Harnessing Modern Agricultural Biotechnology for Africa's Economic Development

Recommendations to Policymakers

by:
NETWORK OF AFRICAN
SCIENCE ACADEMIES
(NASAC)

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The Network of African Science Academies (NASAC) was established on 13th December 2001 in Nairobi, Kenya, under the auspices of the African Academy of Sciences (AAS) and the Inter Academy Panel (IAP). NASAC is a consortium of merit-based science academies in Africa and aspires to make the "voice of science" heard by policy and decision makers within Africa and worldwide. NASAC is dedicated to enhancing the capacity of existing national science academies and champion the cause for creation of new academies where none exist.

This document is an output from the cooperation between NASAC and the German National Academy of Sciences Leopoldina. The Leopoldina is the world's oldest continuously existing academy for medicine and the natural sciences. It was founded in 1652 and has been located in Halle since 1878. Its more than 1,400 elected members are outstanding scientists from all over the world. The Leopoldina was appointed Germany's National Academy of Sciences in July 2008. In this function, one of the Leopoldina's responsibilities is to provide science-based advice to policymakers and to the public. It represents German scientists in international academy circles and maintains links with scientific institutions in European and non-European countries.

The cooperation project between NASAC and the Leopoldina is funded by the German Federal Ministry of Education and Research (*Bundesministerium für Bildung und Forschung*, BMBF). Education and research are a Federal Government policy priority in Germany, based on the firm belief that they are the foundations on which we will build our future in a changing world, and that we will only be able to master the challenges of the 21st century through international cooperation in education, research and science. BMBF therefore cooperates with individual states and institutions on many interdisciplinary projects.

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Design and layout
Dezine Creationz Ltd.

Printers
Paperbrand Conqueror Enterprises

Publishers
Network of African Science Academies (NASAC)

Contents

Foreword

For the past two decades, modern biotechnology, particularly the use of genetically modified (GM) organisms, has been at the centre of global conversations on public policy. Agriculture remains the main user of modern biotechnology, applied mainly to mitigate various production constraints and enhance production, quality and nutritional value through commercial production of genetically modified crops. The development of GM farm animals or environmentally important animals is still at its nascent stages. Global conversations have therefore been centred on commercial production of GM crops in agricultural systems within sustainably balanced bio-diverse ecosystems.

The potential for GM organisms to make a significant contribution in the development of better health care and enhanced food security through sustainable agricultural practices was recognised in Agenda 21 of the United Nations Conference on Environment and Development held in Rio de Janeiro, Brazil in 1992. Africa hosted the subsequent World Summit on Sustainable Development (WSSD) in Johannesburg, South Africa 2002, where the full implementation of Agenda 21, the Programme for Further Implementation of Agenda 21 and the Commitments to the Rio principles, was strongly reaffirmed. Despite all these involvements, Africa's progress towards tapping on the potential of GM technology and reap real benefits accruing from its use in the continent's economic mainstay is not happening fast enough.

The urgency for African governments to facilitate the application of modern agricultural biotechnology through the adoption of favorable biotechnology development policies and biosafety regulatory frameworks cannot be overemphasised. This will pave the way for the development and application of appropriate agricultural biotechnologies, particularly genetic modification of crop plants. The deployment of these genetic modification technologies in African agriculture is especially relevant now, in addressing the challenges of climate change, the increasing population growth that has resulted in an increased demand for food, the reducing area of arable land and biotic and abiotic constraints to agricultural productivity while ensuring a healthy balance of bio-diverse ecosystems.

Against this backdrop, the Network of African Science Academies (NASAC), in collaboration with the European Academies Science Advisory Council (EASAC), the German National Academy of Sciences (Leopoldina), the United Nations Economic Commission for Africa (UNECA) and the African Union Commission (AUC), jointly organised an expert workshop on Agricultural Biotechnology with funding from the German Federal Ministry of Education and Research in Addis Ababa, Ethiopia on 25–26th February 2014. Following this conference, NASAC continued the collaboration with Leopoldina to facilitate the development of an agricultural biotechnology policymakers' booklet to present African governments and business leaders with a source of scientific evidence to help them in policy and decision making processes.

This document, which is an outcome of the NASAC and Leopoldina collaboration, focuses on why adoption of Agric-Biotech is important to Africa. Through key messages, the document elaborates on how food security, environmental health, economic development and the general human wellbeing can be achieved and sustained through targeted policy actions that relate to: Governance of biotech development and biosafety; the place of Africa in the global Agric-biotech enterprise; Capacity Building for Biotechnology Research and Product Development; Addressing Key Issues of Concern; Public Awareness and Communication. These issues had earlier been discussed in great detail during the first expert group meeting on Biotechnology for Africa's Sustainable Development by the United Nations Economic Commission for Africa (UNECA) in 2002. The meeting covered the important fields of food security, energy, industry, health and the environment and recommended the creation of an ECA Biotech group to lead the development of biotechnology capacity building in Africa. This recommendation is yet to be actualised more than a decade later.

African Academies of Science, through their network (NASAC) and linkages with global academies, present a rich pool of expertise as a source of evidence based advice to policy formulation and decision making. It is hoped that African governments and private sector champions will be stimulated to enhance their interaction with science academies to harness local biotechnology human capacities for evidence based contribution to national policy and decision making processes.

African governments, under the auspices of the African Union have initiated key Pan African programmes and initiatives namely, the New Partnership for Africa´s Development (NEPAD), the High-level African Panel on Biotechnology and the African Biosafety Network of Expertise (ABNE) aimed at guiding the continent in harnessing the potential of biotechnology for human development, global competitiveness and ecological management. These government driven initiatives have been complemented by the Global Environment Facility of the United Nations Environment Programme (UNEP-GEF) and other private and civil society supported programmes.

So far, the initiatives have made significant contribution in guiding the continent's leadership towards a focus on investment in the development of facilitative biotechnology policies and biosafety regulatory frameworks that will firmly entrench Africa into the global biotechnology enterprise. In this regard, African governments, the private sector, development partners and civil society players have invested in science and technology in general and biotechnology in particular through partnerships designed for capacity building and product development. The next logical step is for Africa to position herself to harness the benefits of agricultural biotechnology within the context of assuring safety to human health and sustainable conservation of biodiversity.

This policy advisory has drawn from the wealth of African expertise under the auspices of the Network of African Science Academies (NASAC). I call upon African government and business leaders to draw from this rich resource in their endeavour to develop and exploit Africa's nascent modern biotechnology enterprise.

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Funding and in-kind support

German Federal Ministry of Education and Research (BMBF)
through the German National Academy of Sciences Leopoldina,
Interacademy Partnership (IAP),
United Nations Economic Commission for Africa (UNECA),
and the African Union Commission (AUC).

List of Acronyms

AATF	African Agricultural Technology Foundation
ABNE	African Biosafety Network of Expertise
AU	African Union
B4FA	Biosciences for Farming in Africa
Bt. Cotton	Cotton variety Transformed with *Bacillus thuringiensis* (Bt) gene
CBD	Convention on Biological Diversity
COMESA	Common Markets for Eastern and Southern Africa
DNA	Deoxyribonucleic Acid
EAC	East African Community
EASAC	European Academies Science Advisory Council
ECOWAS	Economic Community of West African States
FAO	Food and Agriculture Organization
GM	Genetically Modified/Genetic Modification
GMOs	Genetically Modified Organisms
IPR	Intellectual Property Rights
ISAAA	International Service for the Acquisition of Agri-Biotech Applications
LMOs	Living Modified Organisms
MAS	Marker Assisted Selection
NASAC	Network of African Science Academies
NEPAD	New Partnership for Africa's Development
PUB	Public Understanding of Biotechnology
R&D	Research and Development
RABESA	Regional Approach to Biotechnology and Biosafety in Eastern and Southern Africa
RFLP	Restriction Fragment Length Polymorphism
RNA	Ribonucleic Acid
SAASTA	South African Agency for Science and Technology Advancement
SNP	Single Nucleotide Polymorphism
ST&I	Science Technology and Innovation
WEMA	Water Efficient Maize for Africa
WFP	World Food Programme
WHO	World Health Organization

1 Introduction

Viewed as an additional tool in the farmer's tool box, modern agricultural biotechnology (Text box 1) presents a real opportunity for increased agricultural productivity, mitigation of biotic and abiotic stresses that constrain production and enhancing/unleashing the full nutritional value of food crops through bio-fortification and silencing of genes responsible for the synthesis of anti-nutritional compounds. In recognition of this opportunity, African political, business and civil society leadership have invested in deliberate efforts to harness science and technology generally and biotechnology in agriculture specifically through dedicated programmes that address specific needs in the application of the technology including stewardship to ensure its proper deployment.

