A strategic framework for transgenic research and product development in Africa: Report of a CGIAR study

ILRI PROJECT REPORT

A strategic framework for transgenic research and product development in Africa: Report of a CGIAR study

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Acronyms

AATF	African Agricultural Technology Foundation
ABNE	Agricultural Biotechnology Network of Experts
ABSP	Agricultural Biotechnology Support Program
AH	Africa Harvest
ARC	Agricultural Research Council
ARCN	Agricultural Research Council of Nigeria
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
AU	African Union
BecA	Biosciences for eastern and central Africa
BMGF	Bill and Melinda Gates Foundation
CCARDESA	Centre for Coordination of Agricultural Research and Development for Southern Africa
CFT	Confined Field Trials
CGT	Confined Greenhouse Trials
CIAT	Center for International Agricultural Research in the Tropics
CIMMYT	International Maize and Wheat Improvement Center
CIP	International Potato Center
CRP	Consortium Research Program
CSIR	Council for Scientific and Industrial Research
DNA	Deoxyribonucleic acid
EASAC	The European Academies Science Advisory Council
EC	European Commission
ECA	Eastern and Central Africa
EDF	European Development Fund
EIARD	European Initiative for Agricultural Research and Development
EU	European Union
FAO	Food and Agriculture Organization
FARA	Forum for Agricultural Research in Africa
FTE	full-time equivalent
GDP	Gross Domestic Product

GMO	Genetically Modified Organism
ICAR	Indian Council for Agricultural Research
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IFPRI	International Food Policy Research Institute
IITA	International Institute for Tropical Agriculture
ILRI	International Livestock Research Institute
INERA	Environment and Agriculture Research Institutes
INRA	National Agricultural Research Institute of Benin
IRAD	Institute of Agricultural Research and Development
IRRI	International Rice Research Institute (IRRI).
ISAAA	International Services for Acquisition of Agri-Biotech Applications
ISABU	Burundi Institute for Agronomic Sciences
ISPC	Independent Science and Partnership Council
KALRO	Kenya Agricultural and Livestock Research Organisation
MAS	Market Assisted Selection
MoU	Memorandum of Understanding
NABnet	Northern African Biotechnology Network
NARO	National Agricultural Research Organization
NARS	National Agricultural Research system
NEPAD	New Partnership for Africa Development
NGO	Non-Governmental Organizations
NUE	Nutrient Use Efficient
SA	South Africa
SANbio	Southern Africa Network on Biotechnology
SSA	Sub-Saharan Africa
TAC	Technical Advisory Committee
DFID	United Kingdom aid for international development
UNDP	United Nations Development Program
USAID	United State Agency for International Development
WCA	West and Central Africa
WECARD	West and Central Africa Council for Agricultural Research and Development
WHO	World Health Organization

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Scope of the study

The overall objective of the study is to provide a comprehensive analysis of the current capacity for transgenic research in CGIAR centres and National Agricultural Research Systems (NARS) in a sample of countries in Africa. This includes the policy and regulatory situation, donor perspectives on transgenic research, and the implications for research for development as a basis for a strategic framework for transgenic research and product development by the CGIAR centres and partners in Africa.

The study undertook the following tasks:

1. Carry out a comprehensive literature review on the current human resource and infrastructure capacity at national and international level as well as the source of funding for agricultural transgenic biotechnology research by CGIAR centres in Africa.
2. Collate information on the current human and physical capacity, level and source of funding for agricultural transgenic biotechnology research and development in a sample of countries in Africa.
3. Assess the status of agricultural transgenic biotechnology policies, legislations, regulatory frameworks, and institutional capacity for implementation of the same in the sample countries.
4. Review the knowledge base and perceptions of policymakers on agricultural transgenic biotechnology research and development, policies, legislations, regulatory frameworks, and institutional capacity in a sample of countries in Africa.
5. Benchmark with other developing countries, especially from Asia on the status of transgenic biotechnology research and development.
6. Provide details of potential donors and agencies supporting agricultural transgenic biotechnology research in Africa.
7. Review the policies and strategies of key donors of agricultural transgenic biotechnology research in Africa.
8. Analyse the strengths, opportunities and challenges for CGIAR centres for transgenic biotechnology research in Africa.
9. Propose a strategic framework for transgenic biotechnology research for CGIAR in Africa, in partnership with NARS and the process for fast tracking approvals of transgenic products in the pipeline, through the value chain.
10. Compile a comprehensive report of the study.

The study was carried out through literature review; structured meetings with the managers of NARS in 12 countries in Africa; meeting with the managers of the regional and subregional organizations in Africa; and meetings with policymakers (ministers and permanent secretaries) in the same countries as well as law makers (members of parliament of the committees on agriculture) where necessary. Structured meetings were also held with the directors and biotechnology program leaders of all the participating centres and a sample of donors for international agricultural research. In addition, a benchmarking visit was carried out in India in which meetings were held with policymakers and NARS managers to document the status of transgenic research, in the country.

Executive summary

In the last 10 years, centres have invested considerable resources in biotechnology and subsequently transgenic research, in terms of infrastructure, acquisition of state of the art equipment and human resource development. There is clearly, within the centres, the physical and human capacities for the conduct of a wide range of biotechnology research from genomics and genetic engineering, similar to those existing in many advanced research organizations, to field testing under safe and responsible procedures, in line with host country biosafety laws, regulations and guidelines.

Despite the stated technical support by CGIAR, the source of funding for transgenic research for the centres is limited to only a few, mainly bilateral and philanthropic donors. The research system has not been outgoing in sourcing for funding for transgenic research from multilateral donors or the private sector, either due to the highly controversial global debate on safety of genetically modified organisms, or the fear of the anti-GMO lobby groups.

Centres are implementing several transgenic research activities that have great potential to contribute to food security and nutrition in Africa. The centres are working on insect resistance, disease resistance, drought resistance, nutrient efficiency and nutrition enhancing traits that are clearly of great importance for food security and nutrition improvement. Centres are using gene technology from various sources including the private sector provided with freedom-to-operate for the resource-poor farmers in Africa.

To date no transgenic product from the CGIAR centres and NARS has been released for commercialization. While most of the activities have been started recently, some have been going on for the last 5 to 10 years and are expected to be ready for release and subsequent commercialization and or adoption by farmers in the next 2 to 3 years.

While the centres in partnership with the NARS are posed to release transgenic products in the next few years, they exhibit a degree of weakness in communication, interactions with policymakers, and partnerships with the regional, subregional and national research system that poses a serious risk, for deployment and commercialization of transgenic products. In some cases, centres are misunderstood by policymakers to be part and parcel of the multinational companies, posing the risk of being perceived to be promoting their business rather than working for the resource poor farmers.

The situation for livestock transgenic research is quite different from that of crops. While there is physical and human capacity, for biotechnology and subsequently transgenic research, there is only one livestock transgenic research activity that is going on in the CGIAR system. Either livestock biotechnology research has concentrated on animal health and there has been some reluctance due to ethical issues or there has been no interest in funding from donors. Unlike in crops, despite the fact that livestock is more than 40% of the agricultural sector in all aspects of contribution to food security, nutrition, livelihoods and economic development of most developing countries, there is very little funding for livestock transgenic research. The only one research activity that is going on does not have adequate funding to take it to the ultimate conclusion.

The most serious threat for transgenic research for the CGIAR centres in Africa is the lack of trustable and impartial sources of information on the safety and benefits of the current transgenic products under development by the centres and associated NARS which needs to reach policy, opinion and decision-makers. This has given space and opportunity to anti-GMO, organizations and activists to confuse the public and policymakers and hindering decision-making by farmers and policymakers on release, commercialization and adoption of transgenic products. In addition, intellectual property rights, trade issues and the fear of donors who are cautious about genetically modified organisms, also poses a threat not only to transgenic research by centres but also in attracting partnerships.

In the last decade, Africa has established relatively strong regional and subregional organizations in agricultural research, dealing with advocacy, policy development, and coordination of research activities that cut across countries. Organizations such as Forum of Agricultural Research in Africa (FARA), with its memberships of subregional organization, is not only becoming a major player in agricultural research for development but also attracting reasonable donor support for advocacy, policy and setting the agenda for agricultural research in the continent. These organizations have identified lack of human capacity, lack of funding and policy environment as the main impediments for transgenic research and deployment of products therein.

Others such as African Agricultural Technology Foundation (AATF), and the Biosciences eastern and central Africa (BecA)/ILRI hub are key players in technology brokerage and providing advanced bioscience services for transgenic research in Africa.

All African countries, except three have signed and ratified Cartagena Protocol on Biosafety to the Convention on Biodiversity Conservation since it was released in January 2000. The protocol sets the international framework on which governments could develop their own biotechnology policies, biosafety legislations and regulations.

While the process has been slow, currently a critical mass of African countries have national policies, legislations and in some cases regulations to enable transgenic research and deployment of subsequent products. Policymakers are well aware of the pros and cons of the use of GMOs but countries that have not made much progress to put in place biotechnology policies and biosafety legislations are constrained by lack of capacity, pressure from anti-GMO activists, and lack of political will.

Out of the 12 countries selected for this study, 8 have biotechnology policies and biosafety legislations in place, 2 have biotechnology policies and are at advanced stage of legislating their biosafety bills, and 2 do not have either a biotechnology policy or biosafety bill. All the 12 countries, except those without a biosafety policy, have established mechanisms and institutions to regulate biotechnology research and deployment of transgenic products, although some of them may not have the capacity to carry out the regulatory function effectively.

There is the critical mass of physical infrastructure for biotechnology research, in terms of building laboratories and offices in these countries but they lack the equipment and technical staff. The most serious constraint for transgenic research in the countries is lack of scientific capacity, lack of funds and the threat of anti-GMO activists. While some of the countries have some scientists to partner with CGIAR centres' scientists for downstream (adaptive) activities on transgenic research, all except South Africa do not have scientists to take part in upstream (basic) transgenic research activities.

Despite the lack of human capacity and financial resources, there are several transgenic research activities that are going in 9 out of the 12 countries in this study, being led by CGIAR centres and a few by the private sector. Except for South Africa, there is no real investment in transgenic research by the national governments and all research activities are supported by donors and the private sector.

Unlike in crops, the situation in livestock transgenic research is quite desperate. Currently, the policies and legislation in place in the countries included in this study do not seem to cater for transgenic livestock research and deployment of livestock transgenic products. Except in two of the countries, policy and law makers in these countries do not anticipate the role of transgenic livestock research and products.

In all the countries in this study, there is neither the physical capacity nor the human capacity either to undertake or participate in livestock transgenic research. The policymakers see this type of research as too advanced for their meagre human capacity, and the national research system have no plans to partake into this type of research in the near future.

India's experience and progress in transgenic research provides very useful lessons for African countries. Unlike Africa, India has an immense human and physical capacity in transgenic research accumulated over a long period of time. India is also investing heavily on more transgenic research to position itself to be a major global player.

Like in Africa, despite tremendous experience there is only one crop that has been released and commercialized in India, but there are several crops in the pipeline. India, however, is a major consumer of transgenic products in food and feed imported from other countries. There are very strong anti-GMO lobby groups, which challenge transgenic research and deployment even in courts of law but the research system in India is not deterred or distracted.

In consideration of this analysis and the finding in the report it is recommended that:

1 Centres should support the establishment of the CGIAR Biotechnology Support and Planning Group proposed by the Independent Science and Partnership Council (ISPC) study with a focus on Africa. The group will address broad strategic issues; deal with issues of communication, public awareness, interaction with policymakers and legislature; provide oversight of biosafety and trade related issues; and the issues of sharing of the physical resources and information arising from genomics research. The group should include scientists based in Africa because of the potential for impact, level of the debate on GMO, and the need for human capacity (rec. 1).

