# Review report on progress in the implementation of sustainable development commitments related to biotechnology in Africa

United Nations
Economic Commission for Africa

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# Acronyms and abbreviations

| | |
|---|---|
| AATF | African Agricultural Technology Foundation |
| AGERI | Agricultural Genetic Engineering Research Institute |
| AMCOST | African Ministerial Council on Science and Technology |
| ARC | Agricultural Research Council (South Africa) |
| ARC-OVI | Agricultural Research Council-Onderstepoort Veterinary Institute |
| ASARECA | Association for Strengthening Agricultural Research in Eastern and CentralAfrica |
| AU | African Union |
| BIO-EARN | East African Regional Programme and Research Network for Biotechnology, Biosafety and Biotechnology Policy Development |
| CAADP | Comprehensive Africa Agriculture Development Programme |
| CBD | Convention on Biological Diversity |
| CFTs | Confined Field Trials |
| CGIAR | Consultative Group on International Agricultural Research |
| CIAT | International Centre for Tropical Agriculture |
| INERA | Institute of Environmental and Agricultural Research |
| CIMMYT | International Maize and Wheat Improvement Center |
| CIP | International Potato Center |
| COMESA | Common Market for Eastern and Southern Africa |
| CSIR | Council for Scientific and Industrial Research |
| CSIRO | Commonwealth Scientific and Industrial Research Organisation |
| DDPSC | Donald Danforth Plant Science Center |
| IITA | International Institute of Tropical Agriculture |
| EAC | East African Community |
| EMBRAPA | Agricultural Research Corporation (Brazil) |

| | |
|---|---|
| FAO | Food and Agriculture Organization |
| FARA | Forum for Agricultural Research in Africa |
| GMOs | Genetically Modified Organisms |
| IFPRI | International Food Policy Research Institute |
| ILRI | International Livestock Research Institute |
| ISAAA | International Service for the Acquisition of Agri-biotech Applications |
| JPOI | Johannesburg Plan of Implementation |
| KARI | Kenya Agricultural Research Institute |
| LMOs | Living Modified Organisms |
| NARO | National Agricultural Research Organisation |
| NBFs | National Biosafety Frameworks |
| NEPAD | New Partnership for Africa's Development |
| NERICA | New Rice for Africa |
| NGICA | Network for the Genetic Improvement of Cowpea for Africa |
| PBS | Programme for Biosafety Systems |
| PFIA21 | Programme for Further Implementation of Agenda 21 |
| SABIMA | Strengthening Capacity for Safe Biotechnology Management in sub-Saharan Africa |
| SADC | Southern African Development Community |
| SPS | Sanitary and Phytosanitary Measures |
| TBT | Technical Barriers to Trade |
| UNCED | United Nations Conference on Environment and Development |
| UNEP-GEF | United Nations Environment Programme-Global Environment Facility |
| USAID | United States Agency for International Development |
| WEMA | Water Efficient Maize for Africa |
| WHO | World Health Organization |
| WTO | World Trade Organization |

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# Executive summary

This Review report takes stock of progress made in Africa and concrete actions taken to implement sustainable development resolutions and outcomes of the 1992 United Nations Conference on Environment and Development (UNCED) and related summits. It focuses on commitments related to Agenda 21, the Programme for the Further Implementation of Agenda 21 (PFIA21) and the Johannesburg Plan of Implementation (JPOI). The commitments underscore the need to promote access to biotechnology and its benefits in order to achieve sustainable development. It stresses the importance of enhanced scientific and technical cooperation on biotechnology and biosafety. Equally important is the transfer and handling of biotechnology and its benefits, and the need to build biosafety capacity.

The report presents a comprehensive account of Africa-related regional and subregional initiatives on biotechnology. It also addresses constraints and challenges, lessons learned, emerging trends and opportunities for harnessing biotechnology to achieve sustainable development. Given the cross-cutting and universal nature of biotechnology applications, the report has identified important inter-linkages between biotechnology and other relevant sectors for the region, notably biodiversity, forests, tourism and mountains. Biotechnology helps conserve and restore biodiversity, forests, mountains and tourist attractions. Conversely, these ecosystems are an important source of biological resources for biotechnology research and development.

The report acknowledges the role that international regimes, regional processes and country-specific policies and institutional and legal arrangements have played in shaping Africa's sound use of biotechnology in her quest for sustainable development. Progress made by various African countries in integrating biotechnology into their sustainable development agenda is closely linked to the policy/political landscape and the nature of legislation put in place or applied to regulate the technology.

Most African countries have signed and ratified international agreements that govern the responsible and sustainable use of modern biotechnology. The agreements include those that address plant and animal health, environmental and food safety and international trade. Agreements that emphasize the sound management of biotechnology include the Convention on Biological Diversity (CBD), the Cartagena Protocol on Biosafety and the Nagoya-Kuala Lumpur Supplementary Protocol on Liability and Redress.

At the regional and subregional levels, the continent has demonstrated the political will to integrate policies on biotechnology into programmes of the African Union (AU). Many African countries are adopting biotechnology steadily to spur development and alleviate poverty. This is recommended in the Science and Technology Consolidated Plan of Action (CPA) of the AU-New Partnership for Africa's Development (NEPAD) Planning and Coordinating Agency. The CPA focuses on the safe development and application of biotechnology, and on building a common African strategy for biotechnology. A Biosafety unit has been created and institutionalized within permanent structures of the African Union Commission. In 2008 the AU/NEPAD's Office of Science and Technology, established the African Biosafety Network of Expertise to build the capacity of African countries in making informed science- and evidence-based decisions on the application of modern biotechnology. The AU/NEPAD agency, African Biosciences Initiative (ABI), was launched in 2005 to facilitate the use of bioscientific innovations in addressing Africa's problems concerning agriculture, health and the environment.

The Forum for Agricultural Research in Africa (FARA) has expanded its portfolio to include continental priorities on biosafety and biotechnology. This was made concrete with the launch of the project on Strengthening Capacity for Safe Biotechnology Management in sub-Saharan Africa (SABIMA). The Pan African Veterinary Vaccine Centre (PANVAC), located in Ethiopia, is another outstanding regional initiative. It was launched in March 2004 as a specialized agency within the African Union Commission's Department of Rural Economy and Agriculture. Its role is to support AU member States' efforts to control and eradicate animal diseases.

Regional Economic Communities (RECs), including the Common Market for Eastern and Southern Africa (COMESA), the Southern African Development Community (SADC), the Economic Community of West African States (ECOWAS) and the East African Community (EAC) have launched initiatives dedicated to the regional harmonization of biosafety policies. By promoting the sharing of knowledge, expertise, experiences and resources, regional approaches to biosafety are expected to bolster regional integration goals and foster inter-country cooperation.

At the national level, the majority of African countries have made remarkable progress in establishing mechanisms to develop environmentally sound biotechnology applications. This has taken the form of National Biosafety Frameworks (NBFs), whose implementation is, nevertheless, a challenge. Only three countries–Burkina Faso, Egypt and South Africa–have progressed from developing NBFs to implementing them so as to harness the benefits of biotechnology. To date the adoption and commercialization of genetically modified crops on the continent is limited to these three countries. Only six other countries (Ghana, Kenya, Malawi, Nigeria, Uganda and Zimbabwe) have begun confined and/or multilocation field trials. Inadequate capacity, compounded by strict liability regulations and lack of a supportive political environment, has slowed down research trials or made it difficult to market biotechnological products in the other countries.

This notwithstanding, biotechnology has made significant contributions to improving health care and food security in Africa. This is attributed to: the development of appropriate technologies and sustainable agricultural practices; more efficient and clean industrial and environmental processes, and; sustainable approaches for managing and conserving biodiversity. The past two decades have witnessed an increase in investments in biotechnology research and development. As such, the continent has considerably boosted the availability of food, feed, fibre and renewable raw materials. Biotechnology products have played a crucial role in enhancing food security, household incomes and multiplier effects across the socioeconomic welfare spectrum.

Steady progress in medical biotechnology and cutting-edge developments in genomics and bioinformatics have made it possible to develop drugs, diagnosis and the early treatment of many diseases and disorders, such as diabetes. Animal health and livestock experts are using biotechnology discoveries to improve animal health and production. For example, in Uganda, recombinant vaccines have been developed for East Coast fever (*theileriosis*) and New Castle diseases.

Forestry biotechnology is helping African countries to conserve forest resources and use them sustainably. A typical example is the Tree Biotechnology Project Trust in Kenya, which has the largest single forest tree clonal nursery in East and Central Africa. The adoption of pest- and disease-resistant biotech crops, such as Bt cotton and Bt maize, has enhanced the protection of biodiversity and helped reduce the amount of agrochemicals released into the environment.

A number of networks have been established to boost research and development in different aspects of biotechnology, among other agricultural research activities. They include the Association for Strengthening Agricultural Research in Eastern and Central Africa. The West and Central African Council for Agricultural Research and Development has included biotechnology and biosafety among its technical research programmes designed to deliver the goals of the Comprehensive Africa Agriculture Development Programme (CAADP). Incepted in 1998, the Eastern Africa Regional Programme and Research Network for Biotechnology, Biosafety and Biotechnology Policy Development (BIO-EARN) played a pivotal role in developing Eastern Africa's capacity in biosciences, biotechnology policy and biosafety assessment. BIO-EARN has since been rebranded as Bio-Innovate, which works with a broad range of actors to deliver new products, using bioscientific systems of innovation.

## Implementation: challenges and constraints

In spite of the progress in developing legal frameworks, translating policy into practice in Africa has been slow. This is attributed to a variety of reasons, including:

***Political commitment and priority setting***: The majority of African countries have not integrated the biotechnology agenda into national development policies. In the absence of identified priorities, it is difficult for the countries to make informed decisions and formulate long-term policies.

***Funding and capacity building***: Research and development in modern biotechnology demands considerable knowledge and capital, with hefty financial implications. Short-term erratic and low-level financing of research and development in biotechnology is a major constraint across the continent. Few countries have the scientific and technological capacity to conduct modern research and development in biotechnology.

***Biosafety regulation***: Biosafety regulations play a key role in the sound use of biotechnology. However, strict liability laws and regulations may stifle scientific and technological innovations and prevent African countries from implementing sustainable development commitments related to biotechnology.

***Transfer of technology and intellectual property rights***: Many African countries lack elaborate mechanisms and policies for promoting public/private partnerships in the transfer of technology. Institutions for administering intellectual property rights (IPRs) are still in their infancy.

***Communication, awareness and public participation***: Polarizing debates and negative public perceptions make it difficult for biotechnology to take hold. Misinformation remains a key impediment to the adoption of biotechnology in Africa.

## Conclusions and recommendations

African countries are embracing research and development in biotechnology at various levels to cope with the increasing demands for food, feed, fibre and fuel. The application of such research and development in Africa cuts across the sectors of agriculture, environment, health and industry. However, a comparison between Africa and other regions of the world depicts an emerging technological divide. This could be due to several reasons, including: policies and legislation based on precautionary approaches; considerable skepticism surrounding genetically modified applications in agriculture; lack of a strong political will, commitment, and clear policy directions; lack of mechanisms to access scientific evidence for informed decision-making; low levels of funding; the absence of functional biosafety regulatory frameworks, and; inadequate human resources and infrastructural capacity.

The following recommendations are proposed as a means to address the challenges and constraints in the development and application of biotechnology for sustainable development in Africa.

***Political commitment and priority setting***: It is crucial for African governments to demonstrate a sustained political will and commitment to support biotechnology as a matter of priority. Governments should formulate policies to attract and encourage private-sector participation in biotechnology research and development, support the formation of incubation hubs in public universities and help foster links with the private sector for marketing purposes.

***Funding and capacity-building***: There is a need to increase national investment plans in research, including in biotechnology, to ensure adequate and consistent funding for biotechnological research and development. African countries require steady and demand-driven capacity-building to be able to apply cutting-edge biotechnology while keeping up with rapid technological advancement.

***Biosafety regulation***: It is important to support the creation of science-based regulatory systems at the national and institutional levels. However, countries should guard against imposing strict liability provisions that might undermine their potential to implement commitments to biotechnology.

***Technology transfer and IPRs***: African countries should support and strengthen existing and new technology transfer mechanisms. They should also strengthen intellectual property systems that reconcile the need to reward inventors while promoting the freedom to innovate.

***Communication, awareness and public participation***: African governments should take the lead role in promoting understanding of biotechnology. Well-coordinated, credible communication strategies and programmes to enhance public awareness and engagement are crucial in building public confidence, trust and acceptance of the technology.

# 1. Introduction

In 1987, the World Commission on Environment and Development published a landmark report - *Our Common Future* - that first described the concept of sustainable development as, "development which meets the needs of the present without compromising the ability of future generations to meet their own needs" (Drexhage and Murphy, 2010). In 1992, the United Nations Conference on Environment and Development, also known as the Earth Summit, was held in Rio de Janeiro, Brazil. Governments attending the conference reached concrete resolutions and adopted several documents, including Agenda 21 and the Convention on Biological Diversity. The conference reached a global consensus and political commitment at the highest level to pursue sustainable development. Chapter 16 of Agenda 21 deals with the environmentally sound management of biotechnology. The chapter recognizes two fundamental issues. Firstly, biotechnology has the potential to address many environmental and developmental challenges including "better health care, enhanced food security, interventions in areas of forestry and more efficient industrial applications and processes". Secondly, the chapter cautions that efforts to maximize benefits from modern biotechnology should include adequate safety measures (biosafety) and considerations. The Programme for the Further Implementation of Agenda 21 (PFIA21) adopted in 1997 focuses on: facilitating the transfer and handling of biotechnology and its benefits, and; the need for biosafety capacity-building. The JPOI, reached at the conclusion of the World Summit on Sustainable Development in 2002, underscores the need to promote access to biotechnology and its benefits. It also stresses the importance of greater scientific and technical cooperation on biotechnology and biosafety.

Biotechnology is a collection of scientific methods that use living things to make useful products, improve plants or animals or to develop microorganisms for specific purposes. The 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". This report broadly covers traditional and modern biotechnologies as the two major branches of the technology.

Traditional biotechnology refers to early forms of using living organisms to produce new commodities or modify existing ones. The developments and modifications were achieved at the organism, not cellular level. It includes such techniques as selective breeding, fermentation and hybridization. Traditional biotechnology has been used since the ancient times to make new products or modify existing ones, such as bread baking, beer brewing and turning milk to cheese. Historically, farmers have relied on selective breeding and cross-fertilization to modify plants and animals to improve food production and satisfy other human needs (CBD and UNEP, 2003).

Modern biotechnology refers to applications that use genes, cells and living tissues in a predictable and controlled manner. Examples of these techniques include: recombinant DNA techniques (rDNA or genetic engineering), tissue culture, mutagenesis, genomics and bioinformatics. Modern biotechnology began with the 1953 discovery of the structure of deoxyribonucleic acid (DNA). Earlier discoveries enhanced understanding of the functional aspects of genes. The discovery of DNA, which contains the biochemical instructions of how an organism functions, laid the groundwork for the transition from traditional to modern biotechnology. It made it possible to produce desired changes in an organism through the direct use of its genes in a precise, controlled and less time-consuming fashion compared to traditional biotechnology techniques (CBD and UNEP, 2003).

## 1.1 Purpose and outline of the report

The Africa review report on progress in the implementation of sustainable development commitments related to biotechnology in Africa takes stock of gains made on the continent and of concrete actions taken to implement sustainable development. It focuses on commitments related to biotechnology with a focus on Agenda 21, PFIA21 and the JPOI. It also addresses constraints and challenges, lessons learned, emerging trends and opportunities for exploiting biotechnology to achieve sustainable development. Given the cross-cutting and universal nature of biotechnological applications, the report identifies important interlinkages between biotechnology and other relevant sectors for the region, especially biodiversity, forests, tourism and mountains. Biotechnology helps conserve and restore biodiversity, forests, mountains and tourist attractions. Conversely, these ecosystems are an important source of biological resources for biotechnology research and development. The report concludes with pertinent recommendations for the timely implementation of key sustainable development commitments related to biotechnology.

# 2. Trends in the ratification and implementation of international biotechnology-related commitments in Africa

In its quest for sustainable development, Africa has pursued biotechnology, whose sound application is shaped and influenced by international regimes, regional processes, country-specific policies and institutional and legal arrangements. Policies, the political landscape and legislation on biotechnology have all played a key role in the progress that many African countries have made in integrating the technology into their sustainable development agenda. Various sections of this report analyse the notable achievements and capacity-building initiatives at the international, regional and national levels that have brought about such gains.

African countries are signatories and hence contracting parties to many international agreements that govern the responsible and sustainable use of modern biotechnology. Among the agreements are those on plant and animal health, environmental and food safety, including those governing trade. This section describes globally agreed commitments on biotechnology as well as international frameworks that embrace the sound application of biotechnology. See Annex 1 for a list of the main commitments contained in the JPOI, PFIA21 and A21 on biotechnology.

## 2.1 Agenda 21, the Programme for Further Implementation of Agenda 21, and the Johannesburg Plan of Action

### Agenda 21

Agenda 21 is a non-binding, voluntary United Nations action plan for sustainable development. A product of the UNCED, Agenda 21 recognizes the potential contribution of biotechnology to sustainable development, particularly in the following areas:

a) Increasing the availability of food, feed and renewable raw materials;

b) Improving human health;

c) Enhancing the protection of the environment;

d) Enhancing safety in the use of biotechnology and developing international mechanisms for cooperation, and;

e) Establishing enabling mechanisms for the development and environmentally sound application of biotechnology.

## Programme for the Further Implementation of Agenda 21

The United Nations General Assembly adopted the Programme for the Further Implementation of Agenda 21 at the 11th plenary meeting on 28 June 1997. The aim was to speed up the implementation of Agenda 21 and ensure greater measurable progress towards sustainable development, in time for the next comprehensive review of Agenda 21, planned for 2002. The PFIA21 underscores the urgent need for the conservation and sustainable exploitation of biological diversity and the equitable sharing of benefits arising from the use of genetic resources. It calls upon governments and the international community, with the support of the relevant international institutions, to:

a) Take decisive action to conserve and maintain genes, species and ecosystems so as to promote the sustainable management of biological diversity;

b) Ratify the Convention on Biological Diversity and implement it fully and effectively along with the decisions of the Conference of the Parties, including recommendations on agricultural biological diversity and the Jakarta Mandate on Marine and Coastal Biological Diversity, and; to expedite the implementation of other tasks identified by the Conference of the Parties at its third meeting, on terrestrial biological diversity, as part of the approach adopted by the Convention with regard to ecosystems;

c) Pursue the equitable sharing of benefits arising from the harnessing of genetic resources, as stipulated by the Convention and the decisions of the Conference of the Parties; this includes access to genetic resources and the handling of biotechnology and its benefits;

d) Intensify the search for new and additional financial resources for the implementation of the Convention;

e) Facilitate the transfer of technologies, including biotechnology, to developing countries, consistent with the provisions of the Convention;

f) Respect, preserve and maintain knowledge, innovations and practices of indigenous and local communities regarding traditional life-styles, and; encourage the equitable sharing of the benefits arising from traditional knowledge so that those communities are adequately protected and rewarded, as stipulated by the Convention on Biological Diversity and in the decisions of the Conference of the Parties;

g) Expedite the completion of the biosafety protocol under the Convention on Biological Diversity; ensure that the United Nations Environment Programme (UNEP) International Technical Guidelines for Safety in Biotechnology serves as an interim mechanism during the protocol's development, and complements it after its conclusion; ensure that the protocol's completion includes recommendations on capacity-building related to biosafety; and

m) Stress the need for Parties to the Convention to establish a clearing-house mechanism, consistent with the provisions of the Convention.