TEXT BOX 1

MEANING AND CONTEXT OF AGRICULTURAL BIOTECHNOLOGY

Biotechnology has broadly been defined as any technique that uses living organisms or substances from those organisms, to make or modify a product, to improve plants, animals or microorganisms for specific uses (Bailey et al., 2014). The field of biotechnology has different branches including;

- *Microbial biotechnology which entails use of microorganisms for the production of for example, enzymes, antibiotics and bioremediation (the use of microorganisms to clean environment);*
- *Plant biotechnology which includes plant tissue culture, development of genetic markers to fast track selection of natural traits in plant breeding, genetic*

Under the auspices of the African Union (AU) for example, tremendous progress has been achieved in raising the profile of science and technology through the Consolidated Plan of Action (CPA), the Lagos Plan of Action, promotion of higher education through the Pan-African University initiative and investment in agriculture through the Maputo Declaration. In effect, African governments and business leaders now view science, technology and innovation as critical to the continent's socio-economic development. What has been lacking is the translation of these efforts, declarations and expressions into actions and outcomes through dedicated implementation programmes.

In view of its enormous potential to contribute to Africa's food security, environmental health, economic development and the general human wellbeing (Sasson, 2008), modern biotechnology has received special attention of African leaders. However, dissenting voices continue to be heard across Africa expressing skeptisms of the benefit of biotechnology to the continent's socio-economic wellbeing. A number of such voices intimate that biotechnology has no real benefits to offer the continent and instead it presents negative socio-economic impacts.

One aspect of modern biotechnology involves the selection, isolation and transfer of genes from one organism into another through a procedure known as genetic engineering or genetic modification with a wide range of application as a tool in agriculture, environmental management, the study of gene function, health and industrial processing. To leverage on the benefits of modern biotechnology, the African Union initiated the establishment of three key pan African programmes: the New Partnership for Africa´s Development (NEPAD); the High-level African Panel on Biotechnology; and the African Biosafety Network of Expertise (ABNE), engineering of plants for crop improvement such as herbicide resistance, insect and disease resistance, and molecular breeding;

- *Animal biotechnology such as embryo transfer, transgenic animals, animal propagation (artificial insemination and cloning);*
- *Medical biotechnology which involves disease diagnostics, production of vaccines and drugs, and tissue engineering; and*
- *Forensics which involves crime control, paternity and kinship tests.*

Agricultural biotechnology techniques commonly used in crop production include:

- *Plant tissue culture, through which plant cells or parts are grown in laboratory conditions to generate new plants. This offers a number of opportunities including reduced contamination of plants, rapid propagation, and cloning of disease free planting material.*
- *Marker assisted selection (MAS), in which breeders use DNA 'markers' to identify genes associated with certain traits, allowing progeny to be screened for desired genes. This can reduce breeding times significantly, as the conventional process of screening for traits (as opposed to genetic markers) takes longer.*
- *'Omics' Sciences (Genomics, Proteomics, and Metabolomics). These are technologies through which i) the sequences in the entire genome of a particular organism are discovered and sequenced (Genomics); ii) the structure and function of proteins is studied (Proteomics), iii) the profile of metabolic compounds at a specified time under specific environmental conditions is determined (metabolomics). Genomics provides an overview of the complete set of genetic instructions provided by the DNA, while transcriptomics looks into gene expression patterns. Proteomics studies expressed proteins and their interactions, while metabolomics is the final step in understanding an organism's entire metabolism.*
- *Genetic modification (GM) is the term given to the technology through which a gene from one organism is transferred to another. The inserted gene may be from the same species (cisgenics) or from another species (transgenics). It includes gene silencing and artificial mutations.*

While all other fields have basically been accepted by the majority of people, the products of genetically modified (GM) organisms, in some cases also called living modified organisms (LMOs), especially the genetically modified crops continues to draw mixed reactions mainly in Europe and Africa. This area of biotechnology (genetic modification) in agriculture therefore forms the core focus of this policymakers booklet.

TEXT BOX 2

EFFORTS BY AFRICAN GOVERNMENTS TO ENHANCE EFFECTIVE APPLICATION OF MODERN BIOTECHNOLOGY IN THE CONTINENT

In 2003, the New Partnership for Africa's Development (NEPAD) formed a High-level African Panel on Biotechnology (APB) with a mandate to advise Africa on the scientific, policy and legal issues pertaining to the development, commercialisation and application of modern biotechnology. The panel was to provide the African Union (AU) and NEPAD with independent and strategic advice on developments in modern biotechnology and its implications for agriculture, health and the environment, focusing on intra-regional and international issues of regulating the development and application of genetic modification and its products. The panel was tasked to consider a number of factors that affect use of biotechnology in Africa including

1. *Developments in modern biotechnology outlining the implications that may be associated with adoption and non-adoption of such technologies for regional economic and trade integration;*
2. *Priority areas that offer high potential for the regional research and development (R&D), including aspects of risk assessment and management;*
3. *Aspects of the development and regulation of modern biotechnology into a regional/continental regulatory regime for shared R&D and technology management;*
4. *Scientific capacity to ensure the safe application and use of products derived from modern biotechnology and the regulation and management aspects;*
5. *Ways of improving cooperation with other regions to address trade, R&D and regulatory issues pertaining to modern biotechnology.*

The Panel highlighted the importance of agricultural biotechnology in Africa and developed recommendations on the nature of regional institutional arrangements that are required to promote and sustain common regulatory approaches on the application and proposed a strategy

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and policy on the use of modern biotechnology (Juma and Serageldin, 2007). The Panel recommended that:

i. The cooperation between individual countries in central, eastern, western, northern and southern Africa should be enhanced to work together at the regional level to scale up the development of biotechnology;

ii. Priority areas in biotechnology that are of relevance to Africa's development be defined;

iii. Critical capabilities needed for the development and safe use of biotechnology be identified;

iv. Appropriate regulatory measures that can advance research, commercialisation, trade and consumer protection be established;

v. Strategic options for creating and building regional biotechnology innovation communities and local innovation areas in Africa be set up.

aimed at harnessing the potential of biotechnology for the continent's human development, global competitiveness and ecological management (Juma and Serageldin, 2007; Text box 2).

Agriculture is one of the major users of modern biotechnology and worldwide adoption of the technology in commercial planting of genetically modified (GM) crops continues to be rapid (James, 2013). However, despite the tremendous out-puts of the pan African programmes in form of institutional capacity building for research, training and product development as well as practical recommendations by expert groups, the adoption of modern biotechnology in Africa remains low resulting in a minimal participation of Africa in the global biotechnology enterprise. For example, out of the global 181.5 million hectares of GM crops only 3.5 million hectares, representing about 2% were planted in just 3 African countries (South Africa, Burkina Faso and Sudan) in 2014 (James, 2014). Egypt has since 2012 suspended the cultivation of GM maize after health concerns were raised in response to the controversial publication by Seralini *et al.* (2012). Kenya also responded to the publication in the same fashion as Egypt by banning importation of GM foods. This underscores the need to enhance Africa's research capacity and facilitate homegrown interrogation of various claims leveled against biotechnology.

To address the low level of Agric-Biotech adoption in Africa, this policy advisory focuses on addressing limiting factors within five thematic areas, namely: The Potential of Agricultural Biotechnology for Africa's Development; Governance of Biotechnology Development and Biosafety Regulation; Africa in the Global Agricultural Biotechnology Enterprise; Capacity for Biotechnology Research, Product Development and Deployment; Public Awareness, Participation and Communication. This policy makers' booklet presents a brief background on each of these constraints and elaborates on how they can be overcome through targeted policy actions.

The current Africa's development narrative is characterised by a rising population with its commensurate demand for more food; deficiencies of vital dietary nutrients in the continent's population; the continent's vulnerability to the negative impacts of climate change such as droughts; the reducing area of arable land due to rapid urbanisation; the declining soil fertility in the continent's hither-to bread baskets; and the tropical biotic constraints to agricultural productivity. In view of this narrative, the adoption of agricultural biotechnology to mitigate against these impediments to human wellbeing and development cannot wait any longer. It is hoped that the policy advisory presented in this booklet will excite African governments and business leaders to search for science evidence from the boundless source within science academies and apply it to inform policy and decision making processes.