2 The participating centres should review and harmonize their biotechnology policies so that they have some legal backing, and acceptability by third parties (rec. 2).

3 The centres, through the biotechnology support and planning group, should actively engage with donors and stakeholders to provide reliable and accurate information on current GMO under development in a transparent and scientific manner on a periodic basis (rec. 3).

4 Transgenic livestock research on developing disease resistance in cattle should continue to a logical conclusion, not only for the much needed resistance to trypanosomiasis, but also, as a basis for training and capacity building of the NARS in Africa. Furthermore livestock research should make greater use of BecA-ILRI Hub facilities for livestock genomics and transgenic research to have a more comprehensive genomics program to accumulate animal gene information through sequencing of various livestock species, and develop projects to use biotechnology tools to search for disease resistance in small ruminants and poultry (rec. 4, 5, and 6).

5 Centres should strengthen human resources of scientists in biotechnology research ranging from genomics, gene discovery and genetic engineering expertise to the application of transgenic procedures (rec. 7).

6 IRRI and ICRISAT should prepare a framework and proposals for deployment of transgenic products of their mandate crops in Africa (rec. 8 and 9).

7 Africa Rice and IRRI should get into a formal agreement for a joint biotechnology program and use of physical and human capacity to avoid duplication and competition (rec. 10).

8 Centres should ensure that the gene technology they use, is either their own or given to them royalty to avoid IPR restrictions (rec. 11).

9 Centres should work out modalities of partnership arrangements with the national agricultural research institutions particularly on transgenic research with parameters that can be monitored and measured; and implementation mechanisms to ensure release and commercialization of products (rec. 12).

10 Regional and subregional level activities on transgenic research dealing with advocacy, capacity building for biosafety, policy and development, and baseline studies should be coordinated by FARA and SROs for economies of scale and to avoid duplication of efforts (rec. 13).

11 Centres should work out a mechanism with FARA and subregional organizations to be their agencies for upstream biotechnology and consequently transgenic research, and to develop and implement training and capacity building programs in biotechnology research for Africa (rec. 14).

12 BecA-ILRI Hub should be more pro-active in marketing its services and work out mechanisms of collaborative arrangements with ICRISAT to utilize the physical infrastructure and the human capacity of the two institutions to build capacity for African countries (rec. 15 and 16).

13 Centres should engage more proactively with multilateral donors for funding for transgenic research for Africa (rec. 17).

14 Confined field trials on transgenic products, their release and commercialization process, should be the full responsibility of either the NARS or the private companies with funding from government, national donor funded programs or the private sector (rec. 18 and 19).

15 Issues of intellectual property rights, and trade should be elaborated at the event selection stage, and continue to be part and parcel of the communication package of any transgenic research activity (rec. 20).

16 Centres' transgenic research should focus on a few countries that are ready with conducive policies, legislations and regulations; have the political will; and with the critical mass of scientists to carry out and supervise controlled field trials and take responsibility for deployment of the technology (rec. 21).

17 With regard to livestock transgenic research, centres should select two or three countries in Africa to start a program on building livestock biotechnology research capacity (rec. 22).

18 African countries should develop South–South Cooperation programs on science and technology that would include biotechnology and consequently transgenic research, with the CGIAR centres providing backstopping to NARS, in the thematic areas of their competencies (rec. 23).

1 Introduction

1.1 Definitions and the GMO debate

Definitions

Transgenic research is part of the science of biotechnology that involves application of bioscience processes and techniques to develop novel products. *Biotechnology as defined by the Convention for Biodiversity is 'any technological application that uses biological systems, living organisms or derivatives thereof to make or modify products or processes for use'*.[1]

This definition is broad and does not differentiate between natural or conventional breeding or gene movement, from the application of modern laboratory based techniques of gene transfer from one organism, or from a gene construct to an organism. Biotechnology is used to refer to as simple techniques as tissue culture based techniques and micropropagation, to relatively more complex mutagenesis, interspecific or intergeneric hybridization, marker-assisted selection (MAS), disease diagnostics and bio-protection, and biofertilization to the very complex genetic engineering.

In simple terms agricultural biotechnology is therefore any technology application that uses biological systems, living organisms or derivatives thereof to make or modify products or processes for use in agriculture (crops, livestock, fisheries and trees). Biotechnology is one of the most contemporary tools for agricultural research and its application is deemed to have great potential to provide solutions to both agricultural production and food nutritional constraints.

Crop biotechnology refers to the application of these techniques in crop improvement. Techniques such as tissue culture and micropropagation have been widely used for mass propagation of disease free and faster growing plant material and the more relatively complex techniques are used to hasten conventional breeding and produce genetically modified organisms.

Livestock biotechnology is also the application of these techniques in research and development of vaccines, and diseases diagnostic kits and genetically transformed animals.1 Livestock biotechnology techniques and procedures range in sophistication from cryopreservation of semen sexing to transfer of new gene constructs (transgenesis) and genome editing. Products of these techniques includes, sexed semen, recombinant vaccines and rapid diagnostic kits that are used in everyday animal production and animal health service delivery, and transgenic animals.

Genetic engineering is the group of techniques used to cut up and join genetic material especially the DNA from one or more species for introduction to an organism in order to change one or more of its characteristics (Webster dictionary). Genetic engineering is therefore the process of creating new gene constructs for a desired trait, and is commonly referred to as 'modifying genotypes, hence phenotypes by transgenesis'. Such contributions are of significant value to food security and poverty reduction globally and more so in Africa.

1. FAO (2013) 'Biotechnologies for Agricultural Development: Agricultural Biotechnology in Developing Countries (ABDC), FAO, Rome. www.fao.org/biotech/biotechnology-glossary.

Transgenesis is the process of introduction of an exogenous gene either from unrelated or related (cisgenesis) organism into a living organism so that the organism exhibits new properties and transmits those properties to its offspring. The process is therefore defined as 'the introduction of gene or genes into animal or plant cell which leads into transmission of input gene (transgene) into successive generations'

For the purpose of this report transgenic research starts from the science of genomics which is defined as a discipline in genetics that applies DNA sequencing methods, and bioinformatics to sequence, assemble, and analyse the function and structure of genomes so as to better understand all genes and their inter relationships in order to identify their combined influence on the growth and development of the organism.

Genomics then provides the information and knowledge that is required for genetic engineering and gene discovery for the desired traits referred to here as basic research. These basic research stages are referred to as upstream research in this study. Once the genes have been discovered and gene constructs constituted for the desired trait, organisms are genetically transformed to acquire the traits through transgenesis. The process for transferring genes to an organism is facilitated by Agrobacterium tumefaciens, liposomes, plasmid vectors, viral vectors, pronuclear injections, protoplasm fusion, and biolistic DNA transfer. The stages of transformation, controlled greenhouse trials, and the confined field trials are referred to as downstream or adaptive research in this study.

The GMO debate

The products of transgenesis are commonly referred to as genetically modified organisms (GMOs). Sharp category distinction between transgenic and non-transgenic products is somewhat contrived in breeding terms and may not be acceptable by many scientists. The distinction has however been so much used in the common language that it is understood for legislation, policy development and for consumers. This study focuses on transgenic products, which are a result of the new knowledge of the genome, functional analysis, and genetic engineering or genetic transformation for desirable traits in plants and animals.

Since the first transgenic crop was released for cultivating in 1994, cultivation of several varieties in many countries all over the world has grown rapidly, in the last twenty years to currently more than 10% of the world arable land. Furthermore, it has been established beyond any reasonable doubt that application of transgenic products would significantly increase productivity and food nutrition; provide higher net financial and environmental benefits; and after twenty years of consumption the products are as safe as any other food.

However, a vast majority of crops remain non-transgenic owing to limitations on the traits available to major crops; perceived complex Intellectual Property Rights (IPR) and restrictive regulatory regimes; and often negative public perceptions from important stakeholders. In addition the whole process of developing a transgenic product from gene discovery to commercialization is perceived to be long and costly. It is estimated that the process could take as long as 9 to 18 years depending on complexity of the research at various stages and the regulatory process.

The cost of the whole process from gene discovery to adoption by farmers, is reported by multinational corporations to be as high as USD 40 to 100 million per product depending on the rate of failures and cost of approval. The estimated cost per stage are: trait generation for 1 to 2 years at USD 2 to 5 million; trait optimization for 1 to 2 years at USD 5 to 10 million; proof of concept for 2 to 3 years at USD 10 to 15 million; event testing from 1 to 3 years at USD 10 to 15 million; field trials and breeding for USD 2 to 4 years at USD 10 to 15 million and regulatory and commercialization stage at USD 10 to 40 million.

However, these estimates have not been supported by real data and are exclusively from the private sector concerned with highly competitive markets and commercial crops of global importance such as cotton, maize and soybean. There are also arguments that the steps from trait generation to the proof of concept are subjective. Recent studies contradict these estimates when the public sector is the main actor. Indeed, the costs to non-profit institutions for the production and deregulation of one transgenic potato were recently estimated to be between USD 1.4 and 2.3 million over 8 to 9 years (*Ghislain pers. Comm.)*. Currently, difficulties in deregulating GM varieties in most countries is the regulatory and commercialization process, which could be reduced considerably if the regulations were more strictly based on scientific criteria and updated from the body of knowledge accumulated over the last decades on biosafety research on transgenic crops.

With regard to livestock, the process will take even longer and be more expensive, just as is the case in conventional livestock breeding, because of the biological complexity, cost of phenotyping and the generation time in livestock. However, in the future, breeders will have the additional benefit of genomic and metabolomic technologies which will contribute to all forms of livestock improvement. In addition the use of new genetic engineering techniques that are not transgenesis such as gene editing is providing new opportunity for faster development of disease resistance livestock breeds.

While there have been significant successes of adoption of several first generation transgenic varieties by farmers, there have also been unexpected setbacks due to cost of seed and negative publicity by anti-GMO activists. After over twenty years of consumption of transgenic products, it has been proven beyond any reasonable doubt that, there are no negative health issues and that the technology has benefits to farmers. However activists have continued to depict transgenic food products as unnecessary technology that could have negative impact in future, hence creating fear and serious hindrance adoption.

The trends and current status adoption of transgenic products, referred to, as Genetically Modified (GM) crops is well documented in various reports of the International Services for Acquisition of Agri-Biotech Applications (ISAAA). ISAAA has created a global network to collect and disseminate information on agricultural biotechnology research, application of biotechnology techniques and adoption of products there of (www.isaa.org). The reports indicate that adoption of transgenic crops has grown at the rate of over 3% per annum, between 2012/2013 even in developing countries.[2]

Many of these crops also serve as livestock feed, hence a major input into the *livestock productivity but there is now no equivalent source of information on the adoption of transgenic livestock products.*

The advent of transgenic food products has clearly introduced new dimensions of the debate on how to respond to food insecurity and how to achieve longer-term agricultural growth. Scientists and development agencies who continually seek for new solutions to agricultural productivity and nutrition problems that are persistent and evasive, have found biotechnology to play a key role.

Since the inception of transgenic research in 1980 and introduction of transgenic crops in 1994, there is ample scientific and economic proof that transgenic products can contribute significantly to increasing food security and economic development and the products are as safe as any other foods. However, scientists and the development community follow scientific methodologies that are difficult to translate in simple terms to be easily understood by the general public. Scientists are also not so vocal. They tend to believe that facts will eventually find their way into logic and decision-making process, which is not usually the case and if it does, it would take a very long time.