## Plan of Implementation of the World Summit on Sustainable Development (Johannesburg Plan of Implementation)

The Johannesburg Plan of Implementation that was adopted at the conclusion of the World Summit on Sustainable Development in September 2002 provides a framework for action to implement the original UNCED commitments. It focuses on water, energy, health, agriculture and biodiversity (WEHAB). The JPOI seeks to promote pragmatic measures for ensuring access to the outcomes and benefits of applying biotechnologies based on genetic resources, in accordance with Articles 15 and 19 of the Convention. This includes greater scientific and technical cooperation on biotechnology and biosafety through, *inter alia*, the exchange of expertise, training of human resources and development of research-oriented institutional capacities.

## 2.2 The Convention on Biological Diversity

The Convention on Biological Diversity entered into force in December 1993. As at the time of finalizing this report in early 2013, all African countries are Parties to the CBD, with the exception of South Sudan. The CBD recognizes that technology includes biotechnology (Article 16) and foresees the need to exploit the potential benefits of modern biotechnology. At the same time, the CBD stresses the need to safeguard against potential risks to biological diversity and takes into account risks to human health. Indeed, Article 8(g) of the Convention obligates contracting parties to develop national biosafety systems. This is further emphasized in Article 19 of the CBD, which deals with the 'Handling of Biotechnology and Distribution of its Benefits'. The article also provides for Parties to the Convention to consider modalities for establishing a protocol to address safety associated with the transboundary movement of living modified organisms (LMOs). This spurred the development and negotiations that led to the adoption of the Cartagena Protocol on Biosafety. While the CBD has strong provisions for advancing the fair sharing of the benefits of biotechnology, the Cartagena Protocol on Biosafety puts heavy emphasis on managing risks of Genetically Modified Organisms (GMOs). Consequently, many African countries have invested heavily in stringent and precautionary regulatory frameworks at the expense of potential and actual benefits that they could reap from embracing biotechnology. For this reason, the creation of an "International Institute for Biotechnology" to champion, support and promote the growth and development of biotechnology is recommended (Juma, 2011).

### 2.2.1 Cartagena Protocol on Biosafety to the Convention on Biological Diversity

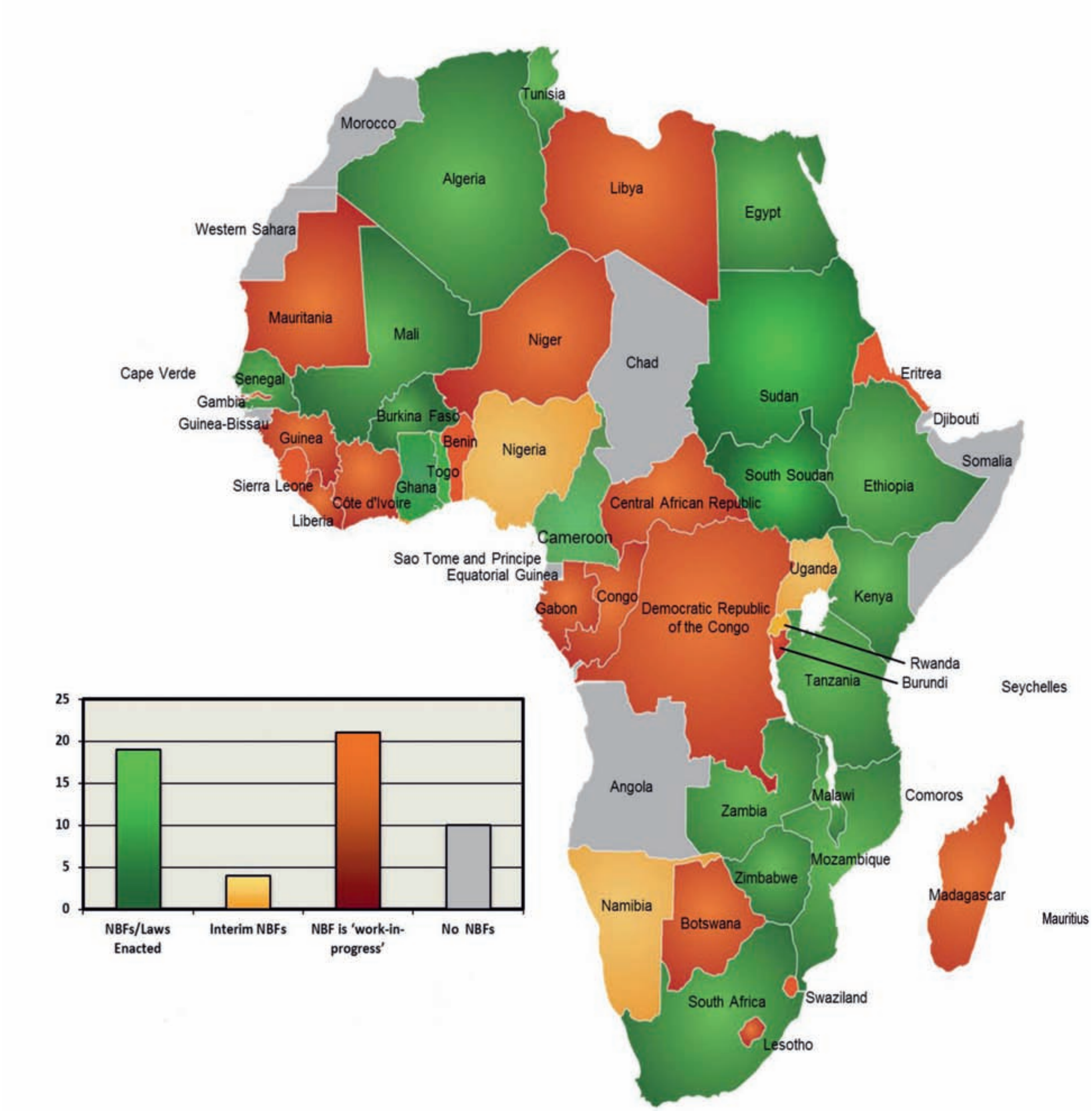
The Protocol was adopted in 2000 as the first global legally binding instrument focusing on living modified organisms. It applies to the transboundary movement, transit, handling and use of all LMOs that could compromise the conservation and sustainable use of biological diversity, and takes into account risks to human health. The Protocol is applicable to all LMOs except those for pharmaceuticals use, which are addressed by other international agreements. In an effort to exploit the potential benefits of modern biotechnology applications, while safeguarding against possible related risks, 49 African countries have so far signed or ratified the Cartagena Protocol on Biosafety. They agreed to take the appropriate legal, administrative and other measures to implement obligations aimed at minimizing the risk that the development, handling, transport, use, transfer and release of LMOs poses to biological diversity. They have also taken into account risks to human health by developing functional national biosafety frameworks. Although components of NBFs tend to vary from country to country, they typically comprise: a policy on biotechnology; a regulatory regime for Biosafety; a system for handling applications and the issuance of permits and; a mechanism for public participation in decision-making on Biosafety. Countries in sub-Saharan Africa typically fall into four categories namely, those: with fully functional NBFs; with interim NBFs; whose NBF is a 'work-in-progress', and; those without NBFs (Nang'ayo and others, 2007). Progress is depicted in Figure 1.

A growing number of African countries are putting in place policies, laws and regulations to govern the development, use and commercialization of GMOs. The state or level of development and application of these instruments varies across the continent. Although many African countries have signed and ratified the Protocol, implementing its requirements remains a daunting challenge to many. Putting in place legal and administrative procedures and structures for the full implementation of the Protocol remains largely a 'work-in-progress'. It will require concerted investment in capacity building to bring Africa to the threshold where it can exploit the benefits of modern biotechnology in a safe and environmentally responsible manner (Nang'ayo and others, 2007).

### 2.2.2 Nagoya-Kuala Lumpur Supplementary Protocol on Liability and Redress

The Nagoya-Kuala Lumpur Supplementary Protocol on Liability and Redress was adopted on 15 October 2010 as a supplementary instrument to the Cartagena Protocol on Biosafety. The objective of the Supplementary Protocol is to support the conservation and sustainable use of biological diversity, while taking into account risks to human health by providing international rules and procedures to regulate liability and redress where LMOs are concerned. The genesis of the Supplementary

## Figure 1. Status of development of NBFs as of May 2012




*Source:* Makinde, 2012.

Protocol can be traced to Principle 13 of the 1992 Rio Declaration on Environment and Development, which appeals to States to "cooperate in an expeditious and more determined manner to develop further international law regarding liability and compensation for adverse effects of environmental damage caused by activities within their jurisdiction or control" (CBD, 2010). Liability and redress refers to the obligation, under the applicable law, to provide for compensation for damage caused by an action for which a particular person is deemed responsible.

Concluding negotiations on liability and redress for damage resulting from the transboundary movements of LMOs was a major milestone in the quest for the environmentally sound application of biotechnology. African countries participated proactively and presented strong position(s) during the deliberations that culminated in the adoption of the Supplementary Protocol. Its entry into force will further reassure African countries and create an environment that will generate maximum benefits from biotechnology while minimizing possible risks to biodiversity and human health. To facilitate the Supplementary Protocol's implementation, countries are allowed to use existing laws or develop new legal, administrative or judicial rules or procedures relevant to liability and redress.

In order for African countries to expedite the ratification of the Supplementary Protocol and incorporate it into national laws, they need to build their capacities for its legal interpretation. They will also need to define and contextualize certain issues so as to determine and meet the Supplementary Protocol's ratification and implementation requirements. This includes deciding whether they need to amend their laws, rules, and/or regulations to implement the Supplementary Protocol. They must take stock of and establish baseline data on biodiversity. They must also develop the necessary skills to evaluate adverse effects on biodiversity, determine the significance of the effects and establish the links between causes and effects (International Food Policy Research Institute (IFPRI, 2011).

## 2.3 The Codex Alimentarius Commission

The Codex Alimentarius Commission was created in 1963 and administered jointly by the World Health Organization (WHO) and the Food and Agriculture Organization's (FAO) Food Standards Programme. It sets sanitary and technical standards for food safety. This includes food standards for commodities, codes of hygiene or technological practices, limits for pesticide residues in foods and standards for contaminants and food additives. The main purpose of the Codex is to ensure that consumers receive products that respect the minimum acceptable quality, and that they are safe and do not present health hazards (Garrett, 2002). The majority of African countries participate in Codex standard-setting processes (http://www.codexalimentarius.org/). In July 2003, the Codex Alimentarius Commission's Ad Hoc Intergovernmental Task Force on Food Derived from Biotechnology reached a landmark agreement to adopt principles on how to evaluate food derived from modern biotechnology (FAO/WHO, 2003a) and on guidelines for assessing the safety of: food derived from recombinant-DNA plants (FAO/WHO, 2003b) and; foods produced using recombinant-DNA microorganisms (FAO/WHO, 2003c).

The 44 African countries listed below participate in Codex standard-setting processes.

**Table 1. Countries participating in the Codex standard-setting processes**

| | | |
|---|---|---|
| • Angola | • Ethiopia | • Mozambique |
| • Benin | • Gabon | • Namibia |
| • Botswana | • Gambia | • Niger |
| • Burkina Faso | • Ghana | • Nigeria |
| • Burundi | • Guinea | • Rwanda |
| • Cameroon | • Guinea Bissau | • Senegal |
| • Cape Verde | • Kenya | • Seychelles |
| • Central African Republic | • Lesotho | • Sierra Leone |
| • Chad | • Liberia | • South Africa |
| • Congo | • Madagascar | • Swaziland |
| • Côte d'Ivoire | • Malawi | • Tanzania |
| • the Democratic Republic of Congo | • Mali | • Togo |
| • Equatorial Guinea | • Mauritania | • Uganda |
| • Eritrea | • Mauritius | • Zambia |
| | • Morocco | • Zimbabwe |

There has been an increased awareness of the practical functions of Codex activities in shaping national legislation and establishing appropriate standards, such as those for labelling. However, many countries have mixed feelings about the adoption and incorporation into national laws of Codex general principles on the labelling of genetically modified foods. While some countries are driven by the need to promote and inform consumer choice, others argue that mandatory labelling and low threshold levels (such as 1 per cent or less) could have adverse effects, ultimately undermining trade and hindering progress in research and development in biotechnology. Studies have found labelling provisions that are precautionary rather than based in science to be discriminatory and excessively stringent compared to Codex requirements. This can influence consumer choice negatively and make genetically modified foods unduly expensive.

## 2.4 World Trade Organization

The World Trade Organization (WTO) is the international body that deals with the rules of trade between member countries. WTO agreements have been negotiated, signed and ratified by the bulk of the world's nations, including most African countries. Two agreements under the WTO have particular relevance to biotechnology. They are: the Agreement on the Application of Sanitary and Phytosanitary (SPS) Measures; and the Agreement on Technical Barriers to Trade (TBT). The SPS Agreement applies when a biotechnology product is likely to pose a risk to human, plant or animal health. It requires that sanitary and phytosanitary measures be applied to ensure safety. The TBT Agreement on the other hand, covers all technical regulations, standards and conformity assessment procedures that do not fall directly under the SPS Agreement. These may include technical regulations and standards on packaging, documentation and labelling requirements. WTO member States are obligated to ensure that TBT prevents deceptive trade practices, without imposing unnecessary obstacles to international trade. However, WTO contracting States are obligated to ensure that any SPS measures they apply are based on existing international standards (developed by the International Plant Protection Convention, CODEX and the *Office international des epizooties*). They must be based on risk assessment that is consistent with the provisions of the SPS Agreement, and must not restrict trade unduly. In case of particularly stringent measures, member countries involved must present scientific justification for such actions or face suits at the WTO arbitration organ. From a policy standpoint, the SPS Agreement is a compromise that permits member countries the sovereign right to safeguard public health within their borders, provided they refrain from restricting trade.

The SPS and TBT agreements under the WTO encourage harmonization among member countries on the basis of internationally accepted scientific standards. The SPS Agreement explicitly recognizes the standards developed by three relevant organizations: the Codex Alimentarius Commission, the World Organization for Animal Health, and the International Plant Protection Convention. These standard-setting bodies have working groups on the safety aspects of GMOs and genetically modified foods. As such, the standards, recommendations and guidelines that they develop should serve WTO members as the basis for sanitary and phytosanitary measures or technical regulations on LMOs (Komen, 2012).

The Agreement on Trade Related Aspects of Intellectual Property Rights is an international agreement administered by the WTO. Biotechnology is often proprietary owing to the heavy investments associated with gene discovery and the entire process of product development, regulatory compliance and product delivery. For these reasons, the protection of intellectual property encourages innovations involving biotechnology. Additionally, intellectual property rights (IPRs) grant incentives for investments, which may lead to new products and processes. Some concerns have been raised about the impact of IPRs on food security. For instance, farmers may be required to enter into contracts with multinational companies for seeds. These contracts, known as Technology use Agreements, would typically prevent farmers from sharing seeds or even saving seeds for the next planting season.

However, the emergence of public-private partnership project models–whereby private-sector owned technologies are negotiated and made available, royalty-free, to African institutions to develop food crops for African farmers–is expected to help overcome the challenges and contribute to food security.

**Box 1: Royalty-free transfer of technology**

The Water Efficient Maize for Africa (WEMA) project is a prime example of the royalty-free transfer of technology. In this instance, the Monsanto Company licensed its technologies, royalty-free, to the African Agricultural Technology Foundation (AATF) and the International Maize and Wheat Improvement Centre (CIMMYT) for use in developing a drought-tolerant variety of maize. Royalty-free seeds will be available to African farmers at a cost comparable to the price of conventional varieties and farmers are free to replant or exchange seeds without risking legal sanctions. Research organizations, particularly in the public sector, have also developed mechanisms for negotiating Freedom To Operate agreements in order to access and use proprietary technologies in the development of public goods (Wekesa and Sihanya, 2005).

## 2.5 International Plant Protection Convention

The International Plant Protection Convention came into force in 1952. It is a legally binding multilateral treaty for cooperation in plant protection, aimed at securing common and effective action to prevent the introduction and spread of pests that affect plants and plant products, and at promoting appropriate measures for their control (www.ippc.int). The Convention requires member Governments to cooperate by developing and adopting International Standards for Phytosanitary Measures (ISPMs). With respect to biotechnology, ISPM Number 11 addresses Pest Risk Analysis for Quarantine Pests, Including the Analysis of Environmental Risks and LMOs. This is consistent with the provisions for risk assessment spelled out in the Cartagena Protocol for Biosafety. The Convention, which, as of January 2013, had 177 contracting parties, including several African countries, is administered by the FAO although it implements its activities through the cooperation of members. Non-contracting countries in Africa are Angola, the Democratic Republic of Congo, Gambia, Lesotho, Somalia and South Sudan[1].

## 2.6 Biosecurity provisions

Biosecurity is emerging as a key area in the development and implementation of regulatory frameworks for food, agriculture, fisheries and forestry. Biosecurity has direct relevance to food safety, the conservation of the environment (including biodiversity), and the sustainability of agriculture. In broader terms, it concerns all policy and regulatory frameworks (such as instruments and activities) required to manage risks associated with food and agriculture (including the relevant environmental risks), fisheries, forestry and other sectors. It comprises three sectors, namely food safety, plant life and health, and animal life and health. The sectors cover the: food safety aspect of food production; introduction of plant pests, animal pests and diseases, and zoonoses; introduction and release of GMOs and their products, and; the introduction and safe management of invasive alien species and genotypes.

Provisions for biosecurity, particularly those touching on food and agriculture, are contained in a number of international instruments. The SPS Agreement of the WTO, the Codex Alimentarius Commission, the International Plant Protection Convention and the *Office international des epizooties* provide international standards for food safety, plant health, and animal health, respectively. The majority of the African countries have acceded to these international instruments and different line ministries and government agencies are responsible for their implementation and enforcement.

1 Updated as of 31 January 2013, https://www.ippc.int/index.php?id=1110618 .

# 3. Concrete action taken, progress and achievements made

## 3.1 Regional commitments and actions

African countries have demonstrated the political will to integrate biotechnological policies into AU programme structures. Many of the countries are steadily adopting biotechnology to spur development and alleviate poverty, as recommended in the AU/NEPAD agency's CPA. In Africa, research and development in biotechnology cuts across the agricultural, environmental, health and industrial sectors. African countries are embracing such research and development at various levels to cope with the increasing demand for food, feed, fibre and fuel. For human and animal health, biotechnology is exploited in the diagnosis and treatment of diseases, as well as the development of drugs and vaccines. Biotechnology is also applied in the sustainable use and conservation of forest resources. Industrial use of biotechnology includes the generation of energy (biogas) from industrial wastes and the conversion of renewable raw materials to substitute fossil fuels. An example is the commercialization of biofuels as a potential substitute for petrol and diesel.

The first NEPAD Ministerial Conference on Science and Technology in November 2003 called the NEPAD Secretariat to build broad consensus on issues of common concern and develop effective strategies including joint Research and Development programs. Also, it would be appropriate to seek ways and means to build Africa's capacity on biosafety for risk assessment and management. Equally important would be to promote the establishment of regional and subregional biosafety facilities and enhance Africa's participation in international processes and discussions on global biotechnology issues (AU, 2006).