Key Messages 2

KEY MESSAGE 1: The Potential of Modern Agricultural Biotechnology for Africa's Development

Modern agricultural biotechnology has a great potential of contributing real socio-economic benefits to the African continent given her demonstrably great need for enhanced agricultural productivity. Africa is uniquely exposed to food and nutrition insecurity, impacts of climate change, declining soil fertility and general decline in agricultural productivity owing to numerous biotic and abiotic constraints, all of which can be addressed through the application of modern biotechnology as an additional tool in the agricultural production systems. For maximum impact, the technology must be applied alongside other best agronomic practices and technology stewardship.

African governments are encouraged to invest part of their commitments of allocating 10% of the national budget to Agriculture (Maputo Declaration, 2003) and 1% of their GDP to Science and Technology (April 1980, Lagos Plan of Action) to Agricultural biotechnology to address these long standing developmental challenges. This can be achieved through effective partnerships with private sector and civil society actors who are working towards delivering Agricultural Biotechnology benefits to the people of Africa.

KEY MESSAGE 2: Governing Modern Biotechnology Development and Biosafety Regulation in Africa

The majority of African countries are parties to the Cartagena Protocol on Biosafety and a number have ratified its Supplementary Protocol on Liability and Redress. Taking cue from the Protocol, the African Model Law and drawing from the European approach to modern biotechnology, the governance of modern biotechnology in Africa is characterised by an extreme precautionary approach. This has become a major hindrance to the development and application of modern biotechnology in the continent.

African governments are encouraged to undertake comprehensive reviews of their Biotechnology policy and regulatory frameworks to emphasise (on) the benefits of the technology and base their decision making on scientific evidence. Further, African governments are encouraged to play a more proactive and facilitative role in regional initiatives to harmonise biotechnology policies and biosafety regulations and thus create an enabling environment for a flourishing biotechnology enterprise in Africa driven by the specific needs of the continent.

KEY MESSAGE 3: Africa in the Global Modern Agricultural Biotechnology Enterprise

The global biotechnology enterprise has been expanding exponentially in the last two decades with Africa remaining hesitant to delve into the commercial production of GM crops despite having conducted long term confined field trials on several GM crops and also having developed biotechnology policies and biosafety regulatory frameworks. Africa is endowed with a sizable youthful and well educated population that can be harnessed to support the deployment of modern biotechnology and its associated management stewardship as well as become involved in biotechnology research.

African governments and regional economic communities are encouraged to create a conducive environment that will facilitate the development and application of agricultural biotechnology. Emphasis should be on maximising the socio-economic benefits associated with modern biotechnology and embrace science based advice to inform decision making.

KEY MESSAGE 4: Capacity for Biotechnology Research, Product Development and Deployment

Agricultural biotechnology has a great potential of contributing real socio-economic benefits to the African continent given her demonstrably great need for enhanced agricultural productivity. Africa is uniquely exposed to food and nutrition insecurity, revenges of climate change, declining availability of arable land, rising salinity and declining soil fertility and in general decline in agricultural productivity due to numerous biotic and abiotic constraints, all of which can be addressed through the application of modern biotechnology. The low infrastructure, human and institutional capacities for agricultural biotechnology research, product development and deployment is a long standing obstacle to Africa's desire of becoming a key participant in the global biotechnology enterprise and the knowledge based economy.

African governments are encouraged to enhance their investment in the development and application of agricultural biotechnology as part of their commitments expressed in the Lagos Plan of Action and the Maputo Declaration. The governments are also encouraged to pursue collaborative research programmes within the South-South and North-South framework and facilitate the effective utilisation of the continent's expertise in the Diaspora. This can be achieved through effective partnerships with the private sector, development partners and civil society actors who are working towards delivering agricultural biotechnology benefits to the people of Africa.

KEY MESSAGE 5: Public Awareness, Participation and Communication

Generally, public awareness and participation on matters of modern biotechnology, particularly the genetic modification of organisms, resulting in the development of Genetically Modified Organisms (GMO) is very low worldwide. In Africa the technology is perceived to be foreign/alien, further creating the opportunity for deliberate distortion of facts and non-scientific basis of risk perception. This has made it difficult for African countries to individually and collectively discuss, set priorities and exploit economic and other benefits offered by biotechnology. Awareness of biotechnology and the beneficial impact on agriculture and food security should be introduced to schools so that children learn the correct facts about biotechnology and grow up to become adults that accept the technology, see its potential and can influence governments to become more proactive in the adoption of modern biotechnology.

African governments, as parties to the Cartagena Protocol on Biosafety, have committed to the provisions of Article 23 of the Protocol on Public Awareness and Participation. To fulfill this commitment, African governments are encouraged to partner with the media, civil society and other relevant stakeholders to enhance domestic capacity for public communication, education and participation. The governments can use the experiences of resource poor farmers in African countries that have adopted modern biotechnology as learning points for public education and awareness programmes.

The Potential of Agricultural Biotechnology for Africa's Development

3

Background

Agricultural biotechnology has been billed as the single technology that has witnessed phenomenon growth in adoption within a very short time. This is testament to biotechnology's great potential in delivering real benefits to humankind. The confirmation of this testament came in the form of reports of case studies that have analysed the benefits of GM crop production in various countries representing a wide agro-geo-ecological disposition (Text box 3). Besides these direct benefits derived from tangible products of modern biotechnology in commercial production systems, there are many other benefits that are derived from the application of modern biotechnology as a tool for various processes such as plant breeding and study of gene function.

In this ever expanding agricultural biotechnology enterprise, Africa's approach has remained largely hesitant in the unfolding events. This is in spite of the fact that the African continent is the most exposed to food and nutrition insecurity, impacts of climate change, declining availability of arable land, rising salinity and declining soil fertility and in general decline in agricultural productivity owing to numerous biotic and abiotic constraints (Plate 1 & 2). It is no wonder therefore, that Africa remains a net recipient of emergency food aid. However, there is growing focus on crops that are relevant to Africa's diversified diets including orphan crops that are being

TEXT BOX 3:

OVERVIEW ON ECONOMIC AND SOCIAL IMPACTS OF GM CROPS IN AFRICA AND THE REST OF THE WORLD

Experience over the past two decades of cultivation of GM crops has proven that the technology presents real economic, social and environmental benefits to farmers (Qaim, 2009; Qaim and Kouser, 2013; Traore et al., 2014; Morris and Thomson, 2014). Three main types of GM crops have been extensively cultivated in different countries; Herbicide-tolerant (HT) soybean, Insect-resistant (Bt) and HT maize, and Insect-resistant (Bt) cotton. Since 1996, the GM crops have been approved and commercially used in several countries. Burkina Faso, Sudan and South Africa are the three countries that are currently commercially producing GM

Continued on next page

Plate 1 (Adopted from Ogwok et al., 2012). Cassava brown streak disease (CBSD) symptoms on storage roots. (A) Uprooted storage roots from a transgenic plant beside a non-transgenic plant. (B) Storage roots from plants of transgenic plant showing minimal damage caused by CBSD. (C) Storage roots of non-transgenic plants showing severe damage caused by CBSD. Cassava is an important food crop in East Africa and its production is being threatened by CBSD. So far, conventional breeding has not come up with resistant varieties and genetic engineering is a possible option to solving the problem.

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crops in Africa. Taking examples from Burkina Faso and South Africa, the benefits of GM crops to farmers are outlined below.

Bt cotton production in Burkina Faso

The history of commercialisation of Bt cotton in Burkina Faso is documented by Traore et al. (2014). The country's experience with Bt cotton is an excellent example of how biosafety procedures and processes should be used to facilitate the introduction of a modern biotechnology product into an African market. Bt cotton was first commercialised in Burkina Faso in 2009 after 6 years of controlled field testing for efficacy, safety, and commercial viability. In the first year of commercial production, 129,000 ha of land were put under commercial production of Bt cotton, making it the largest introduction of modern biotechnology on the continent. The area doubled to 256,000 ha in 2010. Since then, the area under Bt cotton production has been on a gradual increase (Table 1). Over 50% of cotton production is now under Bt cotton.

Table 1. Increase in the area under Bt. cotton in Burkina Faso since 2009 (Adopted from Traore *et al.*, 2014)

Year	Total area under cotton production (Hectares)	Area under Bt cotton (Hectares)	Percent are under Bt cotton
2009	420,000	129,000	31
2010	386,000	256,000	66
2011	429,000	251,000	59
2015	530,000	300,000	57

The process of commercialising Bt cotton was made possible by political will from authorities, the determination of stakeholders such as scientists, cotton producers and companies dealing with the product.

Burkina Faso farmers have greatly benefited from the use of Bt cotton. Reduced use of toxic insecticides resulted in lower exposure and therefore reduced incidence of farmer pesticide poisoning. Financial gains per hectare were also achieved due to reduced purchase of chemicals. Increase in farm incomes eventually resulted in reduction of food insecurity among cotton producers.