On the side of those who oppose GM crops, there is a large and highly diverse community of opinion ranging from people demanding more accessible information on GM products, greater priority given to GM products with potential for poverty alleviation and food security. There is also a very vocal minority of anti-GMO activists who refuse to see the benefits of GMO, associate GM crops with danger and risks in what appears to be a scarecrow strategy. The latter would like the development, commercialization and application of the technology immediately stopped as exemplified in Box 1 example of the Ugandan case.[3]

They apply every means of communication, and all sorts of techniques even if it means distorting information to deliver their message.

2. James Clive (2013), 'Global Status of Commercialized Biotech/GM Crops', ISAAA Brief No. 46. ISAAA, Ithaca NY.

3. Rob Baily et al. (2014), 'On Trial, Agricultural Biotechnology in Africa, Chatam House, the Royal Institute of International Affairs, London.

These extreme views tend to confuse many African policymakers and sections of the public because of the lack of reliable information and guidance. There is increasing uncertainty and confusion in many of the African governments' responses to a wide range of social, ethical, environmental, trade and economic issues associated with the development and application of modern biotechnology.

Lack of African consensus and strategic approaches to address these emerging biotechnology issues has allowed different interest groups to exploit uncertainty in policymaking, regardless of what may be the objective situation for Africa. Anti-biotech advocacy groups can affect African decision-making adversely, as they portray agricultural opportunities in extremes, making it appear like it is an 'either–or' situation.

Box 1. Example of the impact of anti-GMO activism, the case for Uganda

In the pipeline are bio fortified bananas and varieties with resistance to pests and BXW, all of which are unable to progress beyond the stage of confined field trials (CFT) owing to a lack of biosafety regulation; attempts to pass new legislation through the Ugandan parliament stalled amid considerable controversy.

Anti-GM activists have, in the words of one interviewee, 'created heat and thrown up dust to create confusion around the bill' with some success. Opponents of GM have played on fears of health risks, for example claiming links with cancer, obesity and infertility, and using lurid images of deformed cattle and human babies growing from GM maize plants. Campaigners have also focused on social-justice issues, portraying the proposed biosafety law as a concession to big business that will erode farmers' rights and undermine 'food sovereignty', despite the fact that the contested technologies have been developed as public goods without the participation of TNCs.

These tactics have undermined consumer confidence and led to concerns among farmers that their costs will increase, their ability to exchange plantlets will decline and their markets will collapse. Government voices—presumably fearful of the toxic politics of GM—have remained largely absent from the national debate, with no clear communication of the potential benefits from the technology or rationale for public investment. Without widespread support among farmers—a key political constituency in Uganda—the biosafety bill remains on ice.

It is argued that most of Africa has lagged behind in adopting new transgenic research mainly because it lacks a conducive policy environment. While there have been concerted efforts in training workshops and seminars on policy development, there are still some countries without policies and legislations to guide biotechnology research and development. The main reason why these countries are lagging behind is that they do not have scientific capacity to elaborate on the role of biotechnology and the policymakers argue they do not get advice from the scientific community to enable them take decisions. Even where there are policies, legislations and regulations, there is no clarity on the position of the governments on transgenic research and application of the products. Furthermore, there are institutional capacity constraints for implementation of the policies, and regulations therein. Such information is imperative as the basis of a strategic framework for research programs in Africa, in particular by the CGIAR centres.

1.2 Background

The debate and discourse on the use of biotechnology techniques and subsequently transgenic research has been going on in CGIAR centres probably from the advent of the science in the 1980s. While the issues may have been discussed informally, it was not until 1997 that the CGIAR decided to create two expert panels under the auspices of the Technical Advisory Committee (TAC) to assist the group in formulating a policy on biotechnology and protection of the intellectual property as well as for the material held in trust.[4] The report was discussed and adopted by the CGIAR mid-term meeting in Brasilia, Brazil in May 1998 but was not produced as a committee document until June 2000. The panel made several recommendations shown in Box 2, most of which could be as relevant today as they were then.

4. TAC Secretariat (2000) , 'Report of the Panel on General Issues in Biotechnology', TAC, FAO, Rome.

The panel emphasized the need for network approach to biotechnology research to optimize knowledge sharing and efficiency in application of the knowledge. The panel also proposed a strategic framework for biotechnology research in CGIAR, but this recommendation does not seem to have been taken up by the centres. Although, not extensively quoted, this report seems to have provided all the requisite background information for position papers that had been used in planning and implementation of biotechnology research by CGIAR centres to that date.

Box 2. CGIAR–TAC panel recommendations, 1998

FOR THE CGIAR

to establish a basic policy framework on biosafety and gene deployment so that mechanisms are always in place to ensure that the benefits and risks associated with the release of transgenic organisms are assessed;

to develop a new strategy to align the CGIAR system with others committed to a greater understanding of germplasm; foster the evolution of international networks for biotechnological research directly associated with the CGIAR mission; and ensure that centres have the capacity to apply their knowledge to the needs of client countries;

to help bring about a 'genome summit' to assure global collaboration among representatives of multinational companies, major funding agencies, charitable institutions, and other organizations;

to expand international networks for biotechnological research in agriculture, fisheries, and forestry;

to create a central biological service unit to provide professional advice to the centres on the proprietary, biosafety, and gene deployment considerations of their projects.

FOR THE CENTRES

to review in-house expertise in genomics and bioinformatics, and in-house capacity to assess biotechnology's potential contributions to their research;

to use 'duty of care' committees to assess risks, consult clients, and adhere to regulatory procedures for biotechnology.

Since then, there are strong indications that the CGIAR and National Agricultural Research Systems (NARS) have invested heavily in various aspects of agricultural biotechnology research in Africa with the hope that it will provide effective solutions to various agricultural production constraints and contribute to increasing food security.

This year 2014, the Independent Science and Partnership Council commissioned a strategic study of biotechnology research in CGIAR. The report was presented and discussed in a stakeholders meeting in Washington in March 2014. While the study did not carry out comprehensive baseline surveys or strategic analysis of pros and cons of transgenic research by the centre, the findings and recommendations follow closely and have similarities with the Technical Advisory Committee (TAC) recommendations of 1997.

The study indicates that while the centres have applied soft biotechnology techniques such as tissue culture, genomics and marker assisted selection, they have been slow and cautious in transgenic research.[5] The study concluded that '*Despite the strong support for biotechnology within the CGIAR programs, the survey of centres suggested that there was inadequate strategic planning or coordination across the system with little opportunity for groups to share experiences, successes and failures. While non-GM approaches have been generally well integrated into breeding projects, the same cannot be said for GM which appeared to be largely opportunistic. In particular, there was concern that many aspects of stewardship, regulatory*

5. ISPC. 2014. Strategic Study of Biotechnology Research in the CGIAR. Rome: ISPC

approvals and delivery pathways had been inadequately addressed by some centres. Previous studies have identified similar problems and made recommendations for change that have not been fully implemented.' A summary of the recommendations is given in Box 3.

Box 3. Summary of the recommendations of iSPC panel

The Panel recommends the establishment of a series of coordination and advisory groups. The first should be the 'CGIAR-wide Biotechnology Support and Planning Group' (Rec. 1), which would take primary responsibility for addressing the broad strategic issues raised in this study. The group should also institute a scientific review of biotechnology capabilities and needs (Rec. 2). Importantly this group would also oversee the establishment of a GM Advisory Board (Rec. 3) and the CGIAR Bioinformatics Network (Recommendation 5).

A Biosafety Network should also be established by the GM Advisory Board (Rec. 6), with the prime task of developing Global GM approvals (Rec. 7). The Biotechnology Support and Planning Group should also work with the CRP for Livestock and Fish to address the needs of the animal production industries (Rec. 4) and ensure implementation of the training and staff development recommendations (rec. 8 and 9)

The study did not include the human and physical infrastructure capacity that is within the centres and the levels of investment by the centres for either the whole range of biotechnology or transgenic research. The study also did not consider the investment and the relevance of the ongoing research in Africa.

This study will complement the study of the ISPC, with details of the human and physical capital and levels of investment by the participating CGIAR centres. The study will also include the details of the human and physical capacity of NARS in selected countries as well as the levels of investment in sample countries. The study will evaluate the status and application of biotechnology policies, legislations and regulations in these countries and key donor perceptions on biotechnology and propose a strategic framework for transgenic research for the participating centres in Africa.

2 Profiles of the participating CGIAR centres

2.1 Context and projects

The six centres participating in this study were: (i) International Livestock Research Institute (ILRI); (ii) International Maize and Wheat Research Improvement Center (CIMMYT); (iii) International Institute for Tropical Agriculture (IITA); (iv) International Potato Center (CIP); (v) International Crops Research Institute for the Semi-Arid Tropics (ICRISAT); and (vi) International Rice Research Institute (IRRI). Africa Rice has also been included in the study due to its mandate of rice research in Africa. While the centres collaborate in several research activities and central services, each has specific mandates, research programs and projects, as well as human, physical and financial resources. Except where there is a consortium program in which the centres are involved, there is no formal collaboration mechanism for centres with large programs in Africa.

ILRI

The International Livestock Research Institute (ILRI) with the main offices in Nairobi and a large campus in Ethiopia is one of the four centres of CGIAR Consortium with their headquarters in Africa. It is also the only one of the fifteen centres in the Consortium that has livestock research as its core mandate. In addition to the headquarters in Nairobi and the campus in Ethiopia, ILRI has offices in West Africa (Burkina Faso), southern Africa (Zimbabwe); China, East Asia (India), and Southeast Asia (Philippines) which are set to be strengthened to serve the regions better.

Livestock forms 25 to 35% to of the agricultural growth domestic product and is the main source of livelihood for pastoralists in Africa. It is also the main source of protein, hence plays a critical role in food security and nutrition. The majority of livestock is found in semi-arid areas, hence prone to the effects of drought. Africa has 45.2% of live animals (heads); 17.6% of cattle, 82% of camel, 27.3% of goats and sheep; 8.1% of chicken and 2.7% of pigs)[6] in the world. Africa is therefore a significant producer of cattle and cattle products, goat and sheep and their products, and camel and camel products. In the last 10 years the production of cattle, sheep, goat, chicken, and even camel in Africa has almost doubled, implying either expansion of the areas and/or increased productivity. The role and mandate of ILRI therefore places the centre in unique and critical circumstances for Africa.

ILRI works with partners to enhance the roles that livestock play in food security and poverty alleviation, principally in Africa and Asia.[7] The institute is leading the Consortium Research Program (CRP) on Livestock and Fish; and a component on agriculture Nutrition and Health. The institute also hosts the Bioscience for eastern and central Africa (BecA) hub which is a joint partnership with the African Union (AU) and the New Partnership for Africa Development (NEPAD).

The Strategic thrusts of livestock transgenic biotechnology research will be anchored in the contexts of its strategic directions 2013–2022 with BecA-ILRI Hub playing a supportive role for transgenic research in ILRI.

6. FAO. 2013. FAO statistics 2013. Rome: FAO.

7. ILRI (2013), 'ILRI strategy 2013–2022', ILRI, Nairobi.

ILRI has biosafety policy and procedures which were approved by the board in 2013. The policy establishes an ILRI Biotechnology research oversight committee headed by the Deputy Director General and comprises directors of programs. This oversight committee oversees and reviews the recommendations of the biosafety committee which comprises of technical staff representing programs appointed by the director. The policy and the structures established thereof appear to be too internal to provide regulations that would be acceptable by a third party.