At its third ordinary session, held in July 2003 in Maputo, Mozambique, the AU Executive Council adopted Decision EX/CL/Dec.26 (III), which urges member States to acquire the human and institutional capacities to manage biosafety issues while implementing the Biosafety Protocol. The decision also endorsed steps taken by the AU Commission to set up an Africa-wide biosafety system and programmes to strengthen member States' abilities to handle biosafety issues. This strengthened the AU Biosafety Project, which in turn will equip the AU with the necessary capacities and instruments to help member States implement the Cartagena Protocol on Biosafety and the African Model Law on Safety in Biotechnology. The Model Law has been widely criticized as being too restrictive and heavily inclined towards risks, at the expense of the benefits of biotechnology. This may hinder progress for countries wishing to achieve sustainable development by embracing modern biotechnology. The creation and institutionalization of a Biosafety Unit within permanent structures of the African Union Commission (human resources, science and technology department) is another major commitment. The Unit will help member States develop common African positions and strengthen the AU's political stand in the ongoing implementation of the environmental conventions to which most member States are parties (Teshome and others, 2011).

Africa's Science and Technology Consolidated Plan of Action focuses on the safe development and application of biotechnology (Programme 1.2) and building on a common African Strategy for biotechnology (Programme 5.4). The adoption of Africa's Science and Technology Consolidated Plan of Action, in August 2005, by the AU and the African Ministerial Council on Science and Technology, led to the creation of a High-Level African Panel on Modern Biotechnology to provide independent advice and guidance on the role of biotechnology in Africa's economic recovery and transformation. The High-Level Panel presented its conclusions in a report in July 2006. The report's main message was that regional economic integration in Africa should embody the building and accumulation of capacities to exploit and manage modern biotechnology. Regional economic integration bodies play a key institutional role in mobilizing, sharing and using existing scientific and technological capacities – including human and financial resources and physical infrastructure –for research, development and innovation in biotechnology. International partnerships in biotechnology are critical to the realization of Africa's strategies on biotechnology and should be pursued aggressively (Juma and Serageldin, 2007).

In November 2006, the Extraordinary Conference of the African Ministerial Council on Science and Technology (AMCOST), held in Cairo, Egypt, considered the report of the High-Level Panel and a draft strategy on biosafety. Thereafter, Conference participants adopted the Cairo Declaration, endorsing the report and pledging to work together to develop a 20-year strategy for biotechnology in Africa. The strategy seeks to strengthen regional groupings and thereby promote the harmonization of regional and national biosafety policies. It has led to the creation of the AU-NEPAD African Biosafety Network of Expertise. The network is a continent-wide biosafety service provider officially approved in 2008 by AMCOST. Its mandate is to strengthen African countries' capacity to make informed science- and evidence-based decisions governing the application of modern biotechnology (ISSD, 2007).

FARA is the umbrella organization that brings together major stakeholders in agricultural research and development in Africa. FARA's mission is to help Africa's subregional organizations strengthen their capacity for agricultural innovation so as to broaden improvements in agricultural productivity, competitiveness and markets. FARA has expanded its portfolio to include continental priorities in biosafety and biotechnology. The project on Strengthening Capacity for Safe Biotechnology Management in sub-Saharan Africa (SABIMA) is the first of many projects to be launched and managed by FARA, under its African Biotechnology Biosafety Policy Platform (ABBPP). The role of the ABBPP is to strengthen capacity in biotechnology and biosafety in Africa. The SABIMA project is implemented by the national agricultural research systems of Burkina Faso, Ghana, Kenya, Malawi, Nigeria and Uganda (Morton, 2010).

## 3.2 Commitments and developments within Regional Economic Communities and at the subregional level

According to Article 14 of the Biosafety Protocol, countries may enter into bilateral, regional and multilateral agreements and arrangements to manage the transboundary movement of GMOs. A number of regional biosafety initiatives have emerged in response to the fact that biosafety issues transcend national boundaries. If they are not well managed at the regional level, the efforts can disrupt trade or facilitate cross-border movements of GMOs. Regional Economic Communities including COMESA, SADC, ECOWAS and EAC have launched initiatives dedicated to the regional harmonization of biosafety policies. Regional approaches to biosafety, including the sharing of knowledge, expertise, experiences and resources, are expected to bolster regional integration goals and intercountry cooperation. By using regionally acceptable decision-making mechanisms, member countries will be able to assess and manage risks in a harmonized manner. Key issues with trans-border implications include the planting of genetically modified crops, intraregional trade in products containing GMOs and the delivery of emergency food aid with a genetically modified content. Progress in the regional harmonization of biosafety policies led by the RECs is discussed below.

Multiple memberships across the RECs are a common phenomenon. For instance, the Eastern and Southern Africa region comprises three regional economic communities including COMESA, SADC and the EAC. The Democratic Republic of Congo, Madagascar, Malawi, Mauritius, Seychelles, Swaziland, Zambia and Zimbabwe belong to both COMESA and SADC. On the other hand Burundi, Kenya, Rwanda and Uganda belong to both COMESA and the EAC. Tanzania belongs to both SADC and EAC.

While the handling of issues that converge may be an opportunity, reconciling divergent issues across the RECs is likely to pose a major challenge.

## The Southern African Development Community

In 2003 a directive issued by the SADC Council of Ministers established the advisory Committee on Biotechnology and Biosafety (SACBB), comprising members from the 15 representative countries. The committee's role was to consider a regional harmonization effort focusing on: policies for the handling of food aid; biosafety policies and regulations; capacity-building, and; public awareness (Karembu and others, 2009). The recommendations it drew up for biosafety were highly precautionary, right down to language taken directly from the AU Model Law. They formulated guidelines to "safeguard member States against potential risks in the areas of human and animal food safety, contamination of genetic resources taking into account ethical and trade-related issues including consumer concerns" (www.sadc.int). The committee's work has faltered in recent years, plagued by member States' widely polarized viewpoints and their inability to reach consensus.

## The Common Market for Eastern and Southern Africa

In 2003, the COMESA ministers of agriculture endorsed a project by the Regional Approach to Biotechnology and Biosafety Policy in Eastern and Southern Africa (RABESA) to establish mechanisms for the regional management of biosafety. The RABESA project has been implemented in two distinct but interrelated phases focused on forging COMESA members' cooperation in handling biosafety. Phase I, which run from 2004 to 2007, concentrated on policy studies and stakeholder dialogue on: potential farm revenues from the adoption of genetically modified crops; the magnitude of commercial export risks associated with genetically modified crops, and; the delivery of emergency food aid with genetically modified content in the COMESA region. National and regional consultative meetings were convened to deliberate on the scope of policies and guidelines. A regionally harmonized approach to biosafety targets three areas: the commercial cultivation of genetically modified crops; trade in genetically modified products, and; emergency food aid with genetically modified content.

The ministerial meeting also recommended the formation of an interim panel of biotechnology and biosafety experts to advise COMESA on ways of leading the harmonization process. The ministerial directives paved the way for the launch of RABESA phase II in 2008.

In March 2009, the COMESA Secretariat began drafting COMESA Regional Biosafety Policies and Guidelines. A biosafety roadmap and a communication strategy were also drafted. The biosafety roadmap was developed to support the harmonization process. The reason was that countries must have functional biosafety systems in order to belong to a regional biosafety framework and enjoy its benefits fully. The roadmap will encourage and guide more countries in the COMESA region to create national biosafety frameworks, and help them pursue common goals. Countries with functional frameworks can share their experiences and decisions. This will benefit the region as a whole and, in particular, countries with less exposure and capacity. The COMESA communication and advocacy strategy seeks to support and facilitate COMESA's harmonization agenda on biotech policies and biosafety frameworks and to create awareness of the benefits of harmonized regional approaches.

The draft policies and guidelines, roadmap and communication strategy were reviewed extensively by technical experts and through consultations among stakeholders. In April 2010, COMESA organized a regional workshop for member States in Nairobi, Kenya. The aim was to obtain broad stakeholder input for the proposed regional biosafety policies and guidelines, roadmap and communication strategy. Subsequent COMESA ministerial meetings held in Zambia in 2010 and Swaziland in 2011 provided further guidance on how to promote consensus and national stakeholder participation and the involvement of all the member States. The need to convene national workshops in all the COMESA member States was underscored.

To implement the ministers' recommendations, the COMESA Secretariat conducted 18 national workshops between September 2010 and February 2012. The policies and guidelines were revised systematically to reflect comments and input from COMESA member States. A final regional workshop was recommended to consider feedback from national consultations and build consensus before submitting the revised policy document to the Joint COMESA Ministers of Agriculture, the Environment and Natural Resources for endorsement. The regional workshop was held in May 2012 in Zambia primarily to review and validate feedback, comments and recommendations incorporated into the revised draft regional policy document on biosafety. The final policy document is awaiting consideration and endorsement by the Joint COMESA Ministers of Agriculture, the Environment and Natural Resources.

### Box 2: Impacts and outcomes of the RABESA project

The AU has recognized the RABESA project as one of the outstanding models of regional harmonization in biosafety on the continent. The AU acknowledges the need for regional economic integration in Africa to include the building and accumulation of capacities to harness and manage modern biotechnology (Juma and Serageldin, 2007). This has elicited the AU's representation and active participation in some of the regional workshops organized by COMESA.

Several studies have been conducted in Africa on the potential effects that adopting genetically modified crops might have on farming. Nevertheless, RABESA made an innovative and valuable contribution by breaking new ground and exposing the effects of GMOs linked to trade and emergency food aid.

In 2010, COMESA created a biotechnology and biosafety unit as part of its specialized agency, the Alliance for Commodity Trade in Eastern and Southern Africa. A major spillover of the RABESA project, the unit has conspicuously emerged as the COMESA regional focal point on biotechnology and biosafety.

#### Lessons learned

Important lessons have been learned during the implementation of the RABESA project over the past eight years. Key among these are the following:

- Issues regarding regional harmonization should be handled in a consultative, participatory and inclusive manner. Deliberations cutting across the entire life cycle of the project have taken place in 24 national workshops and 4 regional workshops.
- Regional harmonization of biosafety policies is a technical and political process that requires strong political will and commitment at various levels within member States. The progress made so far, and political buy-in, are the result of the RABESA project being a key and recurrent agenda item in various ministerial meetings. The ministers initiated the RABESA project, which has been on the agenda of five COMESA ministerial meetings (Sudan 2007, Seychelles 2008, Zimbabwe 2009, Zambia 2010 and Swaziland 2011). Ministerial meetings are held once a year and the project's implementation pace is determined by resolutions and recommendations made during the meetings. The COMESA policy organs will endorse the final decision on the proposed biosafety policies and guidelines. The organs are essentially political and it is important to accommodate the dynamics associated with them.
- National sovereignty is a fundamental and sensitive issue. It is important to spell out clearly the convergence and divergence between national and regional frameworks and handle pertinent concerns carefully. This will help dispel fears that the regional process may infringe on or override national interests.
- There is a need to step up awareness and outreach efforts in order for countries to appreciate the benefits of a harmonized approach to decision-making concerning biosafety. This calls for a focused and demand-driven communication and advocacy strategy.
- The implementation of a regional initiative of RABESA's magnitude calls for strong and sustained partnerships. Right from the onset, COMESA engaged strategic partners with varied strengths and competencies to support the project's implementation and take advantage of complementarity. The diversity and status of the partnerships also reinforce the profile and credibility of the project and the process. A high level of commitment, consistency and patience from the partners is indispensable for long-term regional harmonization processes such as RABESA.

## Economic Community of West African States

The ECOWAS regional biosafety initiative began back in 2004 as a project led by the Sahel Institute (INSAH) to develop a regional convention. The convention established a common biosafety regulatory system in the countries of the Permanent Interstates Committee for Drought Control in the Sahel (CILSS) as well as a regional coordination framework. The draft documents that were developed by the organization established a regional regulatory system where: each country establishes its own national biosafety regulatory system using procedures, definitions and responsibilities laid down by its competent national authority, as stipulated in the Cartagena Protocol process; the national authorities make most of the decisions on the authorization of activities that involve GMOs; the INSAH/CILSS Regional Consultative Committee reviews and advises on proposed national decisions on specific GMOs and provides general technical and policy support to the competent national authorities; and the Regional Consultative Committee makes some authorization decisions for countries without a regulatory framework or when products are to be marketed throughout the region. In most cases, the proposed regional system was a decentralized and nonbinding one that placed legal authority for authorizations with each member country. Its role was primarily to harmonize, support technically and oversee the procedures used to make authorization decisions through the Regional Consultative Committee.

Before the CILSS countries could finalize their regional convention and begin the adoption process, the process was handed over to ECOWAS, which used existing documents as a basis for a broader regional initiative covering all of its countries. After ECOWAS began reviewing the documents, however, the West Africa Economic Monetary Union (WAEMU) launched its regional biosafety project, prompting West African countries to request that the two separate projects work together towards a harmonized approach. That has been done over the past two years, resulting in a regional biosafety regulation discussed below in the section on WAEMU.

It should be noted, however, that the regional regulation currently being reviewed by ECOWAS countries under that joint initiative is significantly different from the documents developed by CILSS. If that process does not result in a single harmonized regulation in the region, ECOWAS countries might benefit from reviewing CILSS biosafety documents afresh because they have laid down valuable procedures and guidelines that would allow for more uniform and science-based biosafety regulatory systems in the region (IFPRI, 2011).

## West Africa Economic Monetary Union

WAEMU launched the West Africa Regional Biosafety initiative in June 2009 with funding from UNEP's Global Environment Facility and the World Bank. The primary objective is to harmonize biosafety regulations in the eight WAEMU countries to protect each member country from potential risks associated with the introduction of LMOs, and to support capacity-building assistance for policy development. WAEMU's four main goals are as follows:

- The development of common methods of risk assessment and environmental risk management
- The development of a common framework for biosafety regulations
- The development of specific regulations and standards covered by the framework
- The establishment of a regional biosafety laboratory in Burkina Faso.

When the project was started in 2009, however, it was agreed that WAEMU would work with ECOWAS. The two bodies drafted a joint regional biosafety framework, which could be adopted by all the West African countries, not just members of WAEMU. They also conducted numerous consultative meetings to discuss the draft in their member countries. While significant feedback has been received from the countries, the current status of the draft remains unclear. WAEMU and the World Bank recently conducted a mid-term evaluation of the biosafety project and regional regulation is no longer a high priority of that project, although it can still move forward if WAEMU and ECOWAS determine that it is of value.

A recent draft of the ECOWAS/WAEMU regional biosafety framework was made public during the country consultation stage. The draft is significantly different from the one developed by CILSS. It sets forth a fairly strong centralized body to approve decisions on commercial GMO products and allows for the mutual recognition of GMOs to make trading in GMO products easier among countries. However, the draft also covers several topics that are highly controversial internationally, including the incorporation of socioeconomic and ethical considerations into approvals and decision-making and the creation of stringent liability and redress standards in the event that GMOs cause harm. Given the feedback that the regional bodies received from member countries and interested international stakeholders, it is unclear whether this document will move forward and what changes, if any, will occur in that process (IFPRI, 2011).

### The East African Community

Some of the RECs have incorporated provisions on biosafety in regional integration instruments. The East African Community Protocol on Environment and Natural Resources Management covers biosafety and biotechnology under Article 26. The Protocol states that Partner States shall develop and adopt common policies and laws that would harness the potential benefits of modern technology and prevent harmful effects of technology (AU, 2011).

## 3.3 Concrete actions taken

By incorporating the Biosafety Protocol into national laws, Parties affirm their commitment to be bound by its provisions. The provisions require Parties to establish biosafety procedures for the transboundary movement, transit, handling and use of LMOs that may have adverse effects on the conservation and use of biological diversity. At the same time the procedures take into account risks to human health. African countries have made remarkable progress in developing mechanisms for the promotion and environmentally sound use of biotechnology. These include developing and implementing National Biosafety Frameworks that combine policy, legal, administrative and technical instruments to ensure adequate protection and safety in the transfer, handling and use of LMOs. The NBFs meet the Cartagena Protocol on Biosafety's requirements for risk assessment and management, contained in Articles 15 and 16 respectively. In developing national biosafety laws, policies and regulations, countries have been careful to identify and assess the potential risks associated with various categories of GMOs. In most countries, national biotechnology policies were developed with similar fundamental objectives covering: the promotion of research and development in biotechnology to alleviate poverty and sustain development; building Africa's capacity to develop and safely apply biotechnology in agriculture, health, mining, industry, biofuels and other areas, and; science-based policies to promote food security and spur economic growth.

In the present setup, decisions on biotechnology are based on and reinforced by explicit or implicit national policies and legislation. Explicit policies are stand-alone and specifically formulated to address biotechnology. Implicit refers to cases whereby sectoral policies and laws concern aspects of biosafety. Generally the regulatory framework addresses important aspects of the handling of GMOs for: research purposes (contained and confined use); provisions for risk assessment and management before and after the environmental release of GMOs, and; issues related to marketing and trade (import, export and transit). Various countries have institutional arrangements for regulating biotechnology. Bodies responsible for biosafety fall under different ministries. Countries with biosafety laws have set up autonomous bodies. For instance, Kenya and Zimbabwe have established a national biosafety authority and a biosafety board, respectively.

**Table 2. Hosting of Biosafety Competent Authorities**

| | Country | Focal Ministry |
|---|---|---|
| 1 | Egypt | Agriculture and Land Reclamation |
| 2 | Ghana | Ministry of Environment, Science and Technology |
| 3 | Kenya | Higher Education, Science and Technology |
| 4 | Malawi | Ministry of Environment |
| 5 | Mauritius | Agriculture, Food Technology and Natural Resources |
| 6 | Swaziland | Ministry of Tourism, Environment and Communication |

### 3.3.1 Eastern and Southern Africa

#### Policies and legislation

More than 90 per cent of the regions' countries have developed their national biosafety frameworks with assistance from UNEP-GEF. However, the implementation of NBFs is at different stages of progress. In Eastern Africa, Kenya, Tanzania and

**Table 3. Summary of subregional status of biosafety policies and legislation in Africa**

| | Eastern | Central | West Africa | Southern Africa | North |
|---|---|---|---|---|---|
| Enacted Biosafety Laws | Ethiopia, Kenya and Tanzania | Cameroon | Burkina Faso, Ghana, Mali, Nigeria, Senegal and Togo | Malawi, Mauritius, Mozambique, Namibia, South Africa, Swaziland, Zambia, and Zimbabwe. | Libya and Sudan |
| Draft biosafety bills | Burundi, Eritrea, Madagascar, Rwanda, Seychelles and Uganda | The Democratic Republic of Congo | Côte d'Ivoire and Guinea-Bissau | | Egypt, Tunisia and Morocco |
| Approved biotech/ biosafety policy | Kenya, Madagascar Seychelles and Uganda | Cameroon | | Malawi, Namibia, Swaziland, Zambia and Zimbabwe | Sudan |
| Draft biotech/ biosafety policy | Eritrea, Comoros and Rwanda | The Democratic Republic of Congo | | | Libya |
| Sectoral legislation with reference to biosafety | | | | | Egypt and Libya |
| Sectoral biotech/ biosafety policies with reference to biotech and biosafety | Djibouti | | | Mauritius | |

***Source:*** Wafula and others, 2012.

Uganda have developed national biotechnology policies. Ethiopia, Kenya and Tanzania have enacted biosafety laws and gazetted biosafety regulations. Uganda has a draft biosafety bill awaiting parliament's approval. Burundi, Djibouti, Eritrea and Rwanda have draft biosafety policies and bills pending approval by the relevant government authorities. Regulatory systems in Kenya and Uganda have granted approvals for contained and confined field trials, as well as the importation and transit of GMOs. Other countries have not achieved similar levels of development.