GM crops production in South Africa

Bt cotton and maize have been in commercial production in South Africa since 1997. Since then, the production of GM crops in South Africa has steadily increased. James (2012) noted that 1.64 million ha of land was under white maize for human consumption, 80.5 % was GM. Yellow maize used for animal fodder and chicken feed covered 1.19

developed by African researchers in African institutions. The African Plant Breeding Academy, a programme of the African Orphan Crops Consortium graduated the first class of plant breeders in Nairobi, Kenya on 11th December 2014. These graduates will greatly contribute to the bio-fortified sorghum and insect resistant cowpea development programmes. Additionally, animal GM products such as vaccines and diagnostic kits are in the development pipeline.

African governments made commitments to allocate 10% of their budgets (Maputo Declaration, 2003) and 1% of their GDP (Lagos Plan of Action, 1980) to Agriculture and Science and Technology respectively, within 5 years for the Maputo declaration and 10 years for the Lagos Plan of Action. Some progress has been made to this end and much can be achieved through effective partnerships with the private sector and civil society actors who are working on the agricultural biotechnology enterprise. In response to the Plan, the AU NEPAD, under its African Biosciences Initiative, has established the following sub-regional bodies for biotechnology:

(1) SANBio (South Africa);
(2) BecA (East and Central Africa);
(3) WABNet (West Africa); and
(4) NABNet (North Africa).

million ha of land, 93% of which was GM. Herbicide tolerance soyabeans were planted in 450,000 ha of land, out of which 93% were GM. By 2012, nine GM maize events, six GM cotton events and one soyabean GM event had been approved for general release (Morris and Thomson, 2014). To-date, 87% of maize, 92% of soyabeans, and 100% of cotton produced in South Africa is GM. GM food is widely consumed in South Africa and no substantiated negative effects have been reported.

Safe production and use of GM crops in other parts of the world

Examples of safe use of GM crops are replicated in all the main GM commodities (HT soybean, Bt and HT maize, and Bt cotton) in different parts of the world such as USA, Brazil, China, India, Argentina, Paraguay, Pakistan, Canada, Australia, Uruguay, Philippines, Burkina Faso, and Bolivia (James, 2012). To-date, there is no validated evidence that GM crops have greater adverse impact on health and the environment than any other technology used in plant breeding. There have been arguments of whether the introduction of Bt cotton has resulted in increased suicide rates in smallholder farmers in India. However, studies have shown that the suicide cases are in no way related to the adoption of Bt cotton as shown in Figure 1 below (Qaim, 2014).

It is however important to note that benefits from the technology can best be made on a case-by-case basis depending on the technology and the situation in which it is being employed. While Bt crops are suitable for the small scale farm sector, herbicide tolerance may be useful in situations of large scale production, labor scarcity or where certain weeds are very difficult to control. Smallholder farmers in Africa often weed manually. Africa should wholly embrace the technology to solve African challenges such as drought, crop pests and diseases, and poor nutrition. Currently, the available crop-trait combinations are still limited. However, the future of GM technology is bright, and many more benefits will be achieved when more crop-trait combinations are commercialised, especially when traits related to challenges facing African farmers are included.

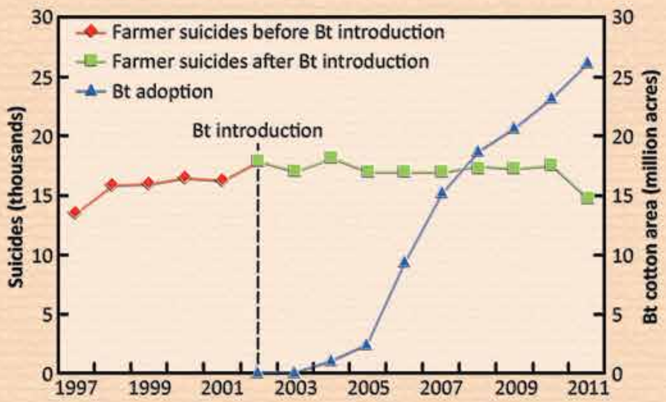

Figure 1. Adoption of Bt cotton by farmers in India and farmer suicides before and after adoption (Qaim, 2014).

To augment these, the Nigerian government has recently (2014) established a centre of excellence in biotechnology at the University of Nigeria in Nsukka with the support of the United Nations Educational, Scientific and Cultural Organization (UNESCO). This centre is yet to start activities.

To support the further development of the nascent biotechnology enterprise in the continent, African governments will need to partner with private sector and civil society actors who are working towards delivering agricultural biotechnology benefits to the people of Africa. Key examples of such potential partners include the African Agricultural Technology Foundation (AATF) which was established to negotiate royalty free agricultural technology (including biotechnology) and the Golden Rice project, which is working towards delivering the Vitamin A bio-fortified rice to Africa. To leverage on this, Africa needs to take strategic measures aimed at promoting the application of agricultural biotechnology within regional economic blocks and trade integration initiatives such as the Common Market for Eastern and Southern Africa (COMESA), the Economic Commission of West African States (ECOWAS), the Southern Africa Development Community (SADC) and the East African Community (EAC).

Key Message

Modern agricultural biotechnology has great potential to contribute real socio-economic benefits to the African continent given her demonstrably great need for enhanced agricultural productivity. Africa is uniquely exposed to food and nutrition insecurity, impacts of climate change, declining availability of arable land, rising salinity and declining soil fertility and in general decline in agricultural productivity due to numerous biotic and abiotic constraints, all of which can be addressed through the application of modern biotechnology as an additional tool in the agricultural production systems. For maximum impact, the technology must be applied alongside other best agronomic practices and technology stewards.

African governments are encouraged to invest part of their commitments of allocating 10% of the national budget to agriculture (Maputo Declaration, 2003) and 1% of their GDP to Science and Technology (April 1980, Lagos Plan of Action) to agricultural biotechnology to address these long standing developmental challenges. This can be achieved through effective partnerships with private sector and civil society actors who are working towards delivering agricultural biotechnology benefits to the people of Africa.

Plate 2. Non-transgenic papaya (left) showing severe symptoms of papaya ringspot virus infection and transgenic virus-resistant papaya (right) in the field (Ferreira, 1998). Transgenic papaya saved the papaya industry from complete destruction by the virus in Hawaii.

Governing Biotechnology Development and Biosafety Regulation in Africa

4

Background

Modern biotechnology includes the isolation, selection and transfer of genes from one organism into another through a procedure known as genetic modification (also known as genetic engineering or transformation), resulting in genetically modified organisms (GMOs: also Living Modified Organisms, LMOs). The governance of modern biotechnology stems from a protocol that was globally negotiated and adopted in Cartagena, Colombia on 29th January, 2000, and entered into force on 11th September, 2003. The core objective of the Cartagena Protocol on Biosafety to the Convention on Biological Diversity (CBD) is to ensure the safe handling, transport and use of LMOs resulting from modern biotechnology that may have adverse effects on biological diversity, taking also into account potential risks to human health. To reinforce the legal liability provisions of the Protocol, a supplementary protocol on liability and redress was negotiated and adopted during the 10th Meeting of Parties held in Nagoya, Japan in 2010.

In compliance with the provisions of the Protocol, individual party states embarked on the development of their domestic policy, legal and regulatory frameworks to govern modern biotechnology. The majority of African states are at various stages of developing their biotechnology policy and biosafety regulatory frameworks, having benefited from the United Nations Environment Programme – Global Environment Facility (UN-GEF). Their regulatory frameworks however, have leaned heavily on the extremely precautionary approach of the Protocol as guided by the African Model Law (OAU, 2002, currently under review) and drawing from the European approach. Due to this overly precautionary approach, biotechnology policy legal and regulatory frameworks in Africa are restrictive to the adoption of the technology. In essence therefore, products of modern biotechnology are among the most regulated products despite the fact that once a GM plant is obtained for example, it has to enter the pipeline of classical breeding and selection to obtain a stable progeny that retains all the fundamental traits of the parent plant.

While most African countries continue to hold on to the extremely precautionary approach, ostensibly taking cue from Europe, the jury out there is that the European Union has moved on to re-invent its approach to modern biotechnology development and biosafety regulation. The EU imports GM soybeans for processing animal feeds from Brazil and Argentina and therefore it is unwise for Africa to keep shunning modern agricultural biotechnology assuming to be in line with the EU approach. Indeed, a study published by the Regional Approach to Biotechnology and Biosafety Policy in Eastern and Southern Africa (RABESA) has demonstrated that the fear by African states of losing EU export markets after adopting biotechnology is unfounded (Minde and Kizito, 2007).