CIMMYT

The International Maize and Wheat Improvement Center (CIMMYT) global mandate is, as the name reads, maize and wheat. Africa produces on average 48 million tonnes of maize which constitutes about 7.1% of the global maize output per year.[7] Production of maize had stagnated to an average of 44 million tonnes between 2002 and 2007 but has increased steadily to 70 million tonnes by 2012 implying increase in productivity, hence contribution from research outputs. Africa is a net importer of maize to meet its human consumption and other uses. Maize is also the main staple food, hence very important for food security in many countries in eastern and southern Africa, where per capita consumption is between 95 and 110 kg per year but not so in central and western Africa.

Africa produces 19.1 million tonnes of wheat which constitutes 3.1% of global output of 670.87 million tonnes[7]. While production of wheat in Africa has generally increased in the last 20 years from 13 million tonnes in 1992 to 25 million in 2012, there has been high fluctuation with production going as low as 14 million tonnes in some years. This could be due to instability in the varieties and production system or, that wheat is highly prone to the effects of drought. Wheat is staple food for several countries in western and northern Africa and the continent is a net importer of wheat and wheat products for its domestic consumption and other uses. The role of CIMMYT in the livelihood, food security and nutrition in Africa can therefore not be over emphasized.

Research activities of CIMMYT are organized into six programs viz: (i) global maize; (ii) global wheat; (iii) Global Conservation Agriculture; (iv) Socio-economics; and (v) Genetic Resources.[8] The centre is leading in the implementation of the WHEAT and MAIZE Consortium Research Programs and participating in Climate Change Agriculture and Food Security (CCAFS).

Transgenic research activities of CIMMYT would fall within the global maize, wheat, and genetic resources programs. The activities of the program are much the same as those of CRP, hence transgenic research is part of MAIZE and WHEAT CRPs. Harvest Plus, seeds of discovery and durable rust resistance wheat global projects also have potential for transgenic research.

CIMMYT has a very strong presence in Africa spanning to 20 countries and has offices in Kenya, Ethiopia and Zimbabwe. In addition to its regular breeding and crop improvement activities, the main projects of CIMMYT in Africa are: (i) drought tolerant maize for African (DTMA), (ii), improved maize for African soils (IMAS), (iii) insect resistant maize for Africa (IRMA); (iv) effective grain storage project (EGSP); (v) Water Efficient Maize for Africa (WEMA); and (vi) Sustainable Intensification of Maize–Legume Systems in eastern and southern Africa (SIMLESA). The insect resistance research has been combined with DT in the WEMA project. CIMMYT is, therefore, working on two transgenic research projects in Africa i.e. WEMA and IMAS projects, with three traits i.e. drought tolerance, nitrogen use efficiency, and insect resistance (Annex 1).

Details of the transgenic research projects are shown in Annex 1. The first transgenic maize research project of CIMMYT in Africa was the Insect Resistant Maize for Africa (IRMA) that was started in 1999, in partnership with Syngenta Foundation for Sustainable Agriculture (SFSA). IRMA started by using public events of Bt genes *cry1Ab and cry1Ba* against five stem borer species (*Chilo partellus, Busseola fusca, chilo orichalcocillielus, Sesamia calamistis,* and *Eldama saccharina)*. The project started with a lot of steam but slowed as challenges were experienced with the resistance to one of the stem borer species, *B. fusca*.

8. CIMMYT (2013), 'CIMMYT Annual Report', CIMMYT–Mexico.

Further work on insect resistance has now been incorporated into the Water Efficient Maize for Africa project which is in its second phase. This project is testing three events all given royalty-free from Monsanto which was also a partner in the project. Drought tolerant event MON87460 is to be deployed to the five countries (Kenya, Mozambique, Uganda, South Africa and Tanzania). Bt maize events MON810 and MON89034 are insect resistant also from Monsanto with MON810 targeting Kenya, Uganda, Tanzania and Mozambique and MON89034 targeting South Africa and expected to be released by 2017.

The project is led by the African Agricultural Technologies Foundation (AATF), and is well funded for the period between 2008–2017 by the Bill and Melinda Gates Foundation (BMGF) and USAID (see annex II). The gene constructs for this project are from the private sector and would require rigorous intellectual property rights process and comprehensive biosafety legislation. African Agricultural Technology Foundation (AATF) is leading this project and is expected to broker the intellectual property rights and manage the stewardship of the product.

CIMMYT is also developing Nitrogen Use Efficient (NUE) maize, in conjunction with pioneer, and funding from BMGF, USAID and Pioneer DuPont Technology, in Kenya and South Africa. Research is at the stage of identifying the NUE gene and is expected to take between 7 and 9 years to release transgenic NUE maize varieties. The gene constructs for this project are also from the private sector and would require rigorous intellectual property rights process and comprehensive biosafety legislation.

CIMMYT has biosafety policy and procedures which were approved by the board in 2011 and revised in January 2014. The policy establishes a CIMMYT transgenic research oversight committee headed by the Director General and comprises of directors of programs and the legal unit. This oversight committee overseas and reviews the recommendations of the biosafety committee which comprises of technical staff representing programs appointed by the director. The policy and the structures are internal to manage internal biosafety issues and more out looking policies and structures may be necessary to accommodate CIMMYT external stakeholders.

IITA

The International Institute for Tropical Agriculture is headquartered and operates only in Africa. Its mandate crops include cassava, yam, banana/plantain, maize, soybean and cowpea. Africa produces 53.6% of cassava, 96.1% of yams, 14.3% of banana, 71.6% of plantain, 7.1% of maize, 0.6% of soy bean, and 95% of cowpea of the global production. Cassava, yam, plantain, and cowpeas can therefore be said to be African crops while banana, maize and soy bean are widely grown elsewhere. Africa is actually a net importer of maize and soybean as well as their products. Except maize and soybean the other of IITA mandate crops can be said to be food security orphans as they do not have a comprehensive seed system and require relatively low external inputs.

Research projects and activities of the institute are organized into nine CGIAR Research Programs, namely, those on the (1) integrated systems for the humid tropics, (2) policies, institutions, and markets, (3) maize, (4) roots, tubers, and bananas, (5) grain legumes, (6) agriculture for improved nutrition and health, (7) water, land, and ecosystems, (8) climate change, agriculture, and food security, and (9) gene bank. IITA is leading in the implementation of the consortium research program on the humid tropics and is participating in climate change and food security; water land and ecosystems; agriculture nutrition and health; and policies, institutions and markets. Transgenic research activities for the institute cut across the three commodity based programs. While there is no indication as to how the consortium programs would be involved in transgenic research, the policies, institutions and markets, as well as nutrition and health program have potential to participate.

At its headquarters at Ibadan in Nigeria, IITA has biotechnology laboratories including molecular laboratories, tissue culture and sequencing but has no biosafety level II facilities. The institute is rehabilitating and expanding these laboratories and biosafety level II facilities in preparation for a Biotechnology Platform for West Africa. Currently, all IITA transgenic research is based at the BecA-ILRI Hub in Nairobi where there are facilities and equipment for sequencing, genotyping, and transformation as well as biosafety. IITA is conducting most of the confined field trials in Uganda with the National Agricultural Research Organisation (NARO).

IITA operates under four hubs: western, central, eastern and southern with a regional/hub office. The regional offices are based in Nigeria, Democratic Republic of Congo, Tanzania and Zambia.

The institute is implementing the following six research projects on transgenic products:

1. Developing transgenic banana with resistance against Xanthomonas wilt, in collaboration with National Agricultural Research Laboratories of NARO–Uganda, KALRO–Kenya and AATF, which is at multi-locational trials stage;
2. Control of bacterial wilt disease in enset in collaboration with the Ethiopian Institute for Agricultural Research (EIAR), which is at proof of concept stage;
3. Genetic transformation and regeneration of yam in collaboration with University of Leeds, at proof of concept stage;
4. Fast breeding for slow crops: doubled haploids in cassava and banana in collaboration with University of California Davis and CIAT, also at proof of concept stage;
5. Evaluation of transgenic plantain for nematode resistance under field conditions in collaboration with University of Leeds and NARO–Uganda which is at confined field trials; and
6. Control of Cassava brown streak through transgenesis; in collaboration with Dantforth Plant Science Centre in USA, KALRO–Kenya and National Agricultural Crops Research Institute of NARO–Uganda, which is at confined field trials stage.

The gene constructs being used in banana and enset transgenic project have been developed by IITA itself using genes sourced from Academia Sinica Taiwan. The freedom to operate for these genes in African countries has already been acquired through AATF. In other transgenic research projects that IITA is working with, the gene constructs are from public advanced international organizations, hence expected to have minimal complication with intellectual property rights. The work on transgenic banana resistance to Xanthomonas wilt is at an advanced stage and is expected to release varieties for use by farmers by 2020, while the others are at the stage of confined field trials, development of gene constructs or transformation, hence will take a long time to declare a product.

Transgenic research project being implemented by IITA are quite well funded by Bill and Melinda Gates Foundation and the USAID but some require more funding to be taken to a logical conclusion.

IITA follows the biosafety policy of ILRI for its transgenic research at BecA-ILRI Hub in Kenya and policy at NARO for Uganda.

CIP

The International Potato Center (CIP, headquartered in Lima in Peru) seeks to achieve food security, wellbeing, and gender equity for poor people in root and tuber farming and food systems in the developing world. Its current research and development activities focus on potato, sweetpotato, and Andean root and tuber crops.

Africa produces 5% of potatoes (often referred to as Irish potato in Africa) and 9.7% sweetpotatoes of global production. Production of potatoes in Africa has increased for the last 20 years from 8.6 million tonnes to 29.2 million tonnes in 2012, implying that consumption is increasing tremendously and the role of potatoes for food security is becoming more significant. The main reason for this increase is expansion, better seed system and disease control, hence significant contribution from potato research.

With regard to sweetpotato, production in Africa has increased in the last 20 years from 6.5 million tonnes in 1992 to 18 million tonnes in 2012, which is nearly threefold. This also implies that there has been significant increase in the consumption, hence greater role of sweetpotatoes in food security. Such an increase can be attributed not only to expansion in area planted but also in greater usage of more productive varieties and disease management, hence as a result of research outputs.

CIP has organized its research activities under six strategic objectives, viz (i) Combating micro-nutrient deficiency with resilient nutritious potatoes, (ii) Enhancing food security in Asia through intensification of local cereals based system and adoption of early maturing agile potato; (iii) Improving livelihood of potato farmers in Africa through improved seed quality; (iv) Accelerating the discovery of game changing solution to food security; (v) Addressing food security through roots and tubers ; and (vi) Conserving diversity for the future.[9] Transgenic research in CIP is therefore anchored in strategic objective four. The centre is leading in the implementation of the consortium research program on roots, tubers and bananas.

CIP's regional programs include: Latin America and the Caribbean, with its offices in Quito–Ecuador; sub Saharan Africa with offices in Nairobi, Kenya; Asia with an office based in Delhi–India; East and South East Asia and Pacific office in Limbang—Indonesia; and South, and West and central Asia office in Delhi, India. The centre has liaison offices in another 15 countries 8 of which are in Africa where it is implementing various research activities in collaboration with the national agricultural research systems and partners.

Transgenic research projects currently being implemented by the centre are: i) weevil resistant sweetpotato in collaboration with the National Agriculture Research Organization (NARO) and Jomo Kenyatta University in Uganda and Kenya respectively; ii) virus disease resistant sweetpotato in collaboration with the Donald Danforth Plant Science Center and NARO in Uganda which is already at the confined field trial stage and; ii) potato late bight resistant, in collaboration with Cornell and Wageningen universities which is also at controlled field trials stage with NARO in Uganda (see annex I).

The gene constructs being used in these research projects have been developed by CIP itself using elements sourced from public institutions with no restrictions in use for research purposes. In some of these, freedom to operate in African countries has already been confirmed through rigorous IPR review. Others are waiting for proof-of-concept but CIP intends to release its technology free of restrictions for use by resource-poor farmers in African countries.