Countries that have approved national biosafety policies and enacted relevant laws in Southern Africa include Malawi, Mauritius, Mozambique, Namibia, South Africa, Zambia and Zimbabwe. They have also established competent national authorities. Additionally, Zambia and Zimbabwe have established National Biosafety Authorities, while Malawi has created its National Biosafety Regulatory Committee. South Africa is the regional leader in biotechnological research and development. The country's biosafety system authorizes the production, exportation and importation of genetically modified products. Biosafety regulatory systems of Zimbabwe and Zambia emphasize a cautious approach to GMOs, which has affected research and development in biotechnology.

## Research and development in biotechnology

In Eastern Africa, most of the research and development in agricultural biotechnology focuses on mitigating production constraints (biotic and abiotic) and enhancing the productivity of major crops. The level of progress in Kenya and Uganda is advanced compared to the rest of the region. The two countries are engaged in intermediate and advanced biotechnology applications. Apart from agriculture, the two countries also have a range of biotechnology applications in health, environmental and industrial diagnostic tools, medicine, vaccines and hormones. Biotechnology is also used in bioremediation, biofuels and the production of enzymes (Olembo and others, 2010). The bulk of biotechnology work in Uganda is conducted and led by institutions under the National Agricultural Research Organisation (NARO). Uganda is one of the leading African countries in the testing of genetically modified crops under confined field trials. Approved CFTs include the drought-tolerant WEMA, cassava resistant to the mosaic disease and the cassava brown streak disease, bananas with engineered resistance to black sigatoka disease and Bt cotton with insect-resistant and herbicide-tolerant ('roundup-ready') genes. The emphasis is on: efforts to test traits of insect and disease resistance and drought and herbicide tolerance, and; on enhancing the nutritional content of bananas, which are the main staple food in the country. Trials are under way on a banana variety biofortified with vitamin A and iron.

The School of Agricultural Sciences at Makerere University has a good biotechnology laboratory that has produced many protocols for banana-tissue culture production; the Department of Crop Science developed most of the protocols used in tissue culture banana in the region. This technique has facilitated the production and quick multiplication of disease-free planting material. The use of clean planting material has increased by over 40 per cent compared to the yield of most vegetatively propagated plants, like cassava, sweet potato, banana and so on. The school has also developed molecular diagnostic tools for a number of diseases, including the banana bacterial wilt, sweet potato viral disease, cassava brown streak and the passion fruit woodiness virus.

Biotechnological applications and tools being used in Kenya to improve crop production include tissue culture, marker-assisted selection and genetic modification. In the livestock sector, the focus is largely on the development of vaccines and diagnostic kits for effective vaccination and accurate diagnosis of livestock diseases. In forestry, clonal technology is being used to produce high-quality seedlings. Tissue culture is being used for the production of planting material, including banana, sugarcane, potato, strawberry, flowers, sweet potato, cassava and vanilla by public research institutions led by the Kenya Agricultural Research Institute (KARI), public universities and private sector laboratories. Additionally, Kenya has invested heavily in advanced applications involving genetic modification. The focus is on the development of crops that are resistant to insects and diseases, including the cotton bollworm, maize stem borer, cassava mosaic disease and sweet potato feathery mottle viral disease. Research on drought-tolerant maize is being conducted under the auspices of WEMA. The nutritional enhancement of maize, sorghum and cassava through genetic modification is another important component of the research.

Biotechnology in Tanzania mainly involves tissue culture and micropropagation, marker-assisted breeding, disease diagnostics and livestock vaccines (Mneney, 2001; Rutabanzibwa, 2004).

The bulk of research and development activities in Ethiopia are in agricultural biotechnology, with priority given to coffee, teff, banana, wheat and sorghum. Projects in industrial, health and environmental biotechnology have been gaining ground in recent years. In general, the scope of biotechnology in Ethiopia encompasses tissue culture, biofertilizers, molecular marker, embryo transfer, immunology, vaccine- and diagnostic-kit development and epidemiology (Kassa, 2011).

There is a limited but steadily growing range of biotechnology applications in Rwanda in areas, such as crop husbandry, medicine (HIV/AIDS diagnostics, vaccine trials using recombinant DNA technology), bioenergy production and waste treatment. Rwanda has also made modest progress in industrial biotechnology applications in the brewing of beer and production of juice and yoghurt.

Biotechnology in Burundi is at the embryonic stage. The types of research conducted there include in vitro plant-tissue culture and animal biotechnology for the purposes of bovine genetic improvement, embryo rescue and animal-disease diagnostics.

A number of networks have been established to strenghten research and development in different aspects of biotechnology. The Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) brings together eleven countries. ASARECA's strategic priority is organized thematically around seven research programmes, including one that covers agro-biodiversity and biotechnology. This programme integrates agricultural biotechnology and agro-biodiversity by employing biotechnology to promote the use of agro-biodiversity (Morton, 2010). The programme's themes include: the development, transfer and commercialization of biotechnology; the mobilization and development of biotechnological infrastructure and human capacity; the development and harmonization of biopolicy, and of biotechnology communication and outreach activities. Some of the biotechnology tools being promoted by ASARECA are as follows:

- Plant-genetic engineering to create drought-tolerant maize varieties and transform cassava
- Plant-tissue culture for banana, cassava, sweet potato

**Box 3: Some of ASARECA's flagship projects**

- ASARECA and its partners are introgressing drought tolerance conferring genes into maize. This will translate to a 70 per cent increase in maize production, thereby improving food security and promoting economic development in the region.
- The setup and upgrading of functional genetic transformation platforms and/or laboratories for cassava in Kenya, Tanzania and Uganda: The platforms are being used to develop genetically modified cassava that is resistant to the cassava mosaic disease and cassava brown streak disease.
- Use of tissue culture to improve access to cassava and sweet potato clean planting
- Materials for farmers: ASARECA has enabled partners to develop a DNA-based method to detect cassava and sweet potato viruses.
- Fighting striga: Using marker-assisted breeding, ASARECA and partners in Eritrea, Kenya, Sudan and from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) have developed 50 striga-resistant sorghum lines capable of yielding up to 3.6 t/ha. This breakthrough will enable 300 million people in Africa to achieve food security, move from the poverty bracket and lead better lives.

- *In vitro* conservation for the slow growth and cryopreservation of cassava and sweet potato
- Marker-assisted breeding of sorghum for resistance to striga
- Gene location and comparative mapping for sorghum and cassava
- Disease detection for sweet potato and cassava and *taenia* detection in pigs
- The development of vaccine for pigs

NEPAD has helped establish two bioscience centres of excellence in the eastern and southern Africa regions, which are carrying out substantial research and development in biotechnology. The centres are the Biosciences east and central Africa (BecA), based at the International Livestock Research Institute (ILRI), in Kenya, and the Southern African Network for Biosciences, based at the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in Cape Town, South Africa. The centres mobilize resources at the national and international levels to develop and implement biotechnology projects with substantial capacity development components. BecA in particular has cutting-edge equipment for molecular, genomic and genetic engineering research.

The BIO-EARN Programme was initiated in 1998 to meet the challenge of mobilizing science and technology for Africa's development. The goal was to develop capacities and competencies for the efficient use of modern biotechnology and its integration into agricultural, industrial and environmental management in Ethiopia, Kenya, Tanzania and Uganda. The first and second phases of the BIO-EARN Programme (1999-2005) focused on building human and infrastructural capacity to: use advanced agricultural, environmental and industrial biotechnology, and; develop biopolicy and biosafety regulatory skills. The third phase (2006-2009) built on the capacity of African scientists and policymakers developed in the first two phases to create nine large regional research consortia. The consortia comprise science and market actors engaged in research for development, notably crop productivity, agro-processing and environmental and industrial development. Between 1999 and 2009 the BIO-EARN Programme engaged 35 institutions from Ethiopia, Kenya, Sweden, Tanzania and Uganda, and more than 100 scientists and an even larger number of policymakers and practitioners from the region.

Serving as a "regional network of excellence", the BIO-EARN Programme was effective in developing capacity in biosciences, biotechnology policy and biosafety assessment in Eastern Africa. The programme also developed new products, such as improved varieties of sorghum, cassava and sweet potatoes, new bioprocess technologies for waste-water treatment and energy production. It has also served as a platform for regional collaboration and information sharing on biotechnology and biosafety policy issues.

Ultimately BIO-EARN was transformed into a new programme, Bio-Innovate, which targets bioscience and product-oriented innovation activities in Eastern Africa

(Burundi, Ethiopia, Kenya, Rwanda, Tanzania and Uganda). Bio-Innovate builds on previous investments, achievements and experiences of the BIO-EARN Programme and other regional initiatives. Bio-Innovate concentrates on delivering new products through bioscience innovation systems involving a broad sector of actors: scientists, the private sector, non-governmental organizations and other practitioners. The programme uses modern bioscience, including biotechnology, to improve crop productivity and resilience to climate change in small-scale farming systems. It also aims to boost the agro-processing industry's efficiency so as to add sustainable value to local bioresources. Bio-Innovate will be user-, market- and development-oriented in order to help alleviate poverty and sustain economic growth, and thereby make a difference to people in need. Supported by SIDA, the proposed funding for the 2010-2014 period is approximately US$11.5 million.

South Africa is the regional leader in research and development in biotechnology and has contributed to the commercial production of genetically modified crops since 1998. With a total of 2.3 million hectares under biotech crop cultivation in 2011, South Africa was ranked ninth globally in the commercialization of biotech crops.

The University of Zambia is the only public institution carrying out research and development in biotechnology in Zambia. The university has been involved in tissue-culture plant biotechnology for more than 10 years, focusing on induced mutation techniques to improve cassava. It has had a functioning tissue-culture laboratory for training and research since the mid-1990s. The university offers graduate and undergraduate courses on plant breeding. Aside from the ongoing work on tissue culture, there are no biotechnology projects in the country. No genetically modified crop has been introduced or approved for research trials. However, stakeholders in the cotton industry have expressed an interest in introducing genetically modified cotton and carrying out confined field trials.

In spite of enormous potential, Zimbabwe has limited involvement in research and development in biotechnology. The Biosafety Law, enacted in 1999 and passed as Statutory Instrument 20/2000 was pivotal in setting up the Biosafety Board that then approved the very first set of confined field trials for Bt maize and Bt cotton in 2001. The trials were conducted over three seasons, during which data were collected. The technology performed very well, although no applications were received for commercialization.

While Malawi has moderately equipped laboratories in agricultural institutions and universities capable of conducting research and development activities, research has been limited to the tissue culture of crops, such as banana and beans, with no ongoing research on transgenic crops. In the past few years, the training of five plant breeders to the doctoral level and equipping them with advanced skills in transformations has reinforced biotech research capacity. However, the plant breeders lack the necessary equipment and facilities to carry out research. In 2011, the National Biosafety Regulatory Committee approved the application, by Bunda College, to conduct confined field trials of Bt cotton in Malawi.

Mozambique has limited research capacity in agricultural biotechnology, with activities confined to research on virus-free cassava, Irish potato, banana and sweet potato planting material. The transgenic drought-tolerant maize being developed under the WEMA project is the only product currently being developed that targets Mozambique.

### 3.3.2 West and Central Africa

## Policy and legislation

West African States include Benin, Burkina Faso, Cape Verde, Côte d'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone and Togo. All of them, with the exception of Côte d'Ivoire and Sierra Leone, are parties to the Biosafety Protocol. All, including non-parties, have benefited from UNEP-GEF capacity building projects on the development of national biosafety frameworks. Burkina Faso, Ghana, Mali, Senegal and Togo have enacted biosafety laws. Nigeria's senate passed the Biosafety Bill in June 2011. The bill was awaiting presidential assent.

Countries in central Africa include Cameroon, the Central African Republic, Chad, the Democratic Republic of Congo (DRC), Equatorial Guinea, Gabon and the Republic of Congo. All the countries are parties to the protocol except Equatorial Guinea. Most of them have developed their national biosafety frameworks with the support of UNEP-GEF. However implementation of the frameworks remains a challenge, with Cameroon being the only country in the subregion to have a biosafety law (Mtui, 2011).

The West African Biosciences Network, consisting of ECOWAS countries, was set up in the subregion as part of the NEPAD/African Biosciences Initiative. It is a cluster of three science and technology flagship programmes, namely biodiversity, biotechnology and indigenous knowledge systems. It is being implemented through regional networks involved in research, development and the transfer of bioscience technologies. The Network is involved in cutting-edge biotechnological research and has invested considerable expertise in research and development.

## Research and development in biotechnology

The bulk of biotechnology research conducted in West and Central Africa is on tissue culture for the mass propagation of clean plantlets. Nwalozie and others, (2007) observed that few laboratories in the subregion characterized germ plasm and fewer still had the capacity to conduct molecular marker-assisted breeding. Burkina Faso, Ghana and Nigeria are the only West African countries that have granted approvals for the testing of GMOs. Inadequate capacity, compounded by lack of implementing regulations and of a supportive political environment, has impeded progress in the rest of the countries.

In Nigeria, genetically modified crops undergoing field trials include Bt cowpea, biofortified sorghum and the BioCassava Plus. Bt cowpea and the Africa Biofortified Sorghum (ABS) are undergoing trials at Ahmadu Bello University's Institute for Agricultural Research, in Zaria, while BioCassava Plus is undergoing trial at the National Root Crop Research Institute in Umudike. There is also growing interest in the testing and prompt release of insect-resistant, herbicide-tolerant cotton (GAIN, 2012).

In November 2012, the Ghana National Biosafety Committee approved three applications for confined field trials of LMOs. The Savannah Agricultural Research Institute based in Tamale, applied for the trial of Bt cowpea in collaboration with the AATF, while the Crops Research Institute (CRI), based in Kumasi, applied for two different trials. These are on high protein sweet potato and nitrogen- and water-use efficient, salt-tolerant rice. The high-protein sweet potato trial will be conducted in collaboration with Tuskegee University, in the United States, while the nitrogen- and water-use efficient, salt-tolerant rice trial will be conducted in collaboration with the AATF.[2]

Burkina Faso has commercialized Bt cotton. It has also granted approvals for: greenhouse experiments involving genetically modified sorghum with improved levels of vitamin A and improved zinc and iron content and; trials of genetically modified cowpea (Bt cowpea) resistant to *Maruca vitrata Fab*.

Subregional organizations committed to supporting biotechnology include the Central African Council for Agricultural Research and Development and the West and Central African Council for Agricultural Research and Development (CORAF/WECARD). Biotechnology and biosafety is one of the technical research programmes designed to deliver goals of the CAADP agenda (Morton, 2010). Biotechnology and biosafety programmes are implemented under the CORAF/WECARD Operational Plan for the period 2008 - 2013. The Operational Plan posted a number of achievements in 2011. *These include* helping establish a cassava cleaning and multiplication methodology that combines *in vitro* and *in vivo* greenhouse techniques, carried out as part of a commissioned project of a food security initiative. Additionally, the biotechnology and biosafety programmes developed five isogenic lineages of rice (NIL) on the allele RYMV1 through selection in Burkina Faso, Côte d'Ivoire, Ghana, Nigeria and Sierra Leone. Field observations of two NILS (NIL2 and NIL16) and all the trials in these countries confirmed them as the most promising lineages in terms of agronomic resistance to the rice yellow mottle virus (RYMV). Other significant results include artificially characterizing the actual level and nature of the resistance by using different RYMV isolates collected *in situ*.

Equally noteworthy is an innovative integrated method, combining the tissue culture of cassava and the multiplication on the field (new growth system), to produce large quantities of healthy planting material for farmers.

Twenty seven researchers and technical experts received training to strengthen their capacities to assess and manage risks associated with GMOs, construct greenhouses and requisition laboratory materials

2 http://bch.cbd.int/about/news-post/?postid=104369.

and chemical products for experiments involving biotechnological projects (CORAF/WECARD, 2011).

### 3.3.3 North Africa

#### Policy and legislation

The North African subregion comprises Algeria, Egypt, Libya, Morocco, Sudan and Tunisia. Only Sudan has enacted a biosafety law and developed a policy on biotechnology. Libya has a biosafety law and a draft biosafety policy. Egypt, Morocco and Tunisia have draft biosafety bills and mainly rely on sectoral legislation and policies to manage biotechnological activities.

Only Egypt has made significant progress in biotechnology research and development, thanks to several decrees issued by the ministry of agriculture. The State has used the decrees to make decisions on the handling of GMOs for trials and trade. A bill has been drafted and is awaiting approval by parliament (FARA, 2011).

Morocco does not have a legislative or regulatory framework for biotechnology, whether it is for the domestic production or importation of biotech commodities. In 2008 the ministry of agriculture submitted a draft law on the introduction, use and marketing of GMOs to various ministries for review (GAIN, 2011).

In Tunisia, a draft law currently under consideration aims to establish a legal framework for the importation, marketing and use of biotechnology in agriculture (GAIN, 2011).

Algeria signed the Biosafety Protocol in 2000 and ratified it in 2004. The competent authority and focal point is the ministry of land development and the environment. Ministerial order n° 910, dated 24 December 2000, forbids the importation, production, distribution, marketing and use of genetically modified plant products.

#### Research and development biotechnology

In the region, Egypt is an example of successful application of Bt technology to combat poverty and enhance sustainable development. Developers of Bt maize (Ajeeb YG) have reported economic benefits in the country. These include higher yield per hectare that resulted in US$ 267 of profits. The equivalent of US$ 89 per hectare was saved in insecticide costs, with the total gain being US$ 356 per hectare.  Deduct US$ 75, the cost of seed per hectare, and that makes a net benefit of US$ 281 per hectare (Karembu and others, 2009). Failure to deploy Bt maize would be a loss of opportunity for Egypt. Turning 33 per cent of 75,000 hectares to the cultivation of yellow maize would bring in US$ 7 million annually. If the surface area were increased to 66 per cent, the profits would rise to US$ 14 million. Additionally, the use of Bt maize in Egypt would result in: lower mycotoxin levels; an import substitution value due to increased self-sufficiency in maize production, and; foreign exchange savings.

Morocco and Tunisia are conducting biological research and preliminary trials on palms, potatoes, tomatoes, maize and forest trees (Morris, 2011).

## 3.4 Applications of biotechnology

Research and development in modern biotechnology is now a source of new products that are improving agricultural production, human and animal health, the environment and industry in general. In the past two decades, a number of African countries have intensified their investment in research and development in biotechnology. While conventional technologies will continue to play an important and necessary role, they have limitations in handling contemporary and emerging challenges. On the other hand, modern biotechnology tools offer opportunities to address the challenges in a complementary manner, and in cost-effective, efficient and predictable ways.

### 3.4.1 Increasing the availability of food, feed, fibre and renewable raw materials

In spite of the importance of agriculture in Africa, 16 of the 18 countries with the highest malnutrition rates in the world are in sub-Saharan Africa (James, 2008). Thus, the actual and potential contribution of biotechnology in raising the availability of food and enhancing food security and nutrition is of significant importance. A number of African countries are engaged in crop biotechnology with the aim of increasing food security and alleviating poverty. The adoption, by small-scale farmers in Kenya, of tissue-culture banana has achieved significant impacts and positive outcomes. The technology made it possible for more than 10,000 farmers to obtain large quantities of superior, early-maturing clean planting material (for instance 12-16 months compared to 2-3 years for the conventional banana), with bigger bunch weights (30-45 kg compared to the 10-15 kg from conventional material) and higher annual yield per unit of land (40-60 tonnes per hectare against 15-20 tonnes previously produced with conventional material) (Karembu, 2007).

South Africa is a notable example of a country that has embraced advances in modern biotechnology and benefited tremendously from it. Between 2001 and 2010 the country cultivated genetically modified maize (white and yellow) on approximately 12 million hectares, for food, feed and processing. High demand boosted the cultivation of genetically modified soybeans from 290,000 hectares in 2010 to an estimated 450,000 hectares in 2011. Cumulative farm income gains from the adoption of biotech crops for the period 1998–2010 amounted to US$ 809 million (James, 2011).