The corresponding advice to Africa is to adopt the co-evolutionary approach where consumer and biodiversity protection goes hand in hand with the development of the technology itself. This calls for the review and adjustment of national and regional policies together with their related legislation to provide a conducive environment for the development and application of agricultural biotechnology. Africa's biosafety regulatory institutions need transparent and high quality scientific capacity to assess biotechnology-related risks and to be able to regulate quickly, safely and effectively. A conducive environment will reduce controversial decisions such as the one that resulted in the ban of GM food imports in Kenya, the ban of GM maize cultivation in Egypt and the moratorium on GM products in Zimbabwe (Text box 4).

In conducting the revision, African governments are encouraged to lay emphasis on maximising the benefits associated with modern biotechnology and science based risk assessment to inform decision making. Academies of science are a ready source of such science derived risk assessment for decision making. The case of Sudan is a good example of this approach where the country leadership directed the commercial planting of GM cotton (Bt. cotton) on the basis of its expressed benefits of resistance to the cotton boll worm. Two other countries, Ethiopia and Tanzania have embarked on the revision of their domestic legislations to relax previously strict liability provisions following advice given by their national science academy and the realisation of potential to curtail a research partnership in the Water Efficient Maize for Africa (WEMA) project respectively.

TEXT BOX 4

CHALLENGES TO IMPLEMENTATION OF BIOSAFETY REGULATIONS WHERE POLITICAL CONVENIENCE OVERRIDES SCIENTIFIC EVIDENCE: A CASE OF EGYPT AND KENYA

Egypt was one of the few countries in Africa to realize in the 1980s the importance of modern biotechnology in achieving sustainable agriculture. Capacity building and transfer of biotechnology started in the 1990s and in 2008, Egypt approved commercial production of GM maize. About 700 ha of land were put

At the regional level, the Common Market for Eastern and Southern Africa (COMESA), the West African Economic Community (ECOWAS) and the East African Community (EAC) have initiated harmonisation of biotechnology policy and biosafety regulation. Harmonised approaches ensure cost effectiveness, uniform risk assessment, seamless intra-regional trade and help address the unique informal exchange of commodities across national boundaries. African governments need to facilitate and actively participate in the process of regional initiatives towards harmonisation of biotechnology policies and biosafety regulations. This will reduce the cost of regulation, leverage on synergies and support the growth of regional biotechnology businesses.

Africa should pursue a dynamic 21st century, home grown biotechnology policy and biosafety regulatory regime that assures the maximum benefits from modern biotechnology and takes advantage of the continent's youthful, well educated population to support the deployment of the technology and its associated stewardship. Africa's biosafety regulatory institutions need high quality scientific capacity for a transparent biotechnology-related risk assessment to be able to regulate quickly, safely and effectively. This will ensure that Africa does not miss out on the Gene Revolution in the same way she missed out on the Green Revolution.

Political will

A positive political will and drive is critical to the adoption of agricultural biotechnology in Africa. The enthusiasm with which African governments ratified the Cartagena Protocol on Biosafety and the commitment to the development of their national policies and regulatory frameworks testifies to their positive will and drive to ensure that Africa is fully integrated into the global biotechnology enterprise. In spoken and written policy statements, the current generation of African government leaders have acknowledged the benefits of agricultural biotechnology and expressed positive sentiments in support of its adoption. The dynamic, young and well educated African political leaders are a clear contrast to the yesteryear's *under Bt maize which increased to 1,700 ha by 2011. Despite great strides in commercialisation of modern biotechnology, Egypt does not have official biosafety legislation, though a regulatory framework exists which follows the Cartagena Protocol on Biosafety (Assem, 2014). Lack of biosafety law and fluctuation in political will eventually resulted in the ban(ning) of production of Bt maize in 2012.*

On the other hand, Kenya developed and enacted a biosafety law in 2009. An authority, the National Biosafety Authority, was established to supervise and control transfer, handling and use of GM organisms. However, in November 2012, Kenya's cabinet ordered the ban of GM food imports until the country is able to certify that genetically modified organisms (GMOs) have no negative health effects. This was despite the existence of the biosafety law and the establishment of the National Biosafety Authority (NBA). In both Egypt and Kenya, the ban came after the release of the controversial study (now retracted) by the French scientist Gilles-Eric Séralini (2012) that linked cancer in rats to consumption of GM foods. The ban sent conflicting signals to the scientific community and other government agencies involved in the regulation of the use of GMOs, not only in the countries but all over the continent. This is a case where political convenience overrides scientific evidence and existing laws governing use of biotechnology. Such decisions make progress in the use of technologies difficult to implement.

leaders. For example, Kenya's deputy president is on record calling for the adoption of modern agricultural biotechnology to boost productivity and competitiveness. In addition, Kenya's National Biotechnology Policy (2006) envisaged the active participation of Kenya in the global biotechnology enterprise within a decade. In contrast, Zambia's former president likened GM food to poison.

Despite these positive policy pronouncements, biosafety regulatory regimes of most African states remain extremely restrictive to the development and adoption of modern biotechnology (Wambugu, 2014). For example, Kenya's regulatory regime has very stringent labeling requirements and punitive fines in violation of the law, while Ethiopia's and Tanzania's regimes follow the strict liability and redress approach. This has discouraged potential investors and development partners in research and product development. There is however an awakening to this hindrance leading to initiatives to review these provisions in most of these countries.

African government leaders are encouraged to match word with deed to ensure that their expressed desire to engage in the global and even regional biotechnology enterprise becomes a reality. This will be achieved through a comprehensive review of their biosafety regulatory regimes. It is interesting to note that the adoption of GM insect resistant Bt. cotton in Burkina Faso and Sudan was driven by declarations/directives by their presidents after being convinced of the benefits. The development of regulations has followed.

Safety Concerns and Perceptions

The top most expression of concern over modern biotechnology, and which informed the negotiation and adoption of the Cartagena Protocol on Biosafety is the environmental and health safety of the technology. The precautionary principle portends that modern biotechnology is inherently risky to human and animal health and the conservation of biodiversity, and hence the tough stance on African Model Law on safety of biotechnology. Experience over the past two decades with modern biotechnology in agriculture, environment and health applications, with over 180 million hectares cultivated with GM crops for example, has proven that modern biotechnology does not present any health or environmental risk. To the contrary, it has been demonstrated that the technology presents real health and environmental benefits (Nicolia *et al*., 2013; Qaim and Kouser, 2013).

As early as 1999, the Nuffield Council on Bioethics concluded that "There is a compelling moral imperative to make genetically modified crops readily available to developing countries who want them, to help combat world hunger and poverty" and that "…genetic modification of plants does not differ to such an extent from conventional plant breeding that it is in itself morally objectionable" (Nuffield Council, 1999). In a follow-up discussion paper the Council re-affirmed the conclusions of the 1999 report and provided guidance on addressing the various issues pertinent to the application of agricultural biotechnology in developing countries (Africa) including Intellectual Properties Rights (IPR; Nuffield Council, 2004).

Opinion expressed by the European Commission Research Area – Food, Agriculture and Fisheries and Biotechnology has put the issue of safety of modern biotechnology to rest, stating thus: "The main conclusion to be drawn from the efforts of more than 130 research projects, covering a period of more than 25 years of research, and involving more than 500 independent research groups, is that biotechnology, and in particular GMOs, are not *per se* more risky than conventional plant breeding technologies" (EU, 2010).

Further advice given to the European Union by the European Academies Science Advisory Council (EASAC) goes to reinforce the previous one, stating thus: "There is no validated evidence that GM crops have greater adverse impact on health and the environment than any other technology used in plant breeding. There is compelling evidence that GM crops can contribute to sustainable development goals with benefits to farmers, consumers, the environment and the economy" (EASAC, 2013; Text box 5).

The other issue of concern is socio-economic in nature with the argument that modern biotechnology is a frontage of multinational agribusiness companies with the intention of dominating the global seed system thereby impoverishing the masses. The argument goes further to post that modern biotechnology is not beneficial to small scale resource poor farmers. To reinforce these arguments cases have been cited of increases in farmer suicides in India following the introduction of GM crops due to frustrations resulting from their inability to afford GM crop seeds. Formal case studies conducted in India and other parts of the world (Qaim, 2009; Sadashivappa and Qaim, 2009; Kouser and Qaim, 2013) have however dispelled these arguments.