Funding for the weevil resistant sweetpotato and late blight resistance potato projects is adequate for reaching the proof-of-concept stages according to the principle investigator; however, funding continuity is a major concern and occupies efforts of PI to secure more long term funding (see annex II). Unlike these two GM projects, the virus disease resistant sweetpotato project is currently not funded.

CIP has its own Institutional Biosafety Committee and internal procedures for handling responsibly GM products. In Africa, its transgenic research is conducted mainly at NARO and BecA-ILRI Hub in Uganda and Kenya respectively following the NARO and the ILRI biosafety guidelines.

ICRISAT

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) with its headquarters in Hyderabad-India has geographic mandate for Asia and Africa for chickpea, pigeon pea, groundnut, pearl millet, sorghums and small millets. The mandate crops are mainly grown in the semi-arid tropics, and are often referred to as orphan crops because they are not taken up by private companies for commercial seed production. Africa produces 6% of chickpea, 16% of pigeon pea, 26% of groundnut 40% of sorghum and 54% of millet global production[7]. The climatic condition in Africa is quite suitable for these crops because of the vast tropical environment. These crops are therefore very important for Africa not only for food security but also for export.

A large proportion of rural poor are found in the Semi-Arid Tropics, hence these crops can be said to be crops of the poor. Furthermore, food security is a more serious problem in the semi-arid tropics, due to the harshness of climate, hence a special niche of these crops for food security.

9. CIP (2014), 'CIP Strategy and Cooperate Plan; Research Innovations and Impact', CIP, Lima, Peru.

ICRISAT has organized its research activities into four strategic thrusts, namely: (i) Resilient dry land systems; (ii) Markets, Institutions and Policies; (iii) Grain Legumes; and (iv) Dry-land Cereals.[10] Transgenic research cuts across the mandate crops. Within each of these strategic thrusts, ICRISAT identifies, the need for enhancing genomic and genetic tools and information systems for all its mandate crops as well as incorporating novel, enhanced or high value traits through use of transgenic biotechnology approaches.

ICRISAT has taken a holistic approach to biotechnology research ranging from genomics through to gene discovery, transgenic research and commercialization at the Translational level. The institute has a state of the art centre of excellence in genomics that has the most modern facilities for genome sequencing, marker resourcing, and genotyping platforms. Genome sequencing is being carried out for pigeonpea (72.7%), chickpea (73.8%), sorghum (94.5%), peal millet and groundnuts. Genomic work is carried out for specific maker assisted breeding, and gene or trait mapping for particular constraints. Genetic engineering activities are carried out specifically for developing transgenic products for its mandate crops for high priority traits that cannot be addressed by conventional breeding and/or other biotechnology tools.

ICRISAT in collaboration with the Department of Biotechnology of the Government of India has developed a unique 'Platform for Translational Research on Transgenic Crops' (PTTC) to facilitate the translation of transgenic proof-of-concepts from its own research or those from its NARS partners into products that can be commercialized after the field trials and food and biosafety studies. The infrastructure comprises of high throughput transformation facility, molecular biology laboratories, analytical laboratories, biosafety greenhouses and screen houses, and fields for carrying out confined field trials.

ICRISAT recognizes that it would take 10 to 12 years from gene discovery to release of a transgenic product depending on the regulatory status of a host country. Genetic engineering could take 1 to 2 years; event selection in biosafety greenhouses 2 to 3 years, event selection in the field 2 to 4 years, preparation of biosafety dossier and following on regulatory process 2 to 4 years, and release process 3 to 6 years. Translational activities start from event selection in the field all the way to release of the transgenic product. It is therefore, imperative that only long term investment in the whole continuum of basic research to product development would achieve results that can be taken to the farm level.

The institute also has well laid out Learning Systems Unit (LSU) to take care of training and skill development program. The capacity building activities in biotechnology include training workshops, short and long-term internships, Master's and Ph.D. level research and training for genomics, genetic engineering, and translational research activities in the PTTC.

Currently, the following transgenic research activities are being carried out at ICRISAT:

1 Development of drought tolerant, nutrient dense and low afflatoxin transgenic varieties of groundnut.

2 Development of chickpea and pigeon pea with high levels of resistance to *Helicoverpa armigera* or the legume pod borer.

3 Development of varieties and hybrid parents of sorghum with improved resistance to stem borer.

4 Development of drought tolerant chickpea.

5 Functional validation of candidate genes towards trait development for its mandate crops.

ICRISAT has well-organized strategy for partnerships and fund raising for not only transgenic research activities but also all research programs in the centre. Transgenic research activities in the centre are funded by national governments, philanthropic donors, and bilateral donors. The projects are, therefore somewhat well-funded. Several transgenic product development initiatives are being undertaken under public–public and public–private research partnerships through consortia approach. Proper product deployment and stewardship strategies in partnership

10. ICRISAT (2013), 'ICRISAT annual report 2012', ICRISAT, Pantancheru, India.

with the NARS and private sector have high chances of success and sustainability. Sustained funding for product translational activities are essential to ensure that the products of transgenic research actually reach the farmers.

ICRISAT has biosafety policy and procedures which were approved by its Governing Board in 2009. The policy establishes an ICRISAT biosafety oversight committee, with the Director General as chair and directors of programs as members. There is also an Institutional Biosafety Committee (IBSC) as mandated by the host country India, comprising of technical staff representing relevant disciplines of ICRISAT and representation of local experts and nominee of the Government of India.

IRRI and Africa Rice

International Rice Research Institute, headquartered in Philippines, and Africa Rice currently headquartered in Cotonou–Benin have the global mandate on rice only. Africa produces 26.8 million tonnes of rice which is only 3.7% of the 720 million tonnes global rice production. Rice is a staple crop in many African countries and is expanding in production and consumption rapidly. The production has almost doubled in the last 20 years from 14 million tonnes in 1992 to 26.8 million tonnes in 2012, but Africa remains a net importer of rice. Africa imported an average of 5.1 million tonnes of rice per annum worth approximately USD 1.3 billion between 2001 and 2003.[11] By 2009 this volume to 15 million tonnes, which is three fold of the volume in 2003, valued at USD 5 billion by 2009.[12] It is estimated that rice production in Africa will be about 47 million tonnes by 2020 but the consumption could be well over 60 million tonnes. The role of rice in food and nutrition security in Africa is therefore expanding rapidly.

IRRI has organized its research programs into: (i) Genetic Resources; (ii), Varietal Improvement; (iii) Sustainable Production Systems; (iv) Value Addition; (v) Targeting and Policy; and (vi) Rice Sector Development.[13] IRRI also leads the global rice science partnerships program with participation of Africa Rice Center, IITA, and CIAT. In Africa Rice research programs are organized into: (i) genetic diversity and improvement; (ii), sustainable productivity enhancement, (iii) policy, innovations systems and impact assessment and; (iv) rice sector development.

IRRI has offices in 14 countries of which three—Burundi, Mozambique and Tanzania—are in Africa. The institute has a regional coordination office for eastern and southern Africa based in Burundi and works in close collaboration with the Africa Rice Center. Africa Rice was constituted as West African Rice Development Association (WARDA) by 11 countries but now has membership of 25 countries in Africa. The centre claims to have the mandate for rice research in Africa and seeks to enlist All Africa governments as members. As a quasigovernment organization, decision-making and implementation processes have some relics of government bureaucracy, hence taking time and political considerations. In addition to its headquarters in Benin, the centre has offices in Senegal, Nigeria, Tanzania and Cote d'Ivoire.

IRRI and Africa Rice, together with CIAT are the main implementers of the Global Rice Science Partnership (GRiSP), with each centre assigned Asia, Africa and Latin America respectively. It is therefore implied that research results and technology from IRRI would be taken up by Africa Rice and be directly available in the 25 African countries. *However with each of them having offices in different countries in Africa, especially in eastern and southern Africa is the risk of competition and duplication of efforts.* It has been established that while there is good will and a level of understanding at management level, there is no coordination or sharing of services among the scientists at regional level, due to differences in the way the two institutions operate, with one being an autonomous international organization and the other being a quasigovernment body.

IRRI's transgenic research falls within varietal improvement research program but the products would move through all the other four programs at different stages. Transgenic research for Africa Rice would fall within the program on genetic improvement but currently the centre does not have any transgenic research activity.

11. FARA (2009), 'Patterns of Change in Rice Production in India: Implications for Rice Policy Development', FARA, Accra–Ghana.
12. Africa Rice Center (Africa Rice) (2011), 'Boosting Africa's Rice Sector: A research for Development Strategy 2011', Cotonou, Benin.
13. IRRI (2014), Annual Report 2014, IRRI, Manila.

IRRI has the requisite physical infrastructure for throughput biotechnology and consequently transgenic research. The genomics laboratories and bioinformatics platforms are well equipped with modern sequencers, analytical equipment and servers for upstream genomics research. Already, 3000 rice accessions have been sequenced and are being analysed for various uses in genetic improvement including gene discovery for transgenic research. There are several molecular and transformation laboratories, of which some are allocated for transgenic research on need basis. There are also several greenhouses of which some are allocated for transgenic research at various levels on need basis.

IRRI has the requisite manpower to carry out the ongoing transgenic research activities as well as assist the countries and particularly Africa as the need may arise. The institute has allocated 9 geneticists and 33 molecular biologists, for transgenic research as shown in Table 2 and is capable of deploying additional staff on demand.

Currently IRRI is implementing the following five transgenic research activities:

1 Pro-Vitamin A rice for Philippines, Indonesia and Bangladesh,

2 Reduction of Iron deficiency under the Harvest Plus,

3 Investigations for candidate genes for drought tolerance,

4 Investigations for candidate genes for disease tolerance,

5 Investigations for candidate genes for phosphorous uptake.

The golden rice for Asia project which was started way back in 1999 was probably the pioneer transgenic research activity in the institute. The transformation involves two genes, the *Phytoene synthase* (*Psy)* gene from maize and *Phytoene desaturase* (*crtI)* gene from a common soil bacterium, from Syngenta Foundation. After several years of experimentations and nutrition level trials the initial events did not confer adequate vitamin A into the rice to meet the World Health Organization (WHO) and the national biosafety authority threshold. A second round of events has been tried and it has been confirmed that they confer adequate vitamin A to meet the threshold of both WHO and the National Biosafety Authorities. Currently, the events are in multilocational field trials, in Philippines and in confined field trials in Indonesia.

The iron rich rice (iron clad rice) project, aims at enhancing the iron content of rice by transforming the rice varieties with *ferritin gene* from soybean which codes for iron storage, and another gene from another rice variety to transport iron from the leaves to the grain. This project is at the controlled field trials stage with very promising results. Transgenic research work on developing drought resistance rice is also at an advanced stage, with several events being tried in confined field trials.

The investigations for candidates genes for drought tolerance, disease tolerance and phosphorous uptake in rice are at a proof of concept state while the more ambitious research to develop a more efficient plant by transforming rice from a C3 to a C4 (turbo charged rice) plants so as to enhance the photosynthetic process, is at the proof of concept stage.

In addition to transgenic research activities, IRRI has a comprehensive training and skills development component along every research activity. This training involves practical and attachments for postgraduate students from the NARS and regular training course at IRRI headquarters. This arrangement is not only well taken by the NARS but also critical for capacity building and sustainability of research activities in all whole research and development continuum, hence a good model.

Like ICRISAT, IRRI has a well-organized strategy for partnerships and fund raising in all its research activities, including transgenic research. Research activities in the centre are funded by philanthropic donors, bilateral donors, and by private sector. The national governments and the private sector are well involved with all transgenic research activities right from inception and have a binding agreement to take the responsibility for product deployment and stewardship. The centre is therefore somewhat well-funded for the requisite basic (upstream) transgenic research work, while the deployment and stewardship will be taken up by the seed companies and the government.