Another major achievement and success story in the subregion is the use of biotechnology to develop the New Rice for Africa (NERICA). This is a new variety of hybrid rice developed by the Africa Rice Centre (AfricaRice) by crossing Asian rice and African cultivated rice varieties using modern biotechnology approaches, including tissue culture. Although 240 million people in West Africa rely on rice as their primary source of food energy and protein, most of the rice is imported, at a cost of over US$ 1 billion. The development of NERICA has contributed to a significant increase in rice production and improved food security. NERICA varieties have now been introduced in more than 30 sub-Saharan African countries. Consequently, 17 upland NERICA varieties have been adopted and/or certified in sub-Saharan Africa, while 11 lowland NERICA varieties had been adopted as of 2007 (Diagne, 2009).

In Ghana, microorganisms are used in fermented foods to enhance flavour and maintain quality, often with little or no refrigeration. By increasing product shelf life the microorganisms contribute to food safety and food security. The Council for Scientific and Industrial Research-Food Research Institute (FRI) of Ghana has developed a purified bacterial culture medium to enhance the quality of a fermented corn-dough product, known traditionally as *Ga kenkey*. This technology has been expanded for the traditional factory-type batch production of large volumes of *Ga kenkey* not hitherto possible. The improved quality of the *Ga kenkey* and an increased demand for it made it necessary to scale up production at the traditional food processing point (Amoa-Awua and others, 2004).

Special attention has been paid to the development of technologies that use tools of modern biotechnology and help to enhance foods nutritionally. The emphasis is on reducing the rates of malnutrition on the continent through flagship projects that focus on Africa's priority staple crops, such as cassava and sorghum, which are accessible to poor people. The African Biofortified Sorghum project seeks to develop a more nutritious and easily digestible sorghum variety that contains increased levels of essential amino acids, especially lysine, increased levels of vitamin A and more available iron and zinc. This project is expected to improve the health of a target 300 million people who depend on sorghum as a staple food in Africa. It is a North-South multi-institutional partnership leveraging the best of academic, public and private research and development institutions.[3] This work is being undertaken under the aegis of the BioCassava Plus (BC Plus) project. Cassava is a staple crop consumed by more than 250 million people in sub-Saharan Africa. Increasing the nutritional content of the crop will tremendously reinforce the campaign to reduce malnutrition. BC Plus will be available to farmers, royalty-free.[4]

Adoption of Bt cotton has helped increase the availability of fibre in Burkina Faso and South Africa. Cotton remains Burkina Faso's principal cash crop, generating over US$300 million in annual revenues. This represents over 60 per cent of the country's export earnings (ICAC, 2006). Some 2.2 million people depend directly or indirectly on cotton, often referred to locally as "white gold" (Vognan and others, 2002). In Burkina Faso out of a total of 424,810 hectares under cotton cultivation in 2011, 247,000 hectares or 58 per cent represented Bt cotton cultivated by 76,000 farmers. Benefits from Bt cotton included an average yield increase of almost 20 per cent, in addition to savings in labour and insecticide

3 For details about the project visit http://biosorghum.org/

4 For details about the project visit http://www.danforthcenter.org/science/programs/international_programs/bcp/.

(two rather than six sprays per season). The result was a net gain of about US$ 66 per hectare, compared with conventional cotton. In South Africa Bt cotton accounts for 95 per cent of the total area under cotton cultivation.

Through biotechnology, it is now possible to produce biofertilizers from biological wastes. It is estimated that on average Africa applies 125 gm/ha of fertilizers compared with the world average of 1,020 gm/ha (UNECA, 2009). This state of affairs is compounded by the high and rising cost, which is unaffordable to most small-scale farmers. Many African countries have adopted the biological nitrogen fixation technology to address this challenge. The technology induces the multiplication of microbes in plant roots, known as biofertilizers, which help plants fix nitrogen from the atmosphere. Use of biofertilizers has been reported in many countries, for instance Kenya, Senegal, Tanzania, Tunisia, Zambia and Zimbabwe (Juma and Serageldin, 2007). Biofertilizers are gaining increasing importance for their sustainable and holistic role in maintaining the purity of the soil while enhancing crop productivity. They help reduce the use of chemical fertilizers, which may pollute soil and water basins, and interfere with crucial life forms that maintain the overall ecological balance.

The emergence of bio-based economies is gaining ground in Africa. These are economies that use renewable bioresources, efficient bioprocesses and eco-industrial clusters to produce sustainable bio-products, jobs and income (Wesseler and Demont, 2010). Industrial biotechnology can involve the replacement of conventional processes with biological systems or use biological systems to create new products and services from renewable resources. The expansion of industrial biotechnology has offered new opportunities to substitute fossil fuels, sequester carbon and thereby positively influence climate change dynamics. The government of Ghana supports development and investment in and the marketing of biofuels as a potential substitute for petrol and diesel. This is being encouraged through favourable tax regimes to attract companies to develop alternatives to fossil fuels (Anwi and others, 2010). The use of biofuels is a major initiative to counter high oil prices and support the global reduction of greenhouse gases.

### 3.4.2 Improving human and animal health

Advances in medical biotechnology are making a major contribution to the diagnosis and treatment of diseases and the development of drugs. Cutting-edge developments in genomics and bioinformatics have made it possible for the diagnosis and early treatment of many diseases and disorders. A prime example is diabetes, once considered a rare disease in sub-Saharan Africa. In 2010, over 12 million people in sub-Saharan Africa were estimated to be suffering from diabetes. It is predicted that this figure will almost double in 20 years, reaching 23.9 million by 2030. This means that sub-Saharan Africa will be the region with the highest diabetes rates in the world (Motala and Ramaiya, 2010). Human insulin for the treatment of diabetes, one of the first genetically engineered products to become commercially available, was commercialized in 1982. It is an important drug that has been and will continue to be crucial in the management of diabetes.

Conventional live, attenuated vaccines, which contain a version of a living microbe that has been weakened in the laboratory, have been used widely to treat diseases, such as measles, mumps and chickenpox. In spite of the vaccines' advantages, there are some downsides. There is a remote possibility that an attenuated microbe in the vaccine could mutate and revert to a virulent form and cause disease. Research into the development of recombinant DNA is facilitating the search for better, cheaper and safer vaccines. The use of monoclonal antibodies and recombinant DNA technologies is now making it possible to produce genetically modified vaccines more rapidly. For instance, clinical trials and efforts to develop HIV/AIDS vaccines using recombinant DNA techniques (modern biotechnology) in Africa and other regions of the world are at various stages of progress.

Other developments include using molecular markers to map out disease resistance in the malarial parasite. This is being carried out at the Ifakara Health and Research Development Centre. It is a collaborative research programme involving six countries (Ghana, Nigeria, Malawi, Mali, Tanzania and Uganda) and jointly coordinated by the United Nations Development Programme, the World Bank and WHO. Kenya has developed an affordable diagnostic testing kit for hepatitis B, under the leadership of the Kenya Medical Research Institute, with support from the Japan International Cooperation Agency. The kit, called Hepcell, is now in use in all district and provincial hospitals.

African livestock is affected by several diseases, including: *trypanosomiasis*; contagious bovine pleuropneumonia (CBPP); African swine fever (ASF); *la peste des petits ruminants* (PPR); Newcastle disease (ND); foot and mouth

**Table 4**: Summary of biotechnology applications and research in selected African countries

| Country | Research and development involving genetic modification | | | | Other biotechnology applications |
|---|---|---|---|---|---|
| | Crop | Trait | Institutions involved | Stage as in 2011 | |
| Burkina Faso<br>Bt cotton commercialized in 2008 | Cowpea | Insect resistance | INERA, AATF, NGICA, CSIRO, PBS, MONSANTO | Confined Field Trials (CFT) – 1st season | |
| Egypt<br>Bt maize approved for commercialization in 2008 | Maize | Insect resistance | Pioneer | Open field trials, 4th season | |
| | Cotton | Insect resistance | ARC | Open field trials, F10 stage awaiting approval | |
| | Wheat | Drought and salt tolerance | AGERI | Open field trials, 9th season | |
| | | Fungal resistance | AGERI | Open field trials, 2nd season | |
| | Potato | Viral resistance | AGERI | CGH | |
| | | Insect resistance | AGERI | Field trials, 10th season | |
| | Tomato | Viral resistance | AGERI, Cairo University | CGH, 2nd season | |
| | Sugarcane | Insect resistance | AGERI, Cairo University | Experimental field trial, 1st season | |
| | | Fungal resistance | AGERI | Experimental field trial, 1st season | |
| Kenya<br>Biosafety Act approved in 2009,<br>Biosafety implementing regulations published in 2011 | Maize | Drought tolerance (WEMA) | AATF, CIMMYT, KARI, Monsanto | CFT, 2nd season | Production of disease-free plants and micropropagation of pyrethrum, bananas, potatoes, strawberries, sweet potato, citrus, sugar cane; Micropropagation of ornamentals (carnation, *alstromeria, gerbera, anthurium,* leopard orchids) and forest trees; *In vitro* selection for salt tolerance in finger millet; Tissue culture regeneration of papaya; *In vitro* long-term storage of potato and sweet potato; Well established Microbiological Resources Centre providing microbial biofertilizers in the East African region |
| | Cotton | Insect resistance | KARI, Monsanto | CFTs completed | |
| | Cassava | Viral resistance | KARI, DDPSC | CFT, 1st season | |
| | | Enhanced micronutrient levels | KARI, DDPSC, IITA, CIAT | CFT, 1st season | |
| | Sweet potato | Viral diseases | KARI, Monsanto | CFT, 1st season | |
| | | Weevil resistance | CIP, Kenyatta University | Lab and GH transformation approved by NBA in April 2011 | |
| | Sorghum | Enhanced micronutrient levels | Africa Harvest, Pioneer Hi-bred, DuPont business, KARI | Approved for contained greenhouse trial by NBA | |
| | Pigeon pea | Insect resistance | Kenyatta University | Lab and GH transformation approved by NBA in March 2011 | |
| Uganda | Maize | Drought tolerance | NARO, AATF, Monsanto | CFT, 2nd season | Tissue culture for *In vitro* micro propagation and provision of clean planting material for banana, cassava, coffee, Irish potato, sweet potato and sugar cane<br>*In vitro* screening for disease resistance in banana; Production of disease-free plants of potato, sweet potato, Irish potato, banana, cassava and sugar cane |
| | Banana | Bacterial wilt resistance | NARO, AATF, IITA | CFT, 1st season | |
| | | Enhanced micronutrients | NARO, Queensland University of Technology | CFT, 1st season | |
| | Cassava | Viral resistance | NARO, DDPSC, IITA | CFT, 2nd season | |
| | Cotton | Insect resistance and herbicide tolerance | NARO, Monsanto | CFT, 3rd season | |
| | Sweet potato | Weevil resistance | NARO, CIP | Contained GH trials | |

| Country | Research and development involving genetic modification | | | | Other biotechnology applications |
|---|---|---|---|---|---|
| | Crop | Trait | Institutions involved | Stage as in 2011 | |
| Malawi | Cotton | Insect resistance and herbicide tolerance | Bunda University, Monsanto, Ministry of Agric, Envi. Affairs Dept, National Commission for S&T | CFT, 1st season | |
| South Africa 1st commercialization in 1997 | Maize | Drought tolerance | Monsanto | CFT | Molecular marker applications of: diagnostics for pathogen detection; cultivar identification in potato, sweet potato, ornamentals, cereals, cassava; seed-lot purity testing—cereals; marker assisted selection in maize, tomato; markers for disease resistance in wheat, forestry crops; tissue culture for the production of disease-free plants—potato, sweet potato, cassava, dry beans, banana, ornamental bulbs; micropropagation of potato, ornamental bulbs, rose rootstocks, chrysanthemum, strawberry, apple rootstocks, endangered species, coffee, banana, avocado, blueberry, date palm; embryo rescue of table grapes, sunflower & dry beans; *in vitro* selection for disease resistance to tomato nematodes, guava wilting disease; long-term storage—potato, sweet potato, cassava, ornamental bulbs; *in vitro* gene bank collections potato, sweet potato, cassava, ornamentals; forest trees, medicinal plants, indigenous ornamental plants |
| | | Herbicide tolerance | Pioneer Hi-Bred | CFT | |
| | | Insect resistance | | CFT | |
| | | Insect resistance and herbicide tolerance | Monsanto | CFT | |
| | | | Pioneer Hi-Bred | CFT | |
| | Cassava | Starch enhanced | ARC-Industrial Crops Research Institute | CFT | |
| | Cotton | Insect resistance and herbicide tolerance | Bayer | CFT | |
| | | Herbicide tolerance | | CFT | |
| | Potato | Insect resistance | ARC-OVI | CFT | |
| | Bulb flower | Viral resistance | Agricultural Research Council - Vegetable and Ornamental Plants Institute | CFT | |
| | Sugarcane | Alternate sugar (rattoon); increased yield and sugars; increased cellulose; increased starch; decreased starch | South African Sugar Research Institute | CFT | |
| | Sorghum | Micronutrient enhanced | Africa Harvest, Pioneer Hi-Bred, DuPont business, CSIR | CGH | |
| Cameroon | | | | | Plant tissue culture of *Theobroma cacao* (cocoa tree), *Hevea brasiliensis* (rubber tree), *Coffea arabica* (coffee tree), *Dioscorea* spp (yam) and *Xanthosoma mafaffa* (cocoyam); *In vitro* culture for propagation of banana, oil palm, pineapple, cotton and tea |
| Côte d'Ivoire | | | | | *In vitro* production of coconut palm (*Cocos nucifera*) and yam; Virus-free micropropagation of eggplant (*Solanum* spp); Production of rhizobial-based biofertilizers |
| Ghana | Cowpea | Insect resistance | AATF/Savannah Agricultural Research Institute | | Micropropagation of cassava, banana/plantain, nutrient enhanced sweet potato, development of marker-assisted selection cassava and sorghum, tc sugar cane, yam, pineapple and cocoa; polymerase chain reaction (PCR) facility for virus diagnostics |
| | Rice | N-use efficiency, Water-use efficiency, Salt tolerance | AATF/CRI | | |
| | Sweet potato | Enhanced protein | Tuskegee University/CRI | | |

| Country | Research and development involving genetic modification | | | | Other biotechnology applications |
|---|---|---|---|---|---|
| | Crop | Trait | Institutions involved | Stage as in 2011 | |
| Nigeria | Cowpea | Insect resistance<br>Virus resistance | | CFTs | Micropropagation of cassava, yam and banana, ginger; Embryo rescue for yam; Transformation and regeneration of cowpea, yam, cassava and banana; Marker-assisted selection of maize and cassava; DNA fingerprinting of cassava, yams, banana, pests and microbial pathogens; Genome linkage maps for cowpeas, cassava, yams and banana; Tissue culture applications |
| | Sorghum | Enhanced nutritional content | | CFT | |
| | Cassava | Enhanced nutritional content | | CFT | |
| Morocco | | | | | Micropropagation of forest trees, date palms; Development of disease-free and stress tolerant plants; Molecular biology of date palms and cereals |
| Senegal | | | | | Well established Microbiological Resources Centre programme; Production of rhizobial-and mycorhizal-based biofertilizers for rural markets; Well established *in vitro* propagation of tree species in cooperation with several international agencies |
| Ethiopia | | | | | Virus-free sweet potato, tissue culture in coffee, banana, potatoes, pineapple, apples; Micropropagation of forest trees; Tissue culture has increased sugarcane cultivation from 30,000 hectares in 2006 to 300,000 hectares in 2011 |
| Zimbabwe | | | | | Micropropagation of potato, cassava, tobacco, sweet potato, ornamental plants, coffee; Marker-assisted selection |
| Zambia | | | | | Micropropagation of cassava, potato, trees (Uapaca), banana and hosts SADC Nordic-funded gene bank of plant genetic resources |

disease (FMD); Rift Valley fever, and; highly pathogenic avian influenza. These diseases constitute serious constraints for livestock production and international trade in animals. In Africa, animal diseases cause damage to the economy estimated at US$ 4 billion per year. Moreover, the diseases have a severe impact on food security and Africa's capacity to achieve self-sufficiency in food proteins. Some diseases, such as highly pathogenic avian influenza and Rift Valley fever, are zoonotic and affect public health.

Professionals in animal sciences are using biotechnological discoveries to improve animal health and production. Genetically engineered vaccines, monoclonal antibody technology, and growth hormones are some of the developments in this area. Uganda has developed recombinant vaccines for East Coast fever and Newcastle diseases. This is particularly important, given that East Coast fever kills a million cattle every year in East, Central and Southern Africa, and is responsible for up to 50 per cent of all calf deaths in pastoral and agro-pastoral communities, adversely affecting livelihoods (Agfax, 2010).

Africa hosts several international research bodies active in animal biotechnology. A good example is the International Livestock Research Institute. ILRI is one of the centres of the Consultative Group for International Agricultural Research (CGIAR). ILRI has exploited biotechnological techniques to obtain antigens that can be used in specific and sensitive diagnostic tests for tick-borne livestock diseases. Compared with conventional techniques, these new generation tests are cheaper, easier to use and better suited to national programmes of tropical countries. In 1996 ILRI released a recombinant vaccine (designated p67) against East Coast fever for field trials. Research is now under way to develop second-generation vaccines that target a later stage of the parasite, once it has invaded the white blood cells of the host and stimulated a response from cytotoxic T cells. Regarding diagnostics, ILRI is applying molecular biology technology to identify unique proteins in four parasites: *Babesia bigemina*, *Theileria parva*, *Theileria mutans* and *Anaplasma marginale*. The proteins have been used to develop improved enzyme-linked immunosorbent assay (ELISA) tests specific to each parasite. This makes the diagnosis of diseases caused by the parasites more sensitive and specific.

The Pan African Veterinary Vaccine Centre (PANVAC) is another exemplary regional initiative. It was launched in March 2004 as a specialized agency of the African Union Commission's Department of Rural Economy and Agriculture. The Centre is located in Debre Zeit, Ethiopia. Its goal is to support AU member States' efforts to control and eradicate animal diseases, and is founded on the belief that the health of livestock in Africa can be improved significantly by using good quality vaccines and diagnostic tools.[5]

One of the broader objectives of PANVAC is to improve the efficacy of vaccines currently used in Africa to treat contagious bovine pleuropneumonia. This trans-boundary animal disease, with major economic implications, is widespread in sub-Saharan Africa. Most African veterinary services consider it the most threatening infectious disease. A CBPP outbreak in Botswana in 1995 caused direct and indirect losses estimated at US$100 million and US$400 million, respectively. The disease is highly contagious and has adverse effects on regional and international trade in animals and animal products. It is therefore a major setback to livestock economies as it prevents the majority of African countries from getting access to highly profitable markets because of non-tariff trade barriers imposed by importing countries.

The most cost-effective method to control trans-boundary animal diseases is by preventive vaccination. PANVAC seeks to improve the efficacy of the current CBPP vaccines used in Africa by employing new technologies to produce and transfer the vaccines to AU member States. PANVAC is also strategically positioned to focus on better strategies for the control and eradication of animal disease by using the newest laboratory technologies. Diagnostic molecular biology tools, such as Real-Time PCR (QPCR) and immuno-enzymatic technologies are now commonly used for the diagnosis of animal diseases. It is expected that these efforts will help consolidate AU member States' efforts to control and eradicate animal diseases.