Finally and most dear to the African socio-cultural setting (Article 26 of the Protocol), is the ethical question in which genetic engineering has been equated to playing God by altering the original creation or even creating new organisms. Although this argument is difficult to conceptualise from a scientific point of view, it stems from the technology's ability to overcome species barriers in exchange of genetic material. It makes sense to a religious adherent for example whose religious beliefs forbid using some organisms as food and may therefore consider trans-genes from such organisms to have transferred the taboo. The question is whether transferring a DNA fragment amounts to transferring the whole organism's traits. This fixed mind set can only be overcome by effective public education programmes.

Experience with biotechnology in the last 2 decades has demonstrated its safety for human health and the environment. Advisories derived from scientific analysis of evidence and research results by internationally credible institutions confirm that biotechnology and more specifically GMOs do not present any risk to human health and the environment (Table 2). African governments should base their decision making whether to adopt biotechnology on scientific evidence backed by experience from case studies evaluated on a case-by-case basis. Africa should consider adopting specific genetic modifications (traits) that present real benefits for Africa and roll out public education to debunk myths and counter deliberate distortion of facts by anti-biotechnology crusaders.

Table 2. List of impartial institutions that have concluded genetically modified crops are safe to man and the environment and that the technology poses no inherent risk[1]

Institution	Country	Year
Nuffield Council on Bioethics	UK	1999
Organization of Economic Co-operation and Development	International	2000
European Research Directorate	European Commission	2001
French Academy of Science	France	2002
French Academy of Medicine	France	2002
Director General, World Health Organization	International	2002
International Council for Science	International	2003
Royal Society	UK	2003
United Nations, Food and Agriculture Organization	International	2004
British Medical Association	UK	2004
Union of German Academies of Science & Humanities	Germany	2004
European Commission	EU	2010
European Academies Science Advisory Council	EU	2013
American, Brazilian, Chinese, Indian and Mexican Academies of Science	Several	Various

Key Message

The majority of African countries are parties to the Cartagena Protocol on Biosafety and a number have ratified its Supplementary Protocol on Liability and Redress. Taking cue from the Protocol, the African Model Law and drawing from the European approach to modern biotechnology, the governance of modern agricultural biotechnology in Africa is characterised by an extremely precautionary approach. This has become a major hindrance to the development and application of modern biotechnology in the continent.

African governments are encouraged to undertake comprehensive reviews of their biotechnology policy and regulatory frameworks to emphasise (on) the benefits of the technology and base their decision making on scientific evidence. Further, African governments are encouraged to play a more proactive and facilitative role in regional initiatives to harmonise biotechnology policies and biosafety regulation and thus create an enabling environment for a flourishing biotechnology enterprise in Africa driven by the specific needs of the continent.

[1] Source: Sundström and Fagerström (2014)

5 Africa in the Global Modern Agricultural Biotechnology Enterprise

Background

The global hectarage of GM crops has increased more than 100-fold from 1.7 million hectares in 1996 to over 175 million hectares in 2013, making GM crops the fastest adopted crop technology in recent history (James, 2013: Text box 5). This adoption rate is a clear testimony of the technology's resilience and the benefits it delivers to farmers and consumers. Africa continues to make progress with Burkina Faso and Sudan increasing their GM insect resistant Bt. cotton hectarage substantially.

What should be of great concern to African government and business leaders is the fact that in international trade, Europe imports GM products from South Africa, Brazil and Argentina and a lot of food imports into Africa including emergency food aid are sourced from countries growing GM crops. This demonstrates that the commonly held fear of losing the EU as an export market if Africa adopts modern biotechnology is unfounded as confirmed by the RABESA study (Minde and Kizito, 2007). Further it presents an opportunity for Africa to make a saving on imports by becoming self sufficient in food requirements and enhancing regional trade by adopting GM technology.

TEXT BOX 5

IMPORTANT FACTS ABOUT MODERN AGRICULTURAL BIOTECHNOLOGY AND GM CROPS (SUMMARIZED FROM JAMES, 2013)

Fact 1. Production of GM crops has been on the increase

After 17 years of successful commercialisation of GM crops, the area under production increased every year, from 1.7 million hectares in 1996, to over 175 million hectares in 2013 (Figure 2). This is over 100-fold increase, reflecting the confidence and trust of millions of farmers around the world, and making biotech crops the fastest adopted crop technology in recent times. Such a high rate of adoption can only occur if the technology is offering real benefits.

Fact 2. GM crops are grown by smallholder and large scale farmers in developing and developed countries

A total of 28 countries planted biotech crops in 2014, 19 of which were developing and 9 were developed countries. Developing countries had 54% of total global land under biotech crops

Several African countries (Uganda, Kenya, Ghana, and Nigeria) have been conducting confined field trials on various GM crops for far too long without moving to the commercialisation stage (Bailey *et al*., 2014). They have therefore remained at the periphery of the global biotechnology enterprise. There is an urgent need and farmer demands to move these crops to commercialisation since the trials have demonstrated their potential to positively impact on the continent's macro- and micro-economics. The potential for enhanced cotton production through the use of GM insect resistant Bt. cotton will position Africa to reap maximum benefit from the provisions of the Africa Growth Opportunity Act (AGOA) of the United States of America.

The first generation GM crops targeted herbicide tolerance, which was not seen as beneficial to Africa. The situation has since changed with a focus on crops and traits of great relevance to Africa including nutrient bio-fortification, drought and insect tolerance and overcoming the aflatoxin problems in storage. In this emerging sector, China has become a key player in the *compared to 46% industrialised countries, indicating that the technology has been adopted by both smallholder and large scale farmers in all parts of the world.*

Fact 3. Some African and European Union countries are also growing GM crops

In African, South Africa has grown biotech crops for more than a decade. Burkina Faso and Sudan increased the land under Bt cotton by 50% and 300%, respectively, in 2013. Seven countries (Cameroon, Egypt, Ghana, Kenya, Malawi, Nigeria and Uganda) are conducting field trials, the final stages towards approval for commercialisation. Five EU countries increased Bt maize production by 15% from 2012, Spain increased their hectares of Bt maize by 18% from 2012 with a record 31% adoption rate in 2013.

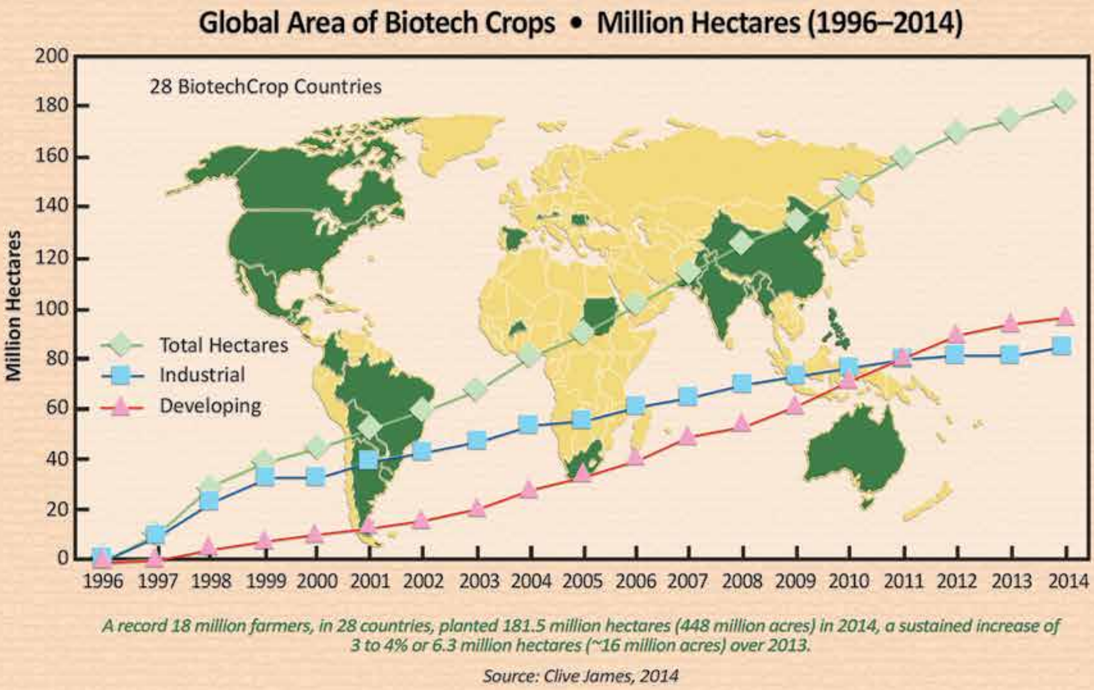

Figure 2. Global adoption of GM crops in the world over the last 18 years of production (James, 2014)

provision of seeds in partnership with local seed associations and public institutions. This kind of partnership is important in addressing Intellectual Property Rights (IPR) and demands of other international trade standards such as CODEX.