All the centres are dealing with first generation set of transgenic traits, i.e. disease, virus, and herbicide resistance. A few centres have started to deal with the second generation productivity traits, i.e. drought resistance, nutrient efficiency and increased yield and others have also started on consumer targeting traits, i.e. bio-fortification. However, new areas such as medicinal, biofuel, animal feed, and industrial process have not yet been touched probably because these traits have little to do with food security, which is the broad mandate of the CGIAR.

2.2 Research assets capacity

Crop based research centres

All crop based centres have the requisite, and in some cases excess physical infrastructure for the whole range of biotechnology research at their headquarters as shown in Table 1. IITA is reviving its bioscience centre facilities at the headquarters in Ibadan by rehabilitating and equipping the laboratories. CIP uses its applied biotechnology laboratory in Peru in conjunction with the BecA–ILRI hub and the facilities they have assisted to establish in NARS. ICRISAT has a modern centre of excellence in genomics, and a recently established Platform for Translational Research on Transgenic Crops (PTTC). IRRI also has state of the art equipment for genetic engineering, genomics and transformation laboratories and several green house and biosafety screen houses. It is therefore confirmed that the centres have adequate physical infrastructure for transgenic research now and into the near future.

Table 1. Physical capacity for transgenic research in the participating CGIAR centres

	Laboratories				BF (levels)			Remarks
Centre	Mol.	Seq.	TF	BIP	1	2	3–4	
ILRI	3	2	1	1	1	1	1	With labs in Nairobi, Ethiopia and Beijing
CIMMYT	5	?	2	0	4	4	0	Includes labs in NARS and Mexico
CIP	yes	0	yes	0	Yes	yes	0	Uses also NARS and BecA-ILRI Hub facilities
ICRISAT	3	3	1	1	1	1	0	A dedicated facility for transgenic research
IITA	2	1	0	0	2	2	0	Uses BecA-ILRI Hub facilities
IRRI	2	1	2	1	1	2	4	
Africa Rice	1	0	0	0	1	1	0	Biosafety greenhouse level II not in use

Note: Mol. = Molecular, TF = Transformation, BF = Biosafety Facility; BIP = Bio-informatics platform.

All the centres have well equipped molecular laboratories, transformation laboratories, sequencers, and bio-informatics platforms as shown in Table 1. IITA is re-equipping its genomics laboratories, with sequencers and analytical equipment and setting up a bioinformatics platform. ICRISAT and IRRI have the most modern state of the art sequencers, servers, and other equipment required for the whole continuum of genomics and transgenic research. CIP and IITA are using the BecA hub facilities at the ILRI campus for their transgenic research activities.

CIMMYT has recently built a state of the art biotechnology centre with financial support from a philanthropic donor that is expected to be fully operational soon. Currently CIMMYT does not have well established on the bench genetic engineering research activities in Africa and it is outsourcing this analysis from partners as when required in its transgenic research activities.

Scientists indicated that it may be cheaper to outsource some of the laboratory analysis such as sequencing and genetic mapping than to carry out themselves in-house. It may be necessary to examine the logic of outsourcing these services in the context of accessibility of data and information.

All the centres together have an immense human capacity for biotechnology and there is a large number involved in transgenic research as shown in Table 2. All the centres put together have over 196 crop geneticists and about 144 crop molecular biologists. Some centres did not provide all the data for geneticists but this is a large number of highly qualified staff by any means. It is therefore confirmed that centres have the human capacity to carry out the whole range of transgenic research and also to assist the NARS in training and building the requisite capacity.

Table 2. Human capacity for transgenic research in the participating CGIAR centres

	Crop geneticists				Plant molecular biologist				Animal geneticists				Animal molecular biologists			
	Total		Transgenic		Total		Transgenic		Total		Transgenic		Total		Transgenic	
Centre	MSc/ BSc	PhD	MSc/ BSc	PhD	MSc/ BSc	PhD	MSc/ BSc	PhD	MSc/ BSc	PhD	MSc/ BSc	PhD	MSc/ BSc	PhD	MSc/ BSc	PhD
ILRI	0	0	0	0	0	0	0	0	10	10	0	0	10	20	1	2
CIMMYT	70	47	5	2	10	12	3	1	0	0	0	0	0	0	0	0
CIP*					6	3	6	1								
ICRISAT			0	0	30	12	16	6	0	0	0	0	0	0	0	0
IITA	11	17	0	0	15	5	15	5	0	0	0	0	0	0	0	0
IRRI	40	21.5	6	3	40	23.5	20	13	0	0	0	0	0	0	0	0
Africa Rice	5	6	0	0	4	4	0	0	0	0	0	0	0	0	0	0
Total		126	91.5	11	5	106	59.5	60	26	10	10	0	0	10	10	2
Grand total (BSc, MSc, PhD)			196.5					144.5				20				10

* CIP argues that due to the nature of the crops it deals with, it does not require crop geneticists,

In total, the five crop based centres have dedicated a total of 16 fte full-time equivalent) geneticist and 86 fte molecular biologist for research that may lead to transgenic products as shown in Table 2. This implies that most of the breeding work for transgenic research is done by the national scientist while transformation and event selection work is done by the international scientists. Some centre's such as CIP and CIMMYT may need additional molecular scientists as they expand their research portfolio and also to avoid the risk of keeping them too occupied with management issues rather than scientific strategic thinking.

With such a human capacity, most centres have the capability to carry out the requisite research in genomics of their mandate crops. The centres can carry out upstream research at any level if the scientists have the incentives and support of the management and development partners to do so. Most of the centres have started some work on the genomics of their mandate crop. Currently only IITA, IRRI and ICRISAT are doing some work on functional genomics and gene discovery, but it is too early to indicate the potential for some gene constructs. They are using gene constructs either from advanced international organizations or the private multinational companies.

The fact that centres are working on insect resistance, disease resistance, drought resistance, nutrient efficiency and nutrition enhancing traits is an indication that the traits being introduced are for both food security and nutrition improvement. For some traits such as some weevil, virus, fungi, and nematode resistance; there are indications that introgression of such traits have been tried for a long time in the past through conventional breeding and without much success. In others such as the nutrient efficiency and drought resistance, conventional breeding has achieved some results but limited.

Based on policymakers interviews, one of the most controversial issues in transgenic research is the intellectual property rights relating to the source of the gene construct. African countries argue that the source of the gene constructs is a business tool with the motive of domination by the multinational private companies through the application of intellectual property rights and the sale of seed. To circumvent this concern, it is desirable that the gene construct the centres are using are free from restrictions resulting from intellectual property rights or are from public institutions who will not seek to commercialize the varieties that result from their research work. However, the centres have long acknowledged that IPR are part of any technology development and have therefore established institutional capacities to address this concern. Some of the centres such as CIMMYT are working with gene constructs only from the private companies, others such as IITA and ICRISAT are working with own gene constructs or those from the public and private sector while others such as CIP are working with their own gene constructs only.

It should be observed that the private sector will not work on products that cannot be commercialized while public institutions can work on products that can be commercialized as well as for food security only. By working only with gene constructs from large private sector companies, the centres run the risk of being perceived to be serving the interest of the companies which may not be compatible with the interest of the poor people. It is therefore advisable that centre work with their own gene constructs or those from public institutions. Noteworthy, other types of restrictions are anticipated since some biosafety legislations in Africa have already included mandatory labelling of food derived from GM crops.

While most of the centres are working with the national research system partners, there are no deliberate efforts for training and capacity building for national research scientists. Much of the training is ad-hoc and meant to deliver the specific product and not based on strategic capacity needs for the national partners. It may not be possible at this stage for any centre on its own to carry out training and skills development that is required for the NARS. In view of the fact that transgenic research is relatively new and cutting edge science; and dire needs of the NARS, it is desirable that CGIAR centres factor training and scales development in their research projects.

It was not possible to accurately establish the total investment of centres on transgenic research activities because the budget and expenditure items are not captured and disaggregated on activity basis in some cases. However, based on project documents it is estimated that the centres have committed approximately USD 19 million for the ongoing transgenic research activities but would require USD 63.7 million to take the research activities to conclusion as shown in Annex II. This does not include the investment in the physical infrastructure and not all the cost of staff time. There is therefore a high risk of some of the activities being terminated midstream due to lack of funding despite the heavy investments that may have been incurred already.

All the funding for transgenic research in the five centres is either from window 2 or window 3 funding sources and there is nothing from window 1. In fact most of the funding is from one bilateral donor and two philanthropic organizations. This implies that either the consortium or the fund council of the CGIAR does not hold transgenic research to be of high priority.

Different scenarios emerge on centre by centre basis. For example, there is very little funding going for transgenic research for food security crops such as potatoes, banana, cassava, and peas whose seed production system cannot be commercialized. There is significant funding going into transgenic research for crops such as maize, and rice which are also for food security and the seed system can be commercialized. These funds are from philanthropic organizations, private sector or USAID. Although the crops they are dealing with are mainly maize, wheat and rice, there are perceptions that this research may be driven more by commercial interest than food security. Such a perception does not auger well for CGIAR centres which are perceived to have been established with international public resources and still running with a large proportion of public resources.

It is also emerging that the private sector partners in all the transgenic research projects are American companies and some American universities. There are indications that some countries in the East, in particular, India, China and Japan are harnessing the tools of transgenic research very fast.

Livestock based research centre

ILRI has the unique situation of being the only centre of the CGIAR with global mandate of livestock research and having it's headquarter in Nairobi–Kenya and another large campus, in Addis Ababa–Ethiopia. The demand and expectations on the centre by the national research system and governments in Africa for services such as simple quality semen to complex feed supply and livestock disease control can be a major challenge. As the only public International centre, ILRI is expected to be held accountable to the overall performance of the livestock sector more so in Africa where its headquarters is situated. It is therefore imperative that the centre positions itself to respond to expectations and face the challenges of the performance of the livestock sector in Africa.

ILRI hosts the BecA-ILRI Hub which has been hailed as one of the most advanced bioscience research facilities in Africa. However, the centre is conducting only one activity of transgenic research to develop disease resistant cattle for Africa (see :https://www.youtube.com/watch?v=3NIxLJY3Ios). The project was developed as an activity of African Bovine trypanosomiasis research consortium of several research institutions including: University of Liverpool, ILRI, University of Manchester, Roslin Institute and University of New York. The gene constructs have been derived from the structure of the APOL1 gene in baboon which has been confirmed to confer resistance to all strains of trypanosomiasis.

Trypanosomiasis—the disease transmitted by tsetse fly, is the most devastating disease that affects vast tracts of land in the humid and subhumid in sub-Saharan Africa. There is no vaccine for the disease and the treatment drugs that are available are no longer effective. The disease makes livestock development in these areas which have ample livestock feed virtually impossible. With increasing demand of livestock and livestock products, it is imperative that livestock farming is developed in these areas, by developing cattle that is resistant to trypanosomiasis. As the project that is applying the contemporary tools of biotechnology, the project has not only the potential to have a major impact on livestock development but also to place ILRI at a respectable position in cutting edge research.

Currently there are hardly any policymakers or research scientists, except in Kenya, in the countries involved in this study who are aware that there is transgenic research activities at ILRI. Most of the NARS managers and policymakers in these countries, except in Nigeria and Kenya were not sure that such research would be useful to them. In any case most policymakers were of the view that transgenic products in animals may have some ethical implications.