### 3.4.3 Enhancing the protection of the environment

Forestry biotechnology has contributed to the sustainable use and conservation of forest resources in Africa. A typical example is clonal forestry, a technology that was developed in South Africa. In Kenya the Tree Biotechnology Project Trust has adopted forestry

5 http://au.int/en/dp/rea/RO/PANVAC.

**Box 4: The Tree Biotechnology Project Trust Project**

The Tree Biotechnology Project Trust has the largest single forest tree clonal nursery in East and Central Africa capable of producing high quality tree hybrid clones and pure selected seedlings. Clonal forestry has helped to:

- supplement the limited supply and use of improved seeds, seedlings, wildings and scions in the mass production of plant material at a relatively low cost
- provide fast-growing plant material
- establish uniform crops for specific purposes
- supply plant material that is pest- and disease-resistant. This has contributed to the creation of wealth through fast-maturing and high quality trees with good wood characteristics, and immensely increased the forest cover.

According to Oeba and others, (2009) and Ngamau and others, (2004), the project has had several successes, including:

- capacity-building and the training of Kenyan scientists in clonal forestry propagation and commercial plantations. Scientists were trained through visits to Mondi Forests facilities in South Africa and training sessions conducted by Mondi staff in Kenya.
- over twenty-two clonal screening and adaptability trials established countrywide. These cover each of the country's agro-ecological zones to identify particular clonal germplasm for specific sites.
- a clonal forestry nursery established at the Kenya Forest Service headquarters in Karura. To date, the nursery has produced over 19 million improved seedlings and clones and has an annual production capacity of over 4 million.
- a nationwide distribution and delivery network for seedlings and clones to target groups. The network is now operational through collaboration with public extension agents, non-government organizations, the private sector, academic institutions and direct delivery to individual growers.
- technical backstopping and partnership with similar facilities in Uganda and Tanzania, and with the Tanzania Forestry Research Institute and the National Forest Research Institute, also in Tanzania.

biotechnology through capacity- building, infrastructural development, agro-ecological trials and delivery networks. A programme for the breeding of eucalyptus has used a sustained broad genetic base, continued field-testing of clonal rooted cuttings before deployment and high-level nursery management to considerably increase variations in species and speed up the breeding process. Thanks to the diversity of species and hybrids made available by the project, eucalyptus can now be grown in diverse sites. Additionally, its growth performance can be assessed to provide both basic wood and non-wood products to farmers (Wakhusama and Kanyi, 2002).

The adoption of pest- and disease-resistant biotech crops, such as Bt cotton and Bt maize, has positive impacts on the protection of biodiversity and reduction of the amount of agrochemicals released into the environment. For instance, farmers growing conventional cotton in Burkina Faso have to spray six times per season to control the bollworm, compared to those growing Bt cotton, who spray only two times in a season (James, 2010 and 2011).

The agro-processing industry in Africa produces large amounts of waste, which contributes to environmental pollution. Projects supported by the former BIO-EARN, now Bio-Innovate, have demonstrated that waste is a resource that could be used to generate bioenergy and value-added chemical products. Waste from sisal and fish processing can offer a great deal in this regard. The waste has the potential to generate considerable revenue and can be turned into a commercially viable business. It can be used in the production of fish oils, fish protein hydrolysates, enzymes and bioenergy. Biotechnology has been used to develop processes for the production of biogas and recovery of valuable products from Nile perch waste. This has attracted industrial partners from the Eastern African region to collaborate on the marketing of fish waste-processing technologies. It has also been used to improve and scale up integrated processes for the production of biogas from sisal waste. The commercial viability of these more efficient biogas bioreactor systems has been demonstrated. This has helped establish collaboration with the sisal industry with the aim of producing biogas more effectively from sisal processing waste (Forsman and others, 2010).

Untreated or insufficiently treated industrial effluents with high contents of organic matter, nitrogen and heavy metals are usually discharged into the environment and fresh water sources. The depletion of dissolved oxygen, toxicity and the eutrophication of receiving waters are some of the major pollution concerns associated with such effluents. This has necessitated the search for environmentally friendly technologies for the treatment of industrial wastes, such as tannery wastewaters. Biological processes are not only cost-effective but also environmentally sound alternatives to the chemical treatment of tannery wastewaters.

In Ethiopia, Addis Ababa University's department of biology commissioned a pilot plant for six months to evaluate its effectiveness for removing biological nitrogen and organic matter from tannery wastewater. The pilot wastewater-treatment plant was fed with raw tannery wastewater obtained from the Modjo Tannery located 70 km south of the capital, Addis Ababa. The plant was found to be operationally efficient for the removal of nitrogen, organic matter and other pollutants from the tannery.[6]

## 3.5 Scientific and technical cooperation on biotechnology and biosafety

One of the key commitments of the JPOI is to foster scientific and technical cooperation on biotechnology and biosafety, including the exchange of expertise, training and human resources, and to develop research-oriented institutional capacities. The AU-NEPAD agency, ABI, launched in 2005, is a typical example of concrete actions taken to enhance scientific and technical cooperation in the region. ABI's strategic objectives are to: address African problems in agriculture, health and the environment by using bioscientific innovations; use new developments in biosciences to protect the environment, conserve biodiversity and improve the livelihoods and well-being of the people of Africa; build and strengthen human capacity in biosciences in Africa; promote access to affordable, state-of-the-art research facilities within Africa in order to address the continent's challenges and improve the quality of bioscientific

**Table 5**: NEPAD OST Networks of centres of excellence in biosciences

| Networks | Nodal Point | Hub National | Centre Focus | Area of Work |
|---|---|---|---|---|
| Northern African Biosciences Network | Egypt | Research Centre | Biopharmaceuticals | North Africa: to lead the continent in research into bio-pharmaceuticals, drug manufacturing and test kits |
| West African Biosciences Network | Senegal | Senegalese Institute of Agricultural Research (ISRA) | Crop Biotech | West Africa: to carry out research using biotechnology tools to develop cash crops, cereals, grain, legumes, fruits and vegetables and root/tuber crops |
| Southern African Network for Biosciences | South Africa | CSIR, Bioscience Unit | Health Biotech | Southern Africa: to deliver health biotechnology by researching into the causes and prevention methods of a range of diseases, in particular, TB, malaria and HIV/AIDS |
| Biosciences East and Central Africa | Kenya | International Livestock Research Institute | Animal Biotech | East Africa: to focus on research into livestock pests and diseases in order to improve animal health and husbandry<br>Central Africa: to build and strengthen indigenous capacity by identifying, conserving and sustainably using natural resources and also researching into the impact on biodiversity of events, such as climate change and natural disasters |

*Source:* Wafula and others, 2012.

6 Biological nitrogen and organic matter removal from tannery wastewater in pilot plant operations in Ethiopia. (S Leta, F Assefa, L Gumaelius, G Dalhammar), http://lib.bioinfo.pl/pmid:15316686.

research; and to harness indigenous knowledge and technology of the African people for the sustainable use of natural resources and the creation of wealth.

### The ABI networks

The AU-NEPAD/ABI adopted the regional networking approach whereby institutions make their resources available to address common challenges. To this purpose, four regional networks were established on the continent, namely: the Southern African Network for Biosciences; the Biosciences Eastern and Central Africa; the West

African Biosciences Network, covering ECOWAS countries, and; the North African Biosciences Network, covering six countries in North Africa.

Within five years of the creation of ABI, some achievements were made based on prior progress. These include:

- Research and development in the various fields and topics of bioscientific research carried out by different networks.
- Human capacity-building in basic and applied sciences through short- and long-term training; the training is well distributed among the networks and involves masters' degrees, doctorates and other required skills.
- Strengthening of infrastructural capacity. The most significant are the upgraded facilities at the laboratories at ILRI that offer opportunities to African scientists to carry out cutting-edge bioscientific research in bioinformatics, gene sequencing, genotyping, molecular breeding, and the genetic engineering of crops, livestock, wild animals and plants.
- Networking. This is viewed as an essential component for speeding up capacity- building and collaborative research efforts among institutions involved in bioscience activities in Africa. It has been found useful in information dissemination among regulators and other stakeholders in the regulatory regime. The NEPAD agency has been able to build a number of partnerships with the regional economic communities on the continent and with subregional agricultural research organizations.

## 3.6 Facilitating the transfer of technologies, including biotechnology

The transfer of technology was considered a critical and indeed integral process in the quest for sustainable development during the 1992 UNCED meeting in Rio de Janeiro, Brazil. Thus, nations of the world made access to and the transfer of technology integral to two major global commitments, namely Agenda 21 and the CBD.

The text of Agenda 21 (Chapter 16) was emphatic on the need for countries to cooperate and build capacities so as to facilitate the transfer of environmentally sound technologies. The Parties present at the UNCED meeting were unequivocal about biotechnology's potential contribution to sustainable development, and overwhelmingly pledged to pursue the environmentally sound management of biotechnology. Among other things, they would do this by recognizing the need to exploit biotechnology in a safe and environmentally responsible manner.

Equally supportive of sound management of biotechnology through responsible access to and the transfer of technology was the CBD. A landmark treaty on the environment and development, the CBD was first opened for signature at Rio de Janeiro in 1992. Although primarily focused on the conservation of biological diversity, the CBD's scope extends to cover access to technology, including biotechnology. More specifically, Article 16 of the CBD obligates contracting Parties to several commitments. They include: instituting technology transfer mechanisms that promote the conservation of biological diversity; defining the basis for the transfer of technology in developing countries, and; developing measures for technology transfer that also respect the protection of intellectual property rights. The section below reviews progress on initiatives undertaken in Africa in the past two decades to facilitate the transfer of environmentally sound technologies.

### 3.6.1 South-South collaboration

Traditionally Africa has benefited from arrangements that favour North-South transfers of technology. The emerging trend favours South-South collaboration involving countries in Asia and Latin America. Some of the documented technology-transfer initiatives include those listed below.

## Africa-Brazil

The idea of stronger Africa-Brazil links is a typical example of a South-South collaboration model. The collaboration was formalized in 2008 with the inauguration of a Regional Office of Brazil's famous Agricultural Research Corporation (EMBRAPA) in Accra, Ghana. Among other things, the Accra Office is tasked with facilitating technical cooperation for agricultural development and the transfer of technology, providing industries with access to research findings and reinforcing human-resource capacity-building. It is designed to support South-South cooperation through collaboration between Ghanaian and Brazilian scientists. The aim is to benefit the two countries as well as other African countries. EMBRAPA, established in April 1973, has developed into a major world player in agricultural research and technological development, contributing an estimated 40 billion dollars to Brazil's gross domestic product. It is also a leader in biotechnological research and development. Close collaboration with Brazilian institutions would promote the sharing of knowledge, transfer of appropriate technologies and best practices for the radical transformation of agriculture in Ghana and other African nations (Galerani and Bragantini, 2007).

## South Africa-East Africa

Partnerships and intraregional collaboration has resulted in the successful transfer of beneficial technologies from South Africa to East Africa. A case in point is the successful negotiation, testing and transfer of tissue-culture technology to mitigate the disease pathogen load in bananas. This has helped to reverse the declining trends in farm productivity and increase farmers' access to clean planting material in East Africa. Another prime example is the transfer of clonal forestry technology to East Africa, which has given farmers access to hybrid fast-growing multipurpose tree seedlings to meet basic fuel wood needs as well as commercial needs. The International Service for the Acquisition of Agri-biotech Applications (ISAAA AfriCenter) played a role in making such initiatives a reality. ISAAA AfriCenter is a not-for-profit international organization that shares the benefits of crop biotechnology with various stakeholders, particularly resource-poor farmers in developing countries. This is made possible through knowledge-sharing initiatives and the transfer of proprietary biotechnological applications.

### 3.6.2 North-South collaboration

## African Agricultural Technology Foundation

In 2002, the African Agricultural Technology Foundation (AATF) was established to serve as a platform for brokering access to and the transfer of proprietary technologies to improve Africa's food security prospects. The work of the AATF rests on the twin approach of: negotiating, on a humanitarian basis, access to proprietary agricultural technologies from anywhere in the world, and; forming public-private partnerships involving various institutions to ensure sustainable testing and delivery of products made from such technologies. The AATF manages matters relating to intellectual property, regulatory compliance, liability protection, licensing, sublicensing and the freedom to operate. Under multi-partnership arrangements, the AATF has spearheaded the transfer of several agro-based technologies. They include Striga weed-control technologies currently being delivered for use by smallholders in Eastern and Southern Africa. In addition, the AATF negotiated and entered into a contractual agreement with Monsanto Company for access to and the use of the insect-protection gene to genetically improve the cowpea's resistance to pests in sub-Saharan Africa. The Foundation also entered into a tripartite agreement with Monsanto and CIMMYT to obtain and deliver drought-tolerant maize varieties as a way of mitigating the effects of climate change.

## Agricultural Biotechnology Support Programme

The Agricultural Biotechnology Support Programme is a USAID-funded consortium of public and private sector institutions that supports scientists, regulators, extension workers, farmers and the general public in developing countries to make informed decisions about agricultural biotechnology. Where demand exists, the consortium concentrates on the safe and effective development and marketing of bioengineered crops as a complement to traditional and organic agricultural approaches. It helps boost food security, economic growth, nutrition and environmental quality in East and West Africa, Bangladesh, India, Indonesia and the Philippines. The consortium develops innovative and pragmatic solutions, building on the successes of the Agricultural

Biotechnology Support Project that was led for over a decade by the Michigan State University. The Project's work in Africa includes efforts to develop disease-resistant banana in Uganda and insect-resistant potatoes in Egypt and South Africa. Progress has been slow and fraught with regulatory obstacles and public resistance.

## 3.7 Capacity-building initiatives for the implementation of commitments on biotechnology and biosafety

A number of international agencies and institutions and donor organizations have initiated programmes dedicated to building African countries' capacities in biotechnology and biosafety. The International Centre for Genetic Engineering and Biotechnology has a project striving to strengthen biosafety across sub-Saharan Africa. The Program for Biosafety System (PBS), managed by the International Food Policy Research Institute, supports partner countries in Africa and Asia in the responsible development and use of biotechnology. The PBS works with stakeholders to develop and implement science-based, functional biosafety systems that ultimately: broaden producer choice, inspire consumer confidence, facilitate trade and promote agricultural research and development. In addition to this, several institutions have been created whose scope of action covers the entire continent. The African Biosafety Network of Expertise is an Africa-based and Africa-led initiative whose overall mandate is to build functional biosafety systems in Africa. The Network's biosafety services aim to empower African regulators with science-based information, targeting members of national biosafety committees, institutional biosafety committees, and plant quarantine officers so that they can make informed decisions on biotechnological products.

Financial contribution from African countries towards the implementation of the Biosafety Protocol has been limited. This has led to dependency on external sources of funding. UNEP-GEF has provided the bulk of financial support for the development and implementation of national biosafety frameworks in various African countries. The support primarily seeks to accelerate the pace of the Protocol's ratification, its integration into national laws, as well as compliance with its various provisions and requirements. The UNEP-GEF support has helped to incorporate biosafety considerations into mainstream national development priorities. Countries have also been able to acknowledge biosafety as an indispensable aspect of the cross-cutting sustainable development agenda (UNEP-GEF, 2006).

The UNEP-GEF pilot project, designed to support biosafety initiatives, that was implemented in 18 countries between 1997 and 2000 benefited 10 African countries, namely Cameroon, Egypt, Kenya, Malawi, Mauritania, Mauritius, Namibia, Tunisia, Uganda and Zambia. In 2004, the GEF approved additional funding for more

**Table 6**: Selected biosafety capacity-building programmes active in Africa

| Initiative | Key Players | Activity/objective |
|---|---|---|
| UNEP/GEF | All African countries | Biosafety in conformity with the CBP |
| International Centre for Genetic Engineering and Biotechnology | SSA countries | Strengthening and expanding biosafety systems |
| PBS | COMESA, Malawi, Kenya, Uganda, Nigeria, Mozambique | Integrated practical, technical, legal, and outreach/ communications expertise to assist African countries in the creation of functional biosafety systems and approaches |
| African Biosafety Network of Expertise/NEPAD | All African countries | Empower Africans to develop and implement biosafety frameworks |
| BIO-EARN | East Africa | Biosafety for research and development |
| FARA-ABBPP | All African countries | Biosafety policy dialogue among diverse stakeholders at all decision-making levels- national, regional, continental |

*Source:* Karembu and others, (2009).

countries to be supported, bringing the total number of African countries assisted to 41. This was followed by the UNEP-GEF project on the implementation of NBFs. Countries supported include Cameroon (US$ 0.560m), Egypt (US$ 0.908m), Kenya (US$ 0.511m), Mauritius (US$ 0.428m), Namibia (US $ 0.672m), Tanzania (US$ 0.777m), Tunisia (US$ 0.849m) and Uganda (US$ 0.560m) (UNEP-GEF, 2006).

Another contribution by UNEP-GEF was the Biosafety Clearing House capacity-building project. The project's goal is to help participating countries meet their obligations to the Cartagena Protocol on Biosafety, with regard to information exchange and the Biosafety Clearing House. It was approved in 2004 and has so far assisted over 46 countries in Africa. The project's goal is to train key stakeholders on how to obtain information from the Biosafety Clearing House and to transmit national information to it. The project also provides the relevant equipment and software for the exchange of information and its transmission to the Biosafety Clearing House.

In conclusion, UNEP-GEF contributed significantly to the strengthening of countries' capacities to engage in biotechnology research and development. Its support helped to reinforce safety in the use of biotechnology and to foster international cooperation, in line with Agenda 21. The support also fulfilled the project's pledge to pursue Agenda 21 by providing new and additional financial resources for the implementation of the Protocol under the CBD (UNEP-GEF, 2006).

### **Box 5**: 2005-2011: The Dutch-German ABS Capacity-Building Initiative for Africa

Negotiating and implementing an international regime on ABS requires capacity development. This is in line with the draft action plan for the development of ABS capacity, adopted by the Sixth Conference of Parties (COP-6) in 2002. Conscious of this situation, the Directorate-General for International Cooperation (DGIS) of the Netherlands Ministry of Foreign Affairs and the German Technical Cooperation Agency (GTZ) met in 2005 to discuss joint support to ABS capacity- building in Eastern and Southern Africa.

As a result, the DGIS co-funded GTZ's supra-regional programme, Implementing the Biodiversity Convention, in order to organize a regional workshop on ABS capacity development. This multi-stakeholder workshop was held in October 2005 in Addis Ababa. Fifty participants from 15 countries took stock of bio-prospecting in Africa and assessed the capacity development needs of the ABS. Participants in particular noted the following challenges:

- lack of awareness of the potential of ABS at the political level;
- inadequate national regulations on ABS;
- inadequate implementation of existing regulations;
- insufficient awareness and exchange among relevant stakeholder groups;
- insufficient regional harmonization;
- unavailability of inventories and information on the value of genetic resources, and;
- inadequately developed negotiation skills.

Based on the substantive workshop results, participants' encouraging feedback and the overwhelming interest of stakeholders from all over Africa, the DGIS and GTZ agreed to continue their cooperation until 2008, under the framework of the Dutch-German ABS Capacity-Building Initiative for Africa. Africa was retained as the priority region, given that, by international comparison, this is where the need for capacity development is greatest. The Initiative was launched at CBDCOP-8 in March 2006 in Curitiba, Brazil, and offers strategic Africa-wide multi-stakeholder workshops, as well as thematically specific or regionally focused ABS workshops and training courses.