Despite the demonstrated safety and potential for agricultural biotechnology, Egypt has since 2012 suspended the cultivation of GM maize after health concerns were raised in response to the controversial publication by Selarini *et al.* (2012). Kenya also responded to the publication in the same fashion as Egypt by banning importation of GM foods. Further, agricultural biotechnology has been highlighted among technologies with a great potential for ensuring food security in a world of natural resource scarcity (Rosegrant *et al*., 2014). With the production of nutritionally enhanced foods and by improving yield and quality traits, agricultural biotechnology is a pathway out of food shortages, malnutrition and poverty.

Key Messages

The global biotechnology enterprise has been expanding exponentially in the last two decades with Africa remaining hesitant to delve into the commercial production of GM crops despite having conducted long term confined field trials on several GM crops and also having developed biotechnology policies and biosafety regulatory frameworks. Africa is endowed with a sizable youthful and well educated population that can be harnessed to support the deployment of modern biotechnology and its associated management stewardship.

African governments and regional economic communities are encouraged to create a conducive environment that will facilitate the development and application of agricultural biotechnology. Emphasis should be placed on maximising the socio-economic benefits associated with modern biotechnology and embrace science based advice to inform decision making.

Capacity for Biotechnology Research, Product Development and Deployment

6

Background

African governments have developed robust science and technology policies that are geared towards the transformation of their economies into knowledge driven economies. Collectively African governments, under the AU have launched specific initiatives to position the continent in the global knowledge economy through science, technology and innovation generally and biotechnology specifically. As a result, Africa's contribution to the global knowledge index through innovations and patents has seen a steady increase. The limiting factor to the full realisation of Africa's potential in this sector is low capacity for knowledge (IPR) management and application including royalty negotiations, brokerage and stewardship. This is clearly a need which the African Agricultural Technology Foundation (AATF) is addressing.

Discussions on IPR in Africa relate only tangentially to biotechnology but affect innovation and scientific progress in general. The dialogue covers a tangled array of issues involving ethical concerns about the "patenting of life," concerns about monopolistic controls on food supplies, and the role of indigenous people as protectors of agricultural biodiversity. Overall, there is a need for much education and training on this topic at senior political levels, as well as at the level of practitioners.

Inadequate infrastructure, human and institutional capacities for agricultural biotechnology research and product development are a long standing obstacle to Africa's desire of becoming a key participant in the global biotechnology enterprise (Plate 3). The ability of African countries to effectively use existing and emerging biotechnologies depends largely on the level of investment in building physical, human and institutional capacities. An incredible resource in biotechnology tools for application in various processes and gene technology procedures, including an ever expanding and rich gene (DNA) sequence database (gene bank) of most of Africa's valued crop varieties is at the continent's disposal. To tap into these resources, African governments must invest in building their national and regional capacities for Bio-informatics.

Plate 3. Biosafety level 2 greenhouse facility at Kenya Agricultural and Livestock Research Organization (KALRO), Kenya. African governments should invest resources in infrastructural development of such facilities to enhance research in modern biotechnology.

More specifically, Africa needs to focus on creating and reforming existing knowledge-based institutions, especially universities and national science academies, to serve as centres of new technology diffusion into the economy. This will entail fundamental reforms in higher technical training for economic development by bringing research, teaching and community outreach together to support biotechnology development goals. To address the "software" component of the training, there is a need to develop a comprehensive continental biotechnology curriculum for all levels of education, focusing on specific areas that offer high economic returns for the continent.

To enhance biotechnology product development, commercialisation and business capacity, African governments need to foster Research and Development (R&D) cooperative partnerships at the local, regional and international levels. Opportunities for these partnerships have expanded greatly with the announcement of various R&D partnerships between Europe and Africa. Further, African governments need to substantially increase their national biotechnology R&D budgets and explore additional special funding mechanisms including public-private partnerships (PPPs). Burkina Faso, China and India present good examples of working PPPs in biotechnology development through commercial production of GM crops.

Private sector players and development partners are in an advantage position to help African governments in building the capacity of national agriculture research systems for biotechnology research, product development and deployment. On the other hand the governments are in a position to provide a favorable policy and regulatory environment for the expansion of the biotechnology industry. This will ensure that biotechnology graduates from higher learning institutions are readily absorbed into industry and that domestic human resource in biotechnology is retained and enhanced.

There is great potential in developing North-South and South-South collaborations supporting biotechnology R&D and capacity-building in Africa. Individual countries need to identify ways of enhancing such collaborations with other regions of the world to effectively address issues pertaining to biotechnology. In addition to facilitating North-South and South-South collaborations, African countries need to mobilise the expertise in the Diaspora for development and make maximum use of ABNE, which is a programme under the AU-NEPAD, wholly dedicated to building African's capacity for biotechnology development and biosafety regulation.

Financing

Capacity building through the entire spectrum ("value chain") of biotechnology product development and commercialisation is resource intensive, requiring large financial commitments. In this regard, financing the process requires a concerted effort by all the actors and stakeholders in the process through well co-ordinated partnerships and collaborations. In this array of partnerships, national governments are expected to play a central role of coordination and regulation.

Through the Lagos Plan of Action and the Maputo Declaration that recommend the allocation of 1 and 10 percent of their national GDP to science and technology and agriculture respectively, African government leaders laid the foundation for the financing of agricultural biotechnology, as a scientific intervention in agriculture. The next logical step is for the African governments to provide budgetary allocations to agricultural biotechnology development considering that it is covered by the two provisions of 1 and 10% GDP.

In working out the financing of agricultural biotechnology product development and commercialisation, governments, development partners, civil society, the private sector and other relevant stakeholders are encouraged to focus on the entire spectrum or value chain composed of the following components:

- Research for proof of concept;
- Product development for innovations;
- Regulation for effective, efficient and quick process;
- Risk assessment, communication and management;
- Management of IPR issues;
- Technology stewardship;
- Communication and public engagement.

Key Message

Agricultural biotechnology has great potential to contribute real socio-economic benefits to the African continent given that it has been demonstrated to have great need for enhanced agricultural productivity. Africa is uniquely exposed to food and nutrition insecurity, impacts of climate change, declining availability of arable land, rising salinity and declining soil fertility and in general decline in agricultural productivity owing to numerous biotic and abiotic constraints, all of which can be addressed through the application of modern biotechnology. The low infrastructure, human and institutional capacities for agricultural biotechnology research, product development and deployment are huge and long standing obstacles to Africa's desire of becoming a key participant in the global biotechnology enterprise and the knowledge based economy.

African governments are encouraged to enhance their investment in the development and application of agricultural biotechnology as part of their commitments expressed in the Lagos Plan of Action and the Maputo Declaration. The governments are also encouraged to pursue collaborative research programmes within the South-South and North-South framework and facilitate the effective utilisation of the continent's expertise in the Diaspora. This can be achieved through effective partnerships with the private sector, development partners and civil society actors who are working towards delivering agricultural biotechnology benefits to the people of Africa.

7 Public awareness and Communication

Background

Quite often, public awareness of new technologies involves scientists and government officials informing members of the public about the technologies that are good for them without expecting to be challenged. This one-way mode of communication assumes that if members of the public possessed additional knowledge of a science or technology, then this would lead to readier acceptance of new technologies. On the contrary, technology acceptance is not linear and the public can reject new technologies for what scientists and public officials may consider to be irrational reasons.

A dedicated strategy for communication, public awareness and participation in engagements with modern biotechnology is critical to the full roll-out of the technology for application in commercial and subsistence production systems in Africa. This is in consideration of the controversy generated by public debates on the merits and demerits of the technology and the need for a coordinated approach on the key components of the strategy (target audiences, messages, carriers, etc). Further, this endeavor must be well coordinated and sufficiently funded since it is a very financially demanding engagement. As the global governance instrument for modern biotechnology, the Cartagena Protocol on Biosafety (Article 20 and 23) provides for a global information sharing mechanism through the Biosafety Clearing House (BCH) as well as public awareness and participation respectively. Most African governments have incorporated these provisions in their biosafety regulatory frameworks and are active in the BCH.

Public acceptance of new technologies needs rigorous and credible regulation in which the public has confidence that their interests and safety are paramount and that the opinions and concerns of non-scientists are considered. These require a genuine partnership between society stakeholders including members of the lay public, professional societies, industry, voluntary associations, young people's and women's groups, faith communities, policymakers, and elected representatives of local and national legislatures. Such partnerships need open dialogue on the benefits and risks of new technologies, evidence-based decision-making and equitable access to information for all. The media and academies of science are important partners with government in the generation and dissemination of targeted information for advocacy, overcoming misinformation and winning political will.