ILRI has over 20 fte animal geneticists of whom 10 fte have PhDs and 10 fte have master's degrees. There is none of these scientists involved with transgenic research activities because at this stage animal geneticists are not required in the ongoing activity. There are over 40 fte animal molecular scientists, 20 of whom have masters and 20 PhD degrees. With such a capacity, ILRI can play an important role to assist in the much needed training and skills development capacity building in livestock transgenic research in Africa.

Despite the large number of scientists, only one fte with masters degrees and 2 fte with PhD degree are working on the transgenic research activity that is ongoing at the centre. Furthermore the only transgenic research activity at ILRI has a budget with very little funding (see Annex V). Assuming that human and financial allocation is an indication of priority and importance of research in a centre, the low budget and few scientists involved in transgenic research at ILRI implies that this is viewed as of low priority. This is an unfortunate situation, bearing the fact that ILRI is the only livestock research centre of the CGIAR, one of four based in Africa, and the only one capable of generating intellectual assets of public good.

Several reasons have been given for such a low investment in transgenic livestock research in the institute. Firstly scientists argue that most priority livestock production and improvement constraints can be addressed using other methods and tools of research, hence it may not be necessary to get into expensive transgenic research. Secondly, due to controversies of genetically modified organisms and ethical issues, not many donors are keen to support transgenic research in livestock. Thirdly, it may be more prudent for such research to be undertaken by private sector institutions than public funded institutions.

2.3 SWOT analysis

An analysis of strengths, weaknesses, opportunities and threats, is a strategic planning process to identify points of intervention at both institutional and implementation level. While it is recommended that such an analysis is done in a workshop mode with participation of the client, the analysis in this case is based on the interaction with the stakeholders during the study visits and the experience of the author of this report. A detailed matrix of SWOT analysis for all centres is shown in Annex III.

Strengths

Location of headquarters and regional offices: The location of the ILRI, IITA, and Africa Rice headquarters being in Africa is one of the most important strategic strengths; the centres can easily mobilize their high level management team for interaction with policymakers in governments and managers in the National Agricultural Research System. However, ILRI has not yet taken advantage of this strength and its recognition and appreciation by policymakers and NARS in all countries visited was minimal. Government in these countries expressed little awareness of the work of ILRI but they were eager to facilitate strong linkages with NARS. Policymakers and national research system managers are not aware that ILRI is carrying out any transgenic research activity. Understandably, both the research systems and the policymakers are aware of BecA but they are not conversant of the relationship between ILRI and BecA.

Africa Rice has also not been able to utilize its advantage of being headquartered in Africa because of the insecurity in Cote d'Ivoire and having to keep on shifting its headquarters from country to country. In addition, as a quasigovernment organization there are relics of government bureaucracy and sluggishness in decision-making, hence reducing the operational efficiency of the centre.

IITA is relatively well recognized by the NARS in most countries visited, and by policymakers in some of the countries. There appears to be strong partnerships with NARS in West and central Africa although there is not much transgenic research activities going on in these countries. The institute is now making inroads in eastern and southern African and has signed Memorandum of Understanding (MoU) with some NARS in these countries. However there is need for these partnerships to be taken to government level.

The presence of regional offices in Africa is also an instrument to enhance interaction with regional organizations, NARS and policymakers. All the centres except IRRI have strong presence in Africa but most of them do not have binding partnership with the National Agricultural Research System. It is for this reason that in most countries, transgenic research is viewed as the work of multinational and private sector. Good partnership with NARS is critical for transgenic research so that they can be responsible for any policy interventions and deployment of the products.

The reason for IRRI being weak in Africa is that it was assumed that Africa Rice would cover Africa, although this is not the case. Recently, IRRI has started to beef up its activities in Africa and has opened a regional office in Burundi. The office has enhanced the activities of IRRI in the region and has great potential for the future.

ICRISAT and CIMMYT in particular have very large and strong regional offices, and CIP is expanding its portfolio in Africa. There is however a need to enhance interactions with government official and policymakers at the high level.

Physical and human capacity: The physical and human capacity is probably the most important strength of all the centres. As indicated earlier all centres, except Africa Rice have the required number of competent scientists to carry out the ongoing activities and take on a lot more as and when necessary. Scientists in the centres may not be as pro-active as they should be in coming up with new research projects due to fear that their GM products might not be adopted due to the prevailing uncertainty in biosafety regulation in the target countries. Currently ICRISAT does not have a transgenic trait development laboratory in Africa since the products are under development at its headquarters in India. The centre has however initiated capacity training and capacity building for Asian and African researchers in preparation for deployment of the products that will show good signs of success in Africa.

Donor support: All the transgenic research activities are financed as direct grants by donors, mainly, Bill and Melinda Gates Foundation, and the United States of America. It may therefore be said that the centres have a relatively good support from donors despite the debate and the anti-GMO lobby by many NGOs.

Weaknesses

Communication: All centres are weak in advocacy, communication and public relations in Africa. None of the centres have a strategic approach to these issues targeting African leadership, policymakers, and the legislature. For a contentious subject such as transgenic research, a strategic approach on communication and public relations is imperative. The centres are not as active as they should be in regional communication and capacity building initiative such as Agricultural Biotechnology Network of Experts (ABNE), bio-innovate programs.

Partnerships with NARS: Strong partnerships with NARS are essential for transgenic research so that they can take responsibility of the debate and the risks at the national level and absorb the international system. While there is good interaction among scientists at project level, most of the institutions do not have legal partnership arrangements that are binding and have monitoring mechanisms at institutional level with NARs. A few centres have signed memoranda of understanding with national institutions but some of these may not be up to the standards of binding partnerships, enforceable in law. Such memorandum of understand are not recognized by the governments or any other third party.

Interaction with policymakers: All centres have relatively low level interactions with policymakers and the legislature in Africa. In many countries the centres are considered as part and parcel of the multinational private sector organizations and in other cases they are taken as ivory tower institutions. This perception has the risk of centre products being held in suspicion or dragged into international business competition and politics.

Opportunities

Potential for increasing productivity and nutritional value: As the last frontier of agricultural expansion and intensification, Africa has immense opportunity for increasing agricultural productivity in sustainable and climate smart manner. While there is still a large yield gap between genetic potential and productivity at farm level, following the old model of the green revolution, may not be the way in view of the climate change and changes in many socio-economic facts. Transgenic technology has potential to increase agricultural productivity by not only enhancing, but also protecting the genetic potential by reducing losses due to weeds, diseases, and pests; and enhance nutritional value of diets and foods.

Chronic and endemic production constraints: There are several constraints in small holder farming in Africa that have become chronic and are so endemic that they are a serious threat not only to food security but also to the whole household livelihoods. Some of these constraints such as insect resistance, diseases resistance, nutrient use efficiency, and nutrition fortification can only be conferred into crops and animals using transgenesis. The transgenic products, would not only increase productivity but also, in some cases, would require less labour, less chemicals, less emission and more sustainably.

Potential for private sector participation: Although farming in Africa is predominantly smallholder low input production systems, most of the countries are now forging to move away from subsistence to commercialization and farming as a business. There is therefore greater potential for private sector to participate not only in production but also in all types of agribusiness. This is an opportunity that transgenic research should take to work with private sector throughout the value chain.

Climate friendly technology: It is now evident that climate change will bring about new challenges of diseases and pests that cannot be resolved with conventional research tools. Such phenomena also provide the opportunity for research to apply the tools of transgenesis to address these constraints.

Threats

Lack of information: The most serious threat to advancing transgenic research is lack of information that can be trusted on the advantages and disadvantages of transgenic research products. This lacuna is being exploited by the anti-GMO lobby groups to misinform farmers, the public and policymakers making it difficult for them to make decisions on whether to adapt or not to adapt transgenic products. The anti-GMO groups in Africa are exclusively, non-governmental organizations which claim to represent resource poor small-scale farmers and consumers and to be advocates of the environment and conservation, hence get a lot of attention from donors. The groups are well resourced and heighten their activities in countries where they find weakness in information flow and where there is potential for deployment of transgenic products. They are mainly financed by European donors and are violently against the seed multinational companies. Most policymakers in Africa believe that the debate on GMOs is a business competition of multinational companies in the North.

Intellectual property rights: Most of the gene constructs that the centres are dealing with are from the private sector or advanced international institutions. While there are enormous efforts by the centres and brokerage institutions such as AATF to ensure that IPR issues are resolved in advance, African governments and civil society will always be weary of the risk of poor farmers being exploited by rich multinational organizations. It is therefore imperative that centres take the responsibility of the intellectual property rights of the gene constructs they are dealing with.

Trade issues: Most countries argue that commercialization of transgenic products may affect trade of agricultural commodities with countries which have restrictive policies on GMO products. This concern is very important bearing in mind that most African countries depend on agricultural trade for their foreign exchange. While this may not be the domain of agricultural research, it is essential that research managers are able to answer such questions when they are raised by policymakers.

Restriction from donors: Most centres fear that donors who have zero tolerance on genetically modified organisms, may withdraw their support to organizations that are heavily involved in transgenic research that would lead to such products. While such a threat may not be real, such fear threatens the efforts and spirit of scientists to invest their time and resources developing concepts and proposal for transgenic research. Furthermore, the dependence on only a few donors poses a serious research in transgenic research and product development.

2.4 Recommendations

In consideration of the analysis and the findings in this section, we propose the following recommendations:

1. Centres involved in this study should support the establishment of a CGIAR Biotechnology Support and Planning Group proposed by the ISPC study. The group will address broad strategic issues; deal with issues of communication, public awareness, interaction with policymakers and legislature; provide oversight of biosafety and trade related issues; and the issues of sharing of the physical resources and information arising from genomics research. The group should include scientists based in Africa because of the potential for impact, level of the debate on GMO, and the need for human capacity in this region.
2. The participating centres should review and harmonize their biotechnology policies so that they have some legal backing, by jointly working with a legal firm to do the policy, which they can all adopt. This would give strength and greater confidence to transgenic research activities and wade off the fear of anti-GMO lobbyist.
3. The centres, through the biotechnology support and planning group, should actively engage with the donors, and the public to provide facts and empirical evidence in the GMO debate in a transparent and scientific manner on periodical basis.
4. ILRI should continue the research on developing disease resistance in cattle to a logical conclusion even if it will take some years. Such a program should not only serve to develop transgenic cattle that is resistant to trypanosomiasis but also a basis for training and capacity building of the NARS in Africa on livestock transgenic research.
5. ILRI should develop programs and projects to make greater use of BecA-ILRI Hub facilities for livestock genomics and transgenic research. The centre should have a more comprehensive genomics program to accumulate animal gene information through sequencing of various livestock species.

6 ILRI should develop projects to use biotechnology tools to search for disease resistance in small ruminants and poultry which are very important for food security and the livelihood of small-scale farmers.

7 Each centre should strengthen and/or maintain a critical mass of scientists in biotechnology research ranging from genomics, gene discovery and genetic engineering expertise to the application of transgenic procedures. The critical mass of scientists will depend on the number of commodities and research activities that the centre is implementing.

8 ICRISAT should prepare a framework and proposal for deployment of transgenic products of its mandate crops in Africa.

9 IRRI jointly with Africa Rice should also do proposal for deployment of the golden rice in Africa, because there is as much need for fortified rice in Africa as there is in Asia. This will not only contribute to food nutrition but also provide the much needed capacity for transgenic research in Africa. In this arrangement, IRRI should take up the responsibility of upstream research (genomics, identification of gene constructs, and transformation), because it already has the capacity and experience. Africa Rice can take the responsibility of testing the transgenic transformed lines in West Africa while the Regional Office of IRRI can take up the responsibility of testing the transformed lines in eastern and southern Africa.