The Initiative has, among other things, helped strengthen African delegates' preparedness to negotiate an international regime for ABS. At the COP-9 in Bonn, Germany, in May 2008, the African group officially expressed its gratitude to the Initiative's assistance to the region, stressing the need for continued support for ABS capacity development in Africa. In 2009 the Norwegian Ministry of Foreign Affairs joined the Initiative, which was extended to 2011, with increased assistance from additional donors and partners. The *Institut de l'énergie et de l'environnement de la Francophonie* joined the Initiative that same year to advance the integration of francophone African countries into the Initiative's activities.

This cooperation was a first step towards building the Dutch-German partnership in a multi-donor initiative to develop Africa's regarding ABS. As such, the Initiative was renamed to the ABS Capacity Development Initiative for Africa.

In 2003, the AU and the German Federal Ministry for Economic Cooperation and Development (BMZ) commissioned a project on capacity-building for an Africa-wide biosafety system. The project's mission was to equip the AU with the necessary capacity and effective instruments to help its member States implement the Cartagena Protocol and enforce the African Model Law on Biosafety. The AU Model Law influenced the legal drafting of biosafety legislations in Ethiopia, Ghana, Mali and Tanzania. The project's substantive activities started in January 2006 and were concluded in April 2011 at a total budget of 2 million Euros. Among the first activities was the establishment of a biosafety office at the seat of the African Union Commission in Addis Ababa. The project also established a technical advisory committee with representation from the five African subregions, the African Union Commission, the German Society for International Cooperation (GIZ), NEPAD and ECA (AU, 2011).

The AU Biosafety Project has played an important role technically and financially in supporting member States to meet regularly and prepare for international negotiations. Since 2006, nine preparatory workshops to support African negotiators have been organized with the overall logistical support of the CBD secretariat. The preparatory workshops were organized a day or two prior to the start of the actual negotiation session and served as a forum for African negotiators to thrash out all elements of the negotiations (AU, 2011).

Responding to Article 23 (Public Awareness and Participation) of the Biosafety Protocol, several institutions are engaged in communication and outreach activities on biotechnology and biosafety. They include the ISAAA AfriCenter, the Africa Biotechnology Stakeholders Forum and Africa Harvest. These organizations provide information to scientists, journalists, policymakers, regulators, farmers and consumers on developments in modern biotechnology and biosafety to facilitate science-based decision-making.

### 3.7.1 Education for biotechnology

Africa's institutions of higher learning have established programmes dedicated to building human resource capacity. They have also invested in facilities and infrastructure for research and development in biotechnology. In Kenya, most of the public universities, including Kenyatta, Nairobi, Jomo Kenyatta University of Agriculture and Technology, Egerton and Moi offer courses in biotechnology at the bachelor's, master's and doctorate degree levels. Kenyatta University has facilities for conducting advanced genetic engineering work. The School of Pure and Applied Sciences conducts research in the development of transgenic maize for drought tolerance and iRNA technology for Striga resistance in sorghum. The Centre for Biotechnology and Bioinformatics at the University of Nairobi conducts research and postgraduate training at the master's and doctorate degree levels in biotechnology and bioinformatics to develop capacity and human resources for health, agriculture, industry, environmental management and related fields.

In Uganda, the faculty of agriculture at Makerere University trains most of the scientists in research institutes. The faculty offers a master's degree in crop science, with an option in biotechnology, focusing on genetic engineering in crop production. The faculty also conducts research in areas, such as diagnostics, DNA mapping and marker-assisted breeding. Bovine hormone for growth and milk production is one of its research projects. The faculty of veterinary medicine at the same university applies molecular techniques to research in diagnostics, veterinary microbiology and pathology. In conjunction with the department of biochemistry, it offers a master's degree in molecular biology and biotechnology.

In Ethiopia, training in biotechnology has been initiated in universities and colleges. Dating back to the 1980s and 1990s, the College of Natural Sciences (the then faculty of science) at Addis Ababa University initiated joint research and training programmes in biotechnology with Swedish universities. The programmes made it possible to train staff members in agricultural biotechnology and industrial biotechnology and to establish a modest facility. This capacity made it possible to launch the Biotechnology Programme in 2006 and to start offering post-graduate training at the master's degree level. The Programme is finalizing preparations to launch a doctoral course in biotechnology at the beginning of the 2012–2013 academic year. Other institutions of higher learning in the country have started graduate and undergraduate training in biotechnology: Gonder University (undergradate programme); Haramaya University (master's degree programme); Jima University (master's degree programme), and; Mekelle University and Mekelle Institute of Technology (undergraduate programme). The Ethiopian Institute of Agricultural Research, with support from the

Ethiopian government, has established a state-of-the-art biotechnology laboratory at Holeta, with a focus on agricultural biotechnology (Forsman and others, 2010).

## 3.8 Impact of liability and redress measures

The Supplementary Protocol defines "damage" as an adverse effect on the conservation and sustainable use of biological diversity that is measurable and significant. It also provides an indicative list of factors that should be used to determine the significance of an adverse effect. Once the threshold of significant damage has been met, the need for response measures arises. The Supplementary Protocol is the first multilateral environmental agreement to define damage to biodiversity. The Supplementary Protocol does not cover traditional damage, which is common in third-party civil liability instruments, and which includes personal injury, loss or damage to property or economic interests.

The Supplementary Protocol has adopted an administrative approach for addressing damage resulting from living modified organisms. Aspects of the administrative approach concern the issue of who should take response measures–in the event of damage or possible damage resulting from LMOs that originate in a transboundary movement–as well as how, and when (CBD, 2010). Realistic liability and redress provisions are necessary for the responsible development, deployment and use of biotechnology. However, countries should be weary of imposing strict liability provisions that could undermine or impede efforts to implement sustainable development commitments related to biotechnology (Mtui, 2012). Believing that they need protection from multinationals, some African countries have established very stringent regulations and regimes for liability and redress. This has not only discouraged foreign technology developers and development partners but also stifled home grown efforts in biotechnology research and development (Cullet, 2006).

Tanzania and Zambia are examples of countries that have demonstrated commitment to integrating the Cartagena Protocol on Biosafety into their national laws by enacting biosafety legislation and instituting key components of NBFs. However, progress in the implementation of sustainable development commitments on biotechnology has been slow owing to stringent liability and redress provisions.

**Box 6: Zambia Biosafety Act Liability and Redress Provisions**

A person who imports, arranges transit, develops, makes contained use of, releases or places on the market a genetically modified organism or product of a genetically modified organism shall be strictly liable for any harm caused by the genetically modified organism or product of the genetically modified organism and shall compensate any person to whom the harm is caused.

Liability shall attach to the person responsible for the activity, which results in the damage, injury or loss as well as to the provider, supplier or developer of the genetically modified organism or of the product of a genetically modified organism. If there is more than one person responsible for the damage, injury or loss, then the liability shall be joint and several.

Liability shall also extend to—

(a) Any harm or damage caused directly or indirectly by any genetically modified organism or a product of a genetically modified organism to the economy or social cultural conditions;

(b) Any negative impacts on the livelihood or indigenous knowledge systems or technologies of any community;

(c) Any damage or destruction arising from any incidents of public disorder triggered by any genetically modified organism or a product of a genetically modified organism;

(d) Any disruption or damage to any production or agricultural system;

(e) Any reduction in yields of the local community;

(f) Any soil contamination or damage to biological diversity;

(g) Any damage to the economy of the area or community or;

(h) Any other consequential disorder.

In Tanzania, biosafety legislation is incorporated in the Environmental management Act. Regulations on its implementation were gazetted in 2009. The regulations state that any person or his agent who imports, transits, makes contained or confined use of, releases, carries out any activity in relation to GMOs or their products, or places on the market a GMO shall be strictly liable for any direct or indirect harm, injury or loss caused by such GMOs or their products or by any activity in relation to GMOs. The liability and redress clause requires that one must have a valid policy of insurance to pay compensation in the event of damage. This new type of liability insurance is not available in Africa. The strict liability provisions have delayed the approval of the Water Efficient Maize for Africa confined field trials. Mock trials (involving non-modified maize lines) were successfully conducted in 2009 but the project failed to proceed to the next step because the government did not grant a permit for Confined Field Trials of genetically modified maize. Approvals to conduct CFTs have already been granted by biosafety authorities in other WEMA-project countries, including Kenya, South Africa and Uganda.

# 4. Implementation challenges and constraints

In spite of the progress in developing legal frameworks, translating policy into practice in Africa has been slow. This is attributed to a variety of reasons. The precautionary approach to GMOs, as laid out in the Cartagena Protocol on Biosafety and integrated into most national legislation, over-emphasizes risks associated with genetic modification technology. The keen focus on risks at the expense of benefits has made it difficult to introduce the technology in many countries. Capacity- building activities to assist countries to create NBFs have not been balanced, their main concern being to manage risks (Morris, 2011). Other challenges include: the lack of strong political will and commitment, and; lack of mechanisms for timely access to scientific evidence and for efficient decision-making on biotechnology. The African sector for biotechnology research and development is also hampered by limited funding, the absence of biosafety regulatory frameworks in most countries and inadequate human resources and infrastructural capacity to engage in cutting-edge biotechnology work.

The aforementioned factors partly explain why the commercialization of genetically modified crops, for instance, is confined to three countries—Burkina Faso, Egypt and South Africa. Only six other countries have confined and/or multilocation field trials in place (Ghana, Kenya, Malawi, Nigeria, Uganda and Zimbabwe). Uganda is quickly moving towards the marketing stage but the passage of the biosafety bill is a prerequisite (IFPRI, 2011).

Challenges and constraints associated with the implementation of sustainable development in biotechnology in Africa are highlighted in various categories below.

## Political commitment and priority setting

The extent to which biotechnology has contributed to sustainable development in various countries is closely linked to and has been dictated by the policy and/or political landscape and the nature of legislation enacted to govern the technology. The majority of African countries have not integrated the biotechnology agenda into national development policies. This is manifested through lack of clear priorities and investment strategies. In the absence of identified priorities, it is difficult for these countries to make informed and long-term policies. Policies on biotechnology need to be based on or informed by clearly articulated national priorities and goals.

To further compound the problem of policy direction and priority setting, there is still limited information available on biotechnology research, development and deployment in some subregions, in particular North Africa and Central Africa. More efforts are needed to collect and analyse information that could boost the implementation of sustainable development in biodiversity at the national, subregional and regional levels.

## Funding and capacity-building

Modern research and development in biotechnology requires considerable knowledge and capital, with hefty financial implications. Short-term erratic and low-level financing of research and development in biotechnology is a major constraint across the continent. Increasingly, the main challenge for public research and development in biotechnology in Africa is how to find investment capital to sustain basic research and to convert laboratory findings to commercial use. Although there has been a surge in funding for research and development in agricultural biotechnology in most countries, the available financial resources are still too low to allow countries to engage effectively in cutting-edge activities. While they are coordinated and managed by public research institutions, most biotechnological research and development programmes are donor-funded. Equally challenging is the low level of private sector participation in biotechnology research and development. In some cases links with the local private sector are either weak or non-existent.

Few countries have the necessary scientific and technological infrastructure to carry out modern research and development in biotechnology. Lack of a critical mass of scientists in advanced areas of modern biotechnology, such as genomics, bioinformatics and molecular biology, is another acute challenge in most countries.

## Biosafety regulation

Biosafety regulations play a key role in the judicious use of biotechnology. However, laws and regulations must balance the potential risks associated with biotechnology with the expected benefits. Regimes for liability and redress can play an important role in ensuring responsible use of biotechnology. For instance, strict provisions for liability and redress that exceed basic scientific principles and the guidance provided by the biosafety protocol and other international instruments could prevent African countries from implementing sustainable development in biotechnology. Beside the high cost of introducing and developing biotechnology products, countries have to bear the cost of setting up and maintaining biosafety regulatory systems. This requires adequate and predictable financial resources and a pool of skilled human resources. Dependency on external funding may cause many countries to jeopardize sustainability when development partners eventually withdraw.

## Technology transfer and IPRs

Many African countries still grapple with the absence of coherent and realistic policies, often exacerbated by the lack of developed mechanisms for promoting public-private partnerships in the transfer of technology. This is in spite of such transfers being critical for sustainable development. Additionally, Africa has limited initiatives and programmes with adequate funding and institutional structures dedicated to facilitating technology transfers.

The role of intellectual property protection and its impact on the acquisition, development and diffusion of biotechnology is not well entrenched. In most African countries institutions for administering industrial property rights (particularly patents) are still in their infancy. While many countries have established patent offices, their utility as sources of scientific and technological information is not adequately exploited. There is also a growing debate on the impact of intellectual property protection on the transfer of modern biotechnology to African countries. There is concern that intellectual property protection is a barrier to the transfer of technology.

## Concerns over GMOs

Wide-ranging concerns surround the development and deployment of modern biotechnology. The concerns are largely directed at GMOs and their products, notably with regard to human health, animal health and impacts on biodiversity. Regarding human health, the fear is that genetically modified foods may contain novel protein toxins arising from the introduction of foreign genes; they may also contain proteins that cause allergies. It is also feared that antibiotic-resistant genes used as markers in genetic engineering may induce a large-scale evolution of drug-resistant bacteria (Hosea, 2004). As for animal health, concerns are raised when GMOs and their products are used as feed for poultry, pigs and ruminants. There are also concerns over chemical compositions, nutritional parameters and the digestibility of genetically modified feed. Fears are voiced about the safety of milk from livestock raised on genetically modified feed, and about risks to animals fed on herbicide-tolerant or insect-protected crop silage. Ecological concerns refer mainly to possible adverse effects of GMOs, such as: negative impacts on non-target organisms; the loss of biodiversity due to the dominance of genetically modified strains; the emergence of super weeds; the escape of genes, and; the trans-genes effect. In addition, there are controversies of a socioeconomic nature. They include the possibility of GMOs interfering with traditional agriculture, commercial export risks, the labelling of products to facilitate consumer choice and intellectual property rights related to ownership of the technology. Not to be overlooked are ethical and cultural considerations and the morality of modifying natural organisms (Hosea, 2004).

Some of the aforementioned concerns may be genuine and should be addressed in a science-based manner on a case-by-case basis. However, it should be noted that studies conducted over the years by credible and internationally recognized bodies have answered most of these concerns and affirmed the safe use of GMOs for the last one and a half decades. In 2010, the European Commission Directorate-General for Research and Innovation published a comprehensive report entitled, "A Decade of EU-funded GMO Research (2001-2010)". The research, *inter alia*, covered environmental impacts of GMOs, as well as the safety of food and human health. The report covered over 130 research projects, involving more than 25 years of research and over 500 independent research groups. It concluded that biotechnology, and in particular the genetic modification of organisms, per se, is not more risky than conventional plant-breeding technologies. The report observed that projects dealing with the development of new products and processes based on GMO technology fully integrate safety assessments in their conception, experimentation and development.

## Communication, awareness and public participation

Polarized debates and negative public perceptions are an obstacle to the acceptance of biotechnology. Misinformation remains a key factor hindering the adoption of biotechnology in Africa. This drawback is compounded by misconceptions and lack of knowledge about the use of biotechnology in general, and about GMOs in agriculture. It does not help that few farmers produce genetically modified crops commercially.

# 5. Biotechnology's interlinkages

Biotechnology is interlinked with other important sectors, including biodiversity, forests, tourism and mountains. The interlinkages, both positive and negative, are summarized in the table below.

**Table 7**: Biotechnology interlinkages with biodiversity, forests, tourism and mountains

| | Biodiversity | Forests | Tourism | Mountains |
|---|---|---|---|---|
| Biotechnology | • Biotechnology can be used as a tool for adding value to biodiversity through plant and animal breeding involving the transfer of genetic information across plants, animals and microorganisms and also the conservation of germplasm in gene banks.<br>• Biodiversity on the other hand has provided biotechnology with the requisite raw materials. This includes plants and animal components, bacteria and microorganisms, for instance *Bacilicus thuringensis* (Bt), which has been extensively used in plant transformation and the development of transgenic plants.<br>• Threats of unintended gene flow from transgenic to wild relatives. It can be a major issue for crops where Africa is a centre of origin.<br>• Loss of biodiversity reduces opportunities for biotechnology development on one hand; and inappropriate biotechnology developments may adversely affect biodiversity and ecosystems, such as the development of superweeds that are herbicide-resistant.<br>• Biotech can prevent or minimize the biopiracy of genetic resources | • Technologies for the improvement of forest species through fast maturing, disease-resistant and climate-change resilient tree species (tissue-culture technology).<br>• Forests are habitats for special species useful in biotechnology for restoring denuded environments.<br>• Conservation of biodiversity through domestication of species currently threatened by unsustainable use in the wild.<br>• Trees developed with higher carbon sequestration capacity to mitigate climate change.<br>• Restoration and rehabilitation of forests and natural habitats through tree biotechnology (re-forestation programmes). | • Biotechnology-based tourism including conferences - Africa has hosted many international and regional biotechnology conferences that also promote tourism and travel.<br>• Tools for the conservation of flora and fauna, especially endangered species, for tourism.<br>• Rehabilitated ecosystems/natural habitats contribute to the enhancement of tourism by restoring the natural aesthetics of mountain landscapes and the diversity of fauna and flora. | • Mountains conserve genetic diversity and resources from which biotechnology developments may draw or depend.<br>• Denuded mountain ecosystems conserved through biotechnology.<br>• Clonal propagation for restoration and vegetation replenishment of denuded mountains.<br>• Mountains harbour many endemic and threatened species, genetic resources, and are nature's last stronghold for those species that have been exterminated in adjacent lowlands. |

# 6. Conclusions and recommendations

The application of biotechnology research and development in Africa cuts across agriculture, the environment, health and industry. African countries are embracing research and development in biotechnology at various levels to cope with the increasing demands for food, feed, fibre and fuel. Biotechnology is being exploited for human and animal health, in the diagnosis and treatment of disease and the development of drugs and vaccines. Biotechnology is also being harnessed in the sustainable use and conservation of forest resources. The industrial application of biotechnology to the generation of energy (biogas) from industrial wastes, and to the conversation of renewable raw materials as a substitute to fossil fuels, is an emerging opportunity.

However, a comparison of Africa with other regions of the world depicts an emerging technological divide in the application of biotechnology. This is attributed to a variety of reasons. The guarded approach to GMOs and biased focus on risks at the expense of benefits has limited the adoption of the technology in many countries. Efforts to assist countries build their capacities to establish NBFs lack balance, because they concentrate on managing risks. While genetic modification technology is used widely in drug development and the diagnosis and treatment of diseases, considerable uncertainty and scepticism surround genetically modified applications in agriculture. Other challenges include limited political will and lack of clarity in policy direction and commitments. Another obstacle is the lack of mechanisms to obtain scientific evidence for timely and efficient decision-making on biotechnology. African research and development in biotechnology is also hampered by limited funding, the absence of biosafety regulatory frameworks in most countries and inadequate human resources and infrastructural capacity for cutting-edge biotechnological work. Combined, these factors curtail Africa's efforts to fully implement its commitments on biotechnology and thereby reach greater heights of sustainable development and poverty reduction.

As such, African countries need to adopt proactive strategies to exploit the economic, health, environmental, and industrial benefits of biotechnology. The strategies should also take into account the management of potential challenges, risks and tradeoffs associated with the use of the technology, product development and deployment. Policy decisions and actions at the national and regional levels must be informed by science-based evidence that takes into account domestic socioeconomic realities and challenges.

The continent must address biotechnology and biosafety strategically with a clear picture of its priorities and constraints. Africa should demonstrate proactive leadership through pragmatic, demand-driven priorities that can enhance its capacity to apply biosafety and harness biotechnology to maximize benefits and mitigate potential risks. It is important to support regional cooperation and integration efforts in biotechnology and biosafety. This will help harness and leverage national and regional expertise, financial resources and facilities for research and development in biotechnology. The specific recommendations below have been put forward as means to address the challenges and constraints identified.