Science communication has become a key element in technology development and the classical approaches that relied on one-way flows of information from scientists to the general public through a variety of media are being replaced by participatory approaches involving a diversity of sources of information and perspectives. In this whole mix, the media becomes an important channel for science communication. In this regard, media training in science writing, including media away-days to biotechnology labs could all be used in efforts to promote good practice in the press. The Burkina Faso experience of a partnership between researchers and the media is a good model from which other African governments can learn.

Generally, there is low public awareness and participation on matters of biotechnology globally and especially in Africa. A study published in 2005 by the Public Understanding of Biotechnology (PUB) project of the South African Agency of Science and Technology Advancement (SAASTA), found that 80% of the 7000 respondents had no idea what the word biotechnology meant

(HRC, 2005). African countries are encouraged to learn from their counterparts who are growing GM crops through the establishment of communities of practice that bring together neighbouring countries. For example, countries in southern Africa can learn from South Africa, those in West Africa can learn from Burkina Faso as those in eastern Africa take lessons from Sudan.

Public awareness and engagement in biotechnology is needed at all levels in Africa. A lack of both creates room for deliberate distortion of facts, non-scientific basis of risk perception and makes it difficult for African countries to individually and collectively discuss, set priorities and exploit economic and other opportunities offered by biotechnology. New stakeholder partnerships, awareness campaigns, and innovation competitions need to be created to facilitate public awareness and education on issues of biotechnology. An excellent example of training facilitation in communication is the just concluded Biosciences for Farming in Africa (B4FA) media fellowship programme that was supported by the Templeton Foundation.

In financing communication, public awareness and participation, African governments and advocacy organisations that support the development and deployment of agricultural biotechnology should be conscious of the fact that it is a resource intensive long term engagement and that anti-biotechnology lobby groups are well funded. The business motive of these anti-technology groups and the way they make a living out of their crusades has indeed been demonstrated (Sundström and Fagerström, 2014).

Key Message

Generally, public awareness and participation on matters of modern biotechnology, particularly the genetic modification of organisms (GMO) is very low worldwide. In Africa the technology is perceived to be foreign/alien, further creating the opportunity for deliberate distortion of facts and non-scientific basis of risk perception. This has made it difficult for African countries to individually and collectively discuss, set priorities and exploit economic and other benefits offered by biotechnology.

African governments, as parties to the Cartagena Protocol on Biosafety, have committed to the provisions of Article 23 of the Protocol on Public Awareness and Participation. To fulfill this commitment, African governments are encouraged to partner with the media, civil society and other relevant stakeholders to enhance domestic capacity for public communication, education and participation. The governments can use the experiences of resource poor farmers in African countries that have adopted modern biotechnology as learning points for public education and awareness programmes.

8 Conclusions and Way Forward

Modern agricultural biotechnology holds the promise of delivering real benefits to the people and economy of Africa. The greatest hindrance to the development, adoption and deployment of the technology in Africa is the prevailing unfavorable biotechnology development policy environment and an extremely precautionary biosafety regulatory regime. This is coupled with insufficient human, infrastructure and institutional capacity for biotechnology product development and biosafety regulation.

As a way forward therefore, African governments:

1. Need to re-think biotechnology development policy and biosafety regulatory regime to create an enabling political environment for the development, adoption and deployment of modern agricultural biotechnology. To achieve this, the continent will have to embrace evidence based decision making by harnessing the technical capacity of the rich network of African academies of science as a source of credible evidence based advice to policy.
2. Should support and fully participate in the on-going regional (COMESA, ECOWAS, EAC and SADC) initiatives towards the harmonisation of biotechnology development policies and biosafety regulations to ensure that Africa becomes a key participant in the global biotechnology enterprise.
3. Should enhance the level of public awareness, education, and engagement in matters of biotechnology development and biosafety regulations in Africa. This will eliminate deliberate distortion of facts, non-scientific basis of risk perception and makes it easy for Africa to exploit economic and other opportunities offered by modern agricultural biotechnology.
4. Must invest in building human, infrastructure and institutional capacity for biotechnology development and biosafety regulation by allocating financial resources and leveraging on global partnerships and collaborations within the South-South and North-South frameworks. As a starting point, Africa should position herself to reap maximum benefit from the current collaborative initiatives with developed countries for Science, Technology and Innovation (ST&I) in general and modern agricultural biotechnology research in particular. To this end, NASAC is uniquely positioned as a strong base for partnerships with governments on matters of science and should take the lead in initiating dialogue with African government leaders on matters of science and technology generally and modern biotechnology specifically.

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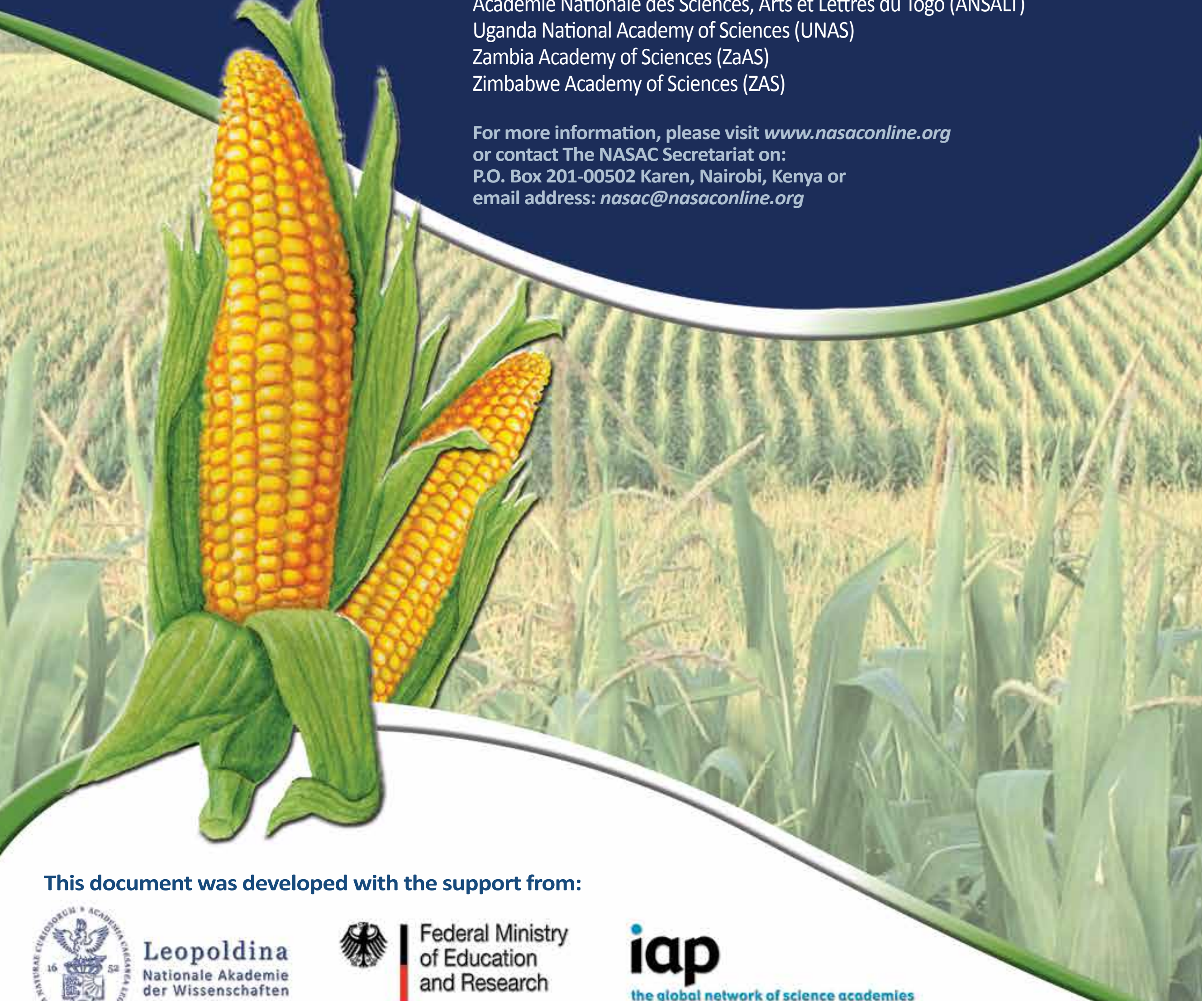

This document was developed with the support from:

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