10 Africa Rice and IRRI should get into a formal agreement for a joint biotechnology program. There is no need for Africa Rice to start setting up its own upstream biotechnology (genomics, proteomics, functional analysis, bio-informatics platforms, and transformation) capacity while there is already one in IRRI for the same crop.

11 Centres should not only ensure the gene constructs they are using are free of royalty but also work on a process of generating their own gene constructs, to contribute to the science and deflate the debate on intellectual property rights and to give confidence to the African governments.

12 Centres should work out modalities of legally binding partnership arrangements with the national agricultural research institutions particularly on transgenic research with parameters that can be monitored and measured; and implementation mechanisms to ensure that the products are released and commercialized.

3 Regional and subregional organizations

The main regional organizations involved in transgenic research in one way or another, encountered in this study, are: the Forum for Agricultural Research in African (FARA); New Partnership for Agricultural Development (NEPAD); and African Agricultural Technologies Foundation (AATF). The International Services on Acquisition and Application of Agri-biotechnologies (ISAAA) that is mainly involved in dissemination of information of the status of application of transgenic products has a very active regional office in Africa and the African Harvest (AH) also undertakes some transgenic research activities.

3.1 Organization profiles

FARA and subregional organizations

The Forum for Agricultural Research in Africa was created in 2001 as a successor of the Special Program for African Agricultural Research (SPAAR). It is an apex organization to bring together stakeholders in agricultural research and development for prioritization and advocacy of research for development in Africa. Its main purpose is to function as a platform for continental and global networking to strengthen the capacities of African agricultural science and innovations community for research. The key stakeholders of FARA are the four subregional organizations, namely:

1. The Association of Strengthening Agricultural Research in Eastern and Southern Africa (ASARECA)
2. North Africa Research Organization (NARO);
3. West and central Africa Council for Agricultural Research and Development (CORAF/WECARD); and
4. Centre for Coordination of Agricultural Research and Development for Southern Africa (CCARDESA).

FARA has been instrumental in baseline studies on the capacity for biotechnology research and currently it is working with the African Union Commission on Agriculture to be assigned the responsibility of the implementation of the science and innovations pillar. It is therefore well placed to play an important advocacy role on transgenic research at the high level across the continent.

The subregional bodies are associations of national agricultural research institutions, for coordination of intercountry research networks and programs, involving both international and national research systems. The forum and the associations, provide the central services, of advocacy, resources mobilization, coordination and management of the networks. Currently, FARA is receiving considerable funding from donors in the form of multidonor trust fund from the European Union and the World Bank. The subregional organizations are also receiving considerable funding in form of trust fund, hence an important stakeholder in transgenic research.

While the forum and the association do not have the physical infrastructure and the human capacity to undertake research, there is now a considerable size of donor financial resources flowing through them that could be tapped for partnership programs. The fact that they bring together the agricultural research fraternity gives them a link between the international research system and African governments. If well engaged in a structured manner they should play an important role to absorb the discourse, communication, and political debate and linkages with policymakers and the legislature in Africa.

With an exception of ASARECA which has indicated it is carrying out two activities on transgenic research, the other organizations are not involved in implementation of biotechnology and consequently transgenic research. As associations of member countries subregional organizations are not expected to carry out their own research but to coordinate and support the networks of the member institutes and CGIAR centres. However ASARECA has reported that it is supporting transgenic research activities on drought tolerant maize and sorghum.

NEPAD

The new Partnership for African Development was started in 2001 as the African Union's Strategic framework for pan-African socio-economic development to spearhead the vision and policy framework in the twenty first century. The organization was integrated into the African Union in 2010, when the secretariat was transformed into an implementing agency by the heads of states. Two of the themes of NEPAD that are relevant for transgenic research are agriculture and food security and climate change and natural resources management. While most of the activities of NEPAD are policy and development in nature two of its activities that are relevant for transgenic research are the African bioscience initiative and the African Biosafety Network of Experts.

The African Biosafety Network of experts has been instrumental in training and advocacy on transgenic products in many countries in Africa. Furthermore, as a NEPAD program the network can play an important role as a reference point on biosafety issues on transgenic products across the continent.

The bioscience initiative has been instrumental in the establishment of the Biosciences for eastern and central Africa (BecA), the Southern Africa Network on Biotechnology (SANBio), and the Northern African Biotechnology Network (NABnet). BecA which was conceptualized by ILRI was the start point of the other two networks and has been quite successful. The establishment of the other two networks has been slow but they are undertaking or spearheading a few biotechnology/transgenic research activities.

BecA-ILRI Hub

The BecA-ILRI Hub was established in 2002, jointly by ILRI and NEPAD, with financial resources from the government of Canada and ILRI, as a centre of excellence in biosciences to support eastern and central African countries. Its mandate is to develop and apply bioscience research and expertise to produce technologies for improving agricultural productivity and income as well as market opportunities of produce. It provides a focal point for the African scientific community to support the activities of national, regional, and international agencies as they address agriculturally related problems of the highest priority for alleviating poverty and promoting development. *BecA-ILRI Hub* consists of a *hub* located on the campus of the International Livestock Research Institute (ILRI) in Nairobi, Kenya, that provides a common biosciences research platform, research-related services and capacity building and training opportunities. It has a *network of regional nodes and other laboratories* distributed throughout eastern and central Africa for the conduct of research on priority issues affecting Africa's development.[14]

At inception, the founding objectives were two-fold: (i) to provide a *focal point* for the African scientific community to support the activities of national, regional and international entities addressing agriculture-related problems and promoting Africa's development using the modern tools of biotechnology; (ii) to create and strengthen *human resources* in biosciences and related disciplines in Africa, and promote scientific excellence by bringing together a *critical mass* of scientists drawn from national, regional and international institutions in modern facilities where they can undertake cutting edge research.

14. Bioscience eastern and central Africa (2005), 'Business Plan 2005–2009 – Executive Summary', BecA-ILRI Hub Secretariat, Nairobi, Kenya.

The whole idea was to increase *access to affordable, world-class research facilities* within Africa, and disseminate bioscience *information and knowledge* relevant to Africa's development. The facility would also serve to advice and train on *intellectual property*, *biosafety* and *other regulatory issues* and forge *partnerships* with other *biosciences laboratories* and with those entities responsible for *product development and delivery, within Africa and globally.*

The core competencies to be developed were:

- Bioinformatics, for genomic analysis into accessible forms diagnostics for accurate and quicker identification of pathogens using new diagnostics based on molecular characterization of the pathogens;
- Genomics research by using the available molecular information about all the genes in selected species, and functional genomics, proteomics, and metabolomics to convert the molecular information into an understanding of gene functions and effects as well as research on the protein function or the whole metabolism of an organism;
- Gene sequencing, and molecular breeding through marker-assisted selection Transformation and tissue culture for transgenic products;
- Vaccine technology to use modern immunology to develop recombinant DNA vaccines for improved control of animal and fish diseases; and
- Cultivation of ticks and tsetse flies, as aids for the study of vector-borne diseases that severely affect people and livestock in Africa.

Over the years, BecA-ILRI Hub has made remarkable achievements, as reflected in its business plan. The hub has developed to be a well-known centre of excellence in bioscience not only for eastern and central Africa but also for Africa as a whole. The facility has evolved from establishment (2002–2007); implementation, (2007–2012); and is now at innovations phase (2013–2018). It now comprises of a built up area of 4200 m^2 of genomics, molecular and transform laboratories, with state of the art equipment and bioinformatics platforms. It also has critical mass of biotechnology scientists including; crop geneticists (8); crop molecular scientists (11); animal geneticists (2) and animal molecular biologists (3), as core staff. The hub is a focal point for practical experience and laboratory services for many biotechnology programs of countries in Africa as well as international research centres.

Currently there are over 12 transgenic research activities going on at the facilities by scientists from various institutions from both the CGIAR and the NARS. In the last couple of years, about 200 scientists per year are using the services and facilities of the hub for training and to carry out various bioscience based laboratory analysis. However the capacity within the facility is not optimally utilized, as it has the capacity to train an average of 400 scientists in a year.

AATF

African Agricultural Technology Foundation, headquartered in Nairobi was founded in 2003 with support from the Rockefeller Foundation and the DFID as a not-for profit organization to facilitate and promote public/private partnerships for access and delivery of agricultural technologies in Africa. The foundation plays the role of brokering and mediating the acquisition of agricultural technologies, and in the case of transgenic products, the gene constructs to the national and international agricultural research systems. Currently AATF is involved in brokerage of gene constructs for transgenic research on cowpea, banana/plantain, maize, and cassava for research and testing in conjunction with CGIAR centres, NARS and private seed companies as shown in Annex IV.

In some of the cases such as the cowpea work, AATF works directly with the private sector which is the source of the gene constructs for testing with NARS, without the involvement of CGIAR centres. AATF also takes the role of advocacy and conveyance of small grants for research activities with NARS and the private sector.

Except for CIMMYT, the other CGIAR centres working on transgenic research in Africa do not have any formal engagement with AATF. It is however imperative that as the issues of intellectual property rights become more and complicated, centres will be find the need to engage more with AATF.

ISAAA and Africa Harvest

ISAAA is a not for profit international organization that shares the benefits of crop biotechnology with various stakeholders, particularly the resource poor farmers in developing countries, through knowledge sharing initiatives and transfer of and delivery of proprietary biotechnology applications. ISAAA has very active regional offices in Nairobi that is heavily involved in advocacy on the pros and cons of transgenic products in Africa. The ISAA Afri-centre provides real time information on research activities, products releases, and ongoing debate on the subject matters in Africa through participation in all country fora, and logistic support for various groups for interactions and study visits.

Africa Harvest was founded in 2001 as a not-for profit organization to carry out research and promote agricultural biotechnology in Africa. The organization is headquartered in Nairobi and is involved in coordination of transgenic research on bio-fortified sorghum, with confined field trials in Kenya, Burkina Faso and Nigeria which is funded by DuPont Pioneer.

Africa harvest has been a vocal proponent of transgenic research, and has a constituency of stakeholders in Africa. It also has the capacity to mobilize stakeholders for a specific purpose, hence could be a good partner for transgenic research with CGIAR centres.

3.2 Recommendations

1. It is recommended that the regional level activities on transgenic research dealing with advocacy, capacity building for biosafety, policy and development, and baseline studies should be coordinated by FARA for economies of scale and to avoid duplication of efforts.
2. It is recommended that centres, either individually or collectively, should get into formal arrangements with FARA and subregional organizations to be their agencies for upstream transgenic research and training and capacity building programs. It may be necessary for the centres to develop a training program at masters and PhD levels on biotechnology related subjects with local universities.
3. BecA-ILRI Hub and ICRISAT should work out mechanisms for joint activities to utilize the physical infrastructure and the human capacity of the two institutions to build capacity for African countries.
4. BecA-ILRI Hub should also be more pro-active in ‘marketing’ its services at the hub to the national, programs including the universities. It may be necessary for BecA-ILRI Hub to get into formal agreements with these institutions to provide practical attachments for their students and scientists.

4 Prognosis of donors

While much of the investment in transgenic research has been by the private sector, some investments have also been made by the public sector, in the form of budgetary allocation by national governments or development aid by multilateral, bilateral and philanthropic donors. The list of donors for transgenic research by the international and the national system could be long but we have included a few that are considered as the main ones and have agreed to participate in this study.

Currently, the main donors of transgenic research in Africa are the United States of America through the United States of Agency for International Development (USAID), the Bill and Melinda Gates Foundation (BMGF), the United Kingdom through the Department for International Development (DFID); and the European Union.

4.1 Bilateral donors

The main bilateral donors for transgenic research that have been encountered in this study are the USAID, the BMGF and