## Political commitment and priority setting

- Sustained political will and commitment from African governments to support biotechnology is imperative. As stipulated in CAADP, governments should formulate policies to attract and encourage private sector participation in biotech research and development, support the formation of incubation hubs in public universities and help foster links with the private sector for marketing purposes. Countries such as Burkina Faso, Egypt, Kenya, South Africa and Uganda have made progress towards the implementation of sustainable development commitments to biotechnology. This is attributed to their governments' exceptional political will and commitment and to an enabling environment that supports and stimulates innovations.

- Priority setting to enable agricultural biotechnologies to meet national needs in terms of food security and poverty alleviation. This is important in identifying areas of focus where interventions in agricultural biotechnologies could have maximum impact. National development plans and strategies should take into account the contribution that biotechnology can make in meeting Millennium Development Goals.

- For agriculture to help meet national development needs, governments should pursue holistic and integrated approaches that consider the entire system of agricultural innovation. These are more effective than fragmented project/programme-based approaches (that operate independently across different sectors and ministries).

## Funding and capacity-building

- It is important to increase national investment plans in research, including in biotechnology, in order to contribute to sustainable development. There is need to give priority to funding for modern biotechnology by setting specific policies that ensure the adequate and consistent funding for research and development in the sector. There is an urgent need for government policies to stimulate venture capital, contract research, partnerships with the corporate sector and other forms of financing. Research is also needed to identify specific policies on alternative/innovative financial mechanisms for biotechnology research and development.

- Biotechnology is dynamic and characterized by rapid developments. Continuous and demand-driven capacity-building is crucial to enable African countries to employ cutting-edge biotechnology applications and also cope with the speed at which technologies are evolving.

- The promotion of partnerships and regional integration and harmonization of biotechnology and biosafety policies creates opportunities for countries to cooperate in capacity strengthening and to pool together scarce financial, human and infrastructural resources.

## Biosafety regulation

- Failure to put in place effective and functional biosafety systems hinders the capacity of African countries to maximize the benefits of biotechnology and minimize potential risks. It is important to support the establishment of science-based regulatory systems at the national and institutional levels. Countries should be encouraged to create stewardship programmes for biotechnology, so as to manage insect resistance and sustain the integrity of products.

- Capacity-building in biosafety regulation should take into consideration the rapidly evolving nature of genetic engineering applications, such as progression from developing crops with single genes to those with multiple (stacked) genes. This requires skills, equipment and regulatory frameworks for managing the technology in order to make informed decisions. Aspects of biosecurity that are relevant to the regulation of biotechnology should be carefully delineated from the broader biosecurity continuum.

- Realistic liability and redress provisions are necessary for the responsible development and deployment of genetically modified products. Countries should weigh the pros and cons of strict liability provisions, which could slow down progress in biotechnological research and development. They must carefully examine strict liability and redress provisions to ensure that these do not hamper the introduction of home grown and/or imported biotechnologies. Governments should use the Nagoya-Kuala Lumpur Supplementary Protocol on Liability and Redress to guide and inform them in developing their liability and redress regimes. The Protocol gives the parameters of what constitutes damage and the basis for seeking redress.

## Technology transfer and IPRs

- African countries should support and strengthen existing and new technology transfer mechanisms. It is crucial to ensure that technologies transferred are sustainable, demand-driven and responsive to local needs and realities.

- Through capacity-building, appropriate policies and institutional arrangements, African countries should also support and strengthen intellectual property systems that reconcile the need to reward inventors with the promotion of the freedom to innovate.

## Communication, awareness and public participation

- African governments should take the lead in promoting and improving the understanding of biotechnology based on scientific evidence for informed decision-making and public participation. Well-coordinated, credible communication strategies and programmes to enhance public awareness and engagement are crucial in building public confidence, trust and acceptance of biotechnology.

# Glossary of terms

***Bacillus thuringiensis* (Bt):** a natural occurring bacterium that produces a toxin against certain insects, particularly *Coloeoptera and Lepidoptera*. Some of the toxin's genes are important for transgenic approaches to crop protection.

**Biodiversity (biological diversity):** means the variability among living organisms from all sources including, 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.

**Biosafety:** a range of measures, policies and procedures for minimizing potential risks that biotechnology may pose to the environment, human and animal health.

**Bioinformatics:** the use and organization of information of biological interest. In particular, it is concerned with organizing bio-molecular databases (particularly DNA sequences), utilizing computers for analysing this information, and integrating information from disparate biological sources.

**Biotechnology**: any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use.

**Confined Field Trial (CFT):** is a restricted environmental release of a GMO under conditions that are designed to prevent the spread of the organism from the trial site to the environment. CFTs are conducted for research purposes to collect agronomic data required to assess the efficacy and safety of the organism with a new trait(s) introduced by genetic modification (GM).

**DNA (abbreviation for deoxyribonucleic acid):** constitutes the genetic material of most known organisms and organelles, and usually is in the form of a double helix, although some viral genomes consist of a single strand of DNA, and others of a single- or a double-stranded RNA.

**Gene:** the unit of heredity transmitted from generation to generation during sexual or asexual reproduction. More generally, the term is used in relation to the transmission and inheritance of particular identifiable traits. The simplest gene consists of a segment of nucleic acid that encodes an individual protein or RNA.

**Genetic engineering (same as genetic modification):** refers to the process of inserting new genetic information into existing cells for the purpose of modifying one of the characteristics of an organism.

**Genomics:** research that uses molecular characterization and cloning of whole genomes to understand the structure, function and evolution of genes and to answer fundamental biological questions.

**Genetically modified organism (GMO):** an organism whose genetic material has been altered/ transformed by the insertion of one or more transgenes using genetic engineering techniques.

**Living modified organism (LMO):** any living organism that possesses a novel combination of genetic material obtained through the use of modern biotechnology.

**Recombinant:** the result of combining DNA fragments from different sources.

**Recombinant DNA technology**: a set of techniques for manipulating DNA, including: the identification and cloning of genes; the study of the expression of cloned genes; and the production of large quantities of gene product.

# References


African Union (2006). Extraordinary conference of the African Ministers of Science and Technology (AMCOST), 20-24 November, Cairo. 'African Strategy on Biosafety'. EXT/AU/EXP/ST/4(II).

African Union (2006). African Strategy on Biosafety.

Agfax (2010). Official approval for East Coast Fever Vaccine.

Amoa-Awua, W.K. Halm and M. Jakobsen, M. (2004). An African Fermented Maize Product. In Handbook of Food and Beverage Fermentation Technology (eds) Y. H. Hui, Lisbeth Meunier-Goddik, Jose Solvejg Hansen, Jytte Josephsen, Wai-Kit Nip, Peggy S. Stanfield, and Fidel Toldra. CRC Press.

Antwi, E., and others, (2010). Ghana's biofuels policy; challenges and the way forward. International Journal of energy and environment. volume 1, Issue 5. p. 805-814.

African Union/New Partnership for Africa's Development, (2006). Freedom to innovate: Biotechnology in Africa's Development. Draft Report of the High Level African Panel on modern biotechnology. AU/NEPAD, July 2006. http://www.nepadst.org/doclibrary/pdfs/abp_july2006.pdf.

African Union/New Partnership for Africa's Development, (2005). Africa's Science and Technology Consolidated Plan of Action. AU/NEPAD, August 2005; http:// www.nepadst.org/doclibrary/pdfs/doc27_082005.pdf.

Convention on Biological Diversity (2010). The Nagoya-Kuala Lumpur Supplementary Protocol on Liability and Redress to the Cartagena Protocol on Biosafety. An Introductory Note in Preparation for Signature and Ratification. Secretariat of the Convention on Biological Diversity and United Nations Environment Programme.

Convention on Biological Diversity and African Union/New Partnership for Africa's Development (2003). Biosafety and the environment. An introduction to the Cartagena Protocol on Biosafety. Secretariat of the Convention on Biological Diversity and United Nations Environment Programme.

West and Central African Council for Agriculture Research and Development (2011). Annual Report.

Karembu, M., F. Nguthi and H. Ismail (2009). Biotech Crops in Africa: The Final Frontier, ISAAA AfriCenter, Nairobi, Kenya.

Cullet, P. (2006). Liability and Redress for Modern Biotechnology. 15-year book of environmental law, 165-195.

Diagne, A. (2009). "Technological Change in Smallholder Agriculture: Bridging the Adoption Gap by Understanding its Source." AERC Conference on Agriculture for Development, Whitesands Hotel, Mombasa, Kenya, May 28-29, 2009.

Drexhage, J. and Murphy, D. (2010). Sustainable Development: From Brundtland to Rio 2012. Background paper prepared for consideration by the High Level Panel on Global Sustainability at its first meeting, 19 September 2010 United Nations Headquarters, New York. International Institute for Sustainable Development (IISD).

Economic Commission for Africa (2009). Developing African Agriculture Through Regional Value Chains: Economic Commission for Africa. Addis Ababa, Ethiopia.

Food and Agriculture Organization/World Health Organization (2003 (a)). Principles for the risk analysis of foods derived from modern biotechnology, *cac/gl 44-2003*.

(2003 (b)). Guideline for the conduct of food safety assessment of foods derived from recombinant-DNA plants, *cac/gl 45-2003*.

(2003 (c)). Guideline for the conduct of food safety assessment of foods produced using recombinant-DNA-microorganisms, *cac/gl 46-2003*.

Forum for Agricultural Research in Africa (2011). Status of Biotechnology and Biosafety in sub-Saharan Africa: A FARA 2009 Study Report. FARA Secretariat, Accra, Ghana.

Forsman, B. Komen, J. and Virgin, I. (2010). A decade of Bioscience Development in Eastern Africa. The BIO-EARN Programme, 1999-2010.

Galerani, P., and Bragantini, C. (2007). Transfer of Tropical Agricultural Technologies from Brazil to African countries. Paper presented in 8th African Science Society Conference, 27-31 October. El Minia, Egypt.

Global Environment Facility (2006). Strategy for Financing Biosafety. GEF/C.30/8/Rev.1, GEF, December 2006. http://www.gefweb.org/Documents/Council_Documents/GEF_30/documents/C.30.CRP.6RevisedBiosafetyStrategy.pdf.

Global Agricultural Information Network (GAIN) (2012). Nigeria Agricultural Biotechnology Annual. USDA Foreign Agricultural Service Global Agricultural Information Network.

—(2011). Morocco Agricultural Biotechnology Annual. GAIN report number 1108. USDA Foreign Agricultural Service.

—(2011). Tunisia Agricultural Biotechnology annual. GAIN report number TS 1104. USDA Foreign Agricultural Service.

International Food Policy Research Institute (2011). A "State of Affairs" Assessment of Agriculture Biotechnology for Africa. A study commissioned by the African Development Bank.

International Institute for Sustainable Development (2007). African Regional Coverage Project. Published by the International Institute for Sustainable Development. Volume 5 Issue No. 1.

James, C. (2010). Global status of Commercialized biotech/GM Crops: 2010. International Service for Acquisition of Agri-biotech Applications.

—(2011). Global status of Commercialized biotech/GM Crops: 2011. Brief 43. International Service for Acquisition of Agri-biotech Applications.

Juma, C. and Serageldin, I. (Lead Authors) (2007). 'Freedom to innovate: biotechnology in Africa's development', A report of the high-level African panel on modern biotechnology. African Union (AU) and New Partnership for Africa's Development (NEPAD). Addis Ababa and Pretoria. Printed in the Republic of South Africa.

Juma, C. (2011). Africa needs new organizations that support innovation. Science Magazine 9th December.

Karembu, M., F. Nguthi, and I. Abdel-Hamid (2009). Biotech crops in Africa: The final frontier. Nairobi: ISAAA AfriCenter.

Karembu, M. (2007). Enhancing the Diffusion of Tissue Culture Banana to Small-Scale Farmers in Kenya. ISAAA brief, Nairobi, Kenya.

Kassa, D.G. (2011). The potential of biotechnology in Ethiopia: Food Chem. Toxicol., 49(3): 685-689.

Komen, J. (2012). The emerging international regulatory framework for biotechnology. In GM crops and Food Biotechnology in Agriculture and the Food Chain 3:1, 78-84; January/February/March 2012.

Makinde, D. (2012). Status of biosafety regulatory frameworks in Africa and the need for a regional approach. Paper presented at the COMESA regional workshop on the draft policy on GMOs.

Morris, J. (2011). Modern Biotechnology—Potential Contribution and Challenges for Sustainable Food Production in Sub-Saharan Africa. Sustainability journal available at www.mdpi.com/journal/sustainability.

—(2010). European Initiative for Agricultural Research for Development (EIARD) Analysis of donor support to CAADP Pillar 4 – Phase 1. A report to Executive Secretary, EIARD, European Commission, Brussels.

Motala, A. and Ramaiya, K. (2010). Diabetes: the hidden pandemic and its impact on sub-Saharan Africa. Diabetes leadership forum 2010.

Mtui, Y. S. G. (2011). Status of biotechnology in Eastern and Central Africa. Biotechnology and Molecular Biology Review Vol. 6(9), pp. 183-198.

Mtui, G. (2012). Biosafety Systems in Eastern and Central Africa. African Journal of Environmental Science and Technology Vol. 6(2), pp. 80-93.

Mneney, E.E. (2010). Status of Biotechnology application in Tanzania: A Country Report. A Paper presented at the Workshop on Theoretical Approaches and Their Practical Applications in Risk Assessment for Release of Genetically Modified Plants. Hermanus, South Africa, pp. 22-26.

Mneney, E.E., Mantel S.H. and Mark B. (2001). Use of random amplified polymorphic DNA markers to reveal genetic diversity within and between populations of cashew (*Anacardium occidentale* L). J. Hort. Sci. Biotechnol., 77(4): 375-383.

Nang'ayo, F. and others, (2007). Bracing for Genetically Modified Crops: Status of Regulations for GM crops in African countries. Proceeding of the African Crop Science Conference, El Mina, Egypt, October 2007.

Ngamau, C and others, (2004). Towards Optimizing the Benefits of Clonal Forestry to Small-scale Farmers in East Africa. ISAAA Briefs No. 33. ISAAA: Ithaca, New York, USA.

Nwalozie, M. and others, (2007). West and Central Africa: Strategizing biotechnology for food security and poverty reduction. In: the Gene Revolution GM Crops and Unequal Development (Fukuda-Parr S ed.), Earthscan, Sterling, Virginia, USA.

Hosea, K.M.M. (2004). Concerns on the effects of GMOs on human, animal and environmental health. In: Hosea KM, Msaki ON, Swai F. (Eds). Genetically modified organisms in Tanzania. Envirocare 26-32. http://www.envirocaretz.org. Cited: December 2011.

Oeba, V.O., Muchiri, M.N. and Kariuki, J.G. (2009). "Growth performance of Eucalyptus hybrid clones and four common landraces in Kenya" East African Natural Resource Management Journal (JEANARM): Journal of East Africa Natural Resource Management Vol (3). Number 1 (i-iv, 219-295) (2009).

Olembo N.K. and others, (2010). Status of biotechnology in Sub-Saharan Africa: A cross-country analysis. Africa Biotechnology Stakeholders Forum. Nairobi Kenya, p. 98.

Rutabanzibwa, A.P. (2004). Policies, regulation processes, monitoring and surveillance of biotechnology materials: In KM Hosea KM, Msaki ON, Swai F. (Eds) (2004). Genetically modified organisms in Tanzania. Envirocare, pp. 36-44. (http://www.envirocaretz.org, cited on 10th October, 2011).

Teshome, M. and others, (2011). Biosafety Policy of the African Union Background, Instruments, Activities. Published by African Union Commission Human Resources, Science and Technology.

United Nations Environment Programme-Global Environment Facility Biosafety Unit (2006). A Comparative Analysis of Experiences and Lessons from UNEP-GEF on Biosafety Projects.

Vognan, G., Ouédraogo, M. and Ouédraogo, S. (2002). Description de la filière cotonnière au Burkina Faso, Rapport intermédiaire, INERA, p.34.

Wafula, D. and others (2012). Biosafety legislation and bio-development gains momentum in Africa. In: GM crops and Food Biotechnology in Agriculture and the Food Chain 3:1, 78-84; January/February/March 2012.

Wekesa, M., Sihanya, B. (2005). Intellectual Property Rights in Kenya. Rule of Law Program for Sub-Saharan Africa, Published by Konrad Adenauer Stiftung.

Wesseler, J., Spielman, D.J. and Demont, M. (2010). The future of governance in the global bioeconomy: Policy, regulation, and investment challenges for the biotechnology and bioenergy sectors. *AgBioForum*, *13*(4), 288-290. Available on the web: http://www.agbioforum.org.

World Commission on Environment and Development (1987). Our Common Future, Report of the Published as Annex to General Assembly document A/42/427, Development and International Co-operation: Environment August 2, 1987.

## **Annex 1**: Indicative list of main commitments/goals contained in the JPOI, PFIA21 and A21 on Biotechnology

(a) Promote practicable measures for access to the results and benefits arising from biotechnologies based upon genetic resources, in accordance with articles 15 and 19 of the Convention on Biological Diversity, including through enhanced scientific and technical cooperation on biotechnology and biosafety;

(b) Increase the availability of food, feed and renewable raw materials using biotechnology as a means;

(c) Establish enabling mechanisms for the development and the environmentally sound application of biotechnology;

(d) Respect, preserve and maintain knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles, and encourage the equitable sharing of the benefits arising from traditional knowledge;

(e) Enhance developing countries' capabilities to compete in the emerging market for biological resources, while improving the functioning of that market;

(f) Improve productivity, nutritional quality and shelf-life of food and animal feed products with efforts including work on pre- and post-harvest losses;

(g) Improve both plant and animal breeding and micro-organisms through the use of traditional and modern biotechnologies, to enhance sustainable agricultural output to achieve food security, particularly in developing countries through:

- Further developing resistance to diseases and pests;
- Developing plant cultivars tolerant and/or resistant to stress from factors such as pests and diseases and from abiotic causes;
- Promoting sustainable agricultural output by strengthening and broadening the capacity and scope of existing research centres to achieve the necessary critical mass through encouragement and monitoring of research into the development of biological products and processes of productive and environmental value that are economically and socially feasible, while taking safety considerations into account;
- Promoting the integration of appropriate and traditional biotechnologies for the purposes of cultivating genetically modified plants, rearing healthy animals and protecting forest genetic resources;
- Developing processes to increase the availability of materials derived from biotechnology for use in food, feed and renewable raw materials production;

(h) Maintain and develop data banks of information on environmental and health impacts of organisms to facilitate risk assessment;

(i) Cooperate on issues related to conservation of, access to and exchange of germ plasm; rights associated with intellectual property and informal innovations, including farmers' and breeders' rights; access to the benefits of biotechnology; and bio-safety;

(j) Accelerate technology acquisition, transfer and adaptation by developing countries to support national activities that promote food security, through the development of systems for substantial and sustainable productivity increases that do not damage or endanger local ecosystems;

(k) Contribute, through the environmentally sound application of biotechnology to an overall health programme;

(l) Prevent, halt and reverse environmental degradation through the appropriate use of biotechnology in conjunction with other technologies, while supporting safety procedures as an integral component of the programme;

(m) Ensure safety in biotechnology development, application, exchange and transfer through international agreement on principles to be applied on risk assessment and management, with particular reference to health and environmental considerations, including the widest possible public participation and taking account of ethical considerations; and

(n) Establish enabling mechanisms for the development and the environmentally sound application of biotechnology.