public interest groups. there is considerable opportunity for developing such partnerships.

Partnerships with the private sector are essential for the sharing of technologies, information and knowledge.

SOUND LEGAL AND POLICY FRAMEWORK

A sound legal and policy framework for assessing risks and benefits, regulating research, monitoring research and commercialization, as well as protecting rights, is essential. There needs to be complementarity between the various levels of law and policy, from the global to the local, as well as across different sectors (eg agriculture and technology) and different sets of rights (eg IPRs and farmers' rights).

Legal frameworks need to recognize key legal principles and rights that are applicable to the development and application of GM technologies. These include precaution; rights to participation and access to information; rights to development as well as a safe and healthy environment; IPRs, indigenous knowledge and farmers' rights; and issues of legal responsibility. Useful measures that can support an effective legal framework could include labelling and risk assessment and management. For traceability of GM products, country of origin labelling should be fully enforced also for the purposes of record-keeping and informing the public who can then make a choice whether or not to use the products.

Although, under WTO agreements, countries need to adopt IPR legislation, in doing so they have a fair amount of latitude. They need to tailor IPR legislation so

that it supports them in achieving their development objectives. They can address concerns about domination of world food production by, for example, excluding plants and animals from patent protection. Farmers can be protected by explicitly allowing them to save, re-use and exchange harvested seed. There may be a need to engage and negotiate with multinational corporations through their global federations (such as Crop Life International). Lessons can be learnt from the experience of countries such as India which have succeeded in attracting investment in this area while at the same time protecting the interests of small farmers.

CAPACITY-BUILDING

Building capacity in biosafety is a broad task. It includes training individuals in the scientific, legal and policy aspects of risk assessment as well as enhancing research capacity. There needs to be capacity-building of existing institutional talent and establishment of sound research, development, and extension, marketing and monitoring units. Efforts to foster cooperation and scientific advisory committees at sub-regional levels are encouraged.

Agricultural research throughout Africa has yielded high returns financially and improved livelihoods. However, today agricultural research is under threat from decreasing capacity as a result of inadequate government investment and a series of externally imposed conditionalities (Scoones 2005). Privately-driven R&D has been unable to fill this gap and it is crucial that Africans increase investment in research systems.

Partnership is central to building capacity in R&D. The application of modern biotechnology to agricultural research systems across the developing world calls for new investments, changes in resource allocations and new responsibilities for policymakers, research managers and scientists alike. Improving research capacity through developing partnerships, to solve local problems, with institutions that have advanced technologies, human resources, laboratory infrastructure and funds for routine administrative work are necessary. African countries might benefit from the pooling of resources for R&D of GMO technologies. Where patentable products are developed, there will be a need for serious consideration on the subsequent equitable utilization of the accrued income. African countries need to increase their own investment in capacity-building.

The application of biosafety principles serves to minimize the risks of GM technologies. Agenda 21, and the CBD and its Cartagena Protocol on Biosafety (2000) are international instruments that address biosafety issues. Many African nations do not have the capacity

to implement this protocol; they lack capacity in terms of expertise, equipment, infrastructure, legislation and regulatory systems (Diouf 2001).

Capacity needs to be built to enable African countries to engage more effectively in global policy fora so that multilateral instruments do not compromise Africa's interests.

CONCLUSION

Developing a sustainable agricultural strategy that ensures food security, does not threaten the environment or biodiversity, and promotes human well-being must be a priority for Africa. Africa is faced with the decision of whether GM crops can be part of this, and if so, how to manage the risks and uncertainties associated with GM technology. In evaluating the options, Africa needs to consider the potential benefits from possible yield gains and a decrease in the need for chemical use against the threats posed to biodiversity, livelihoods and cultural systems.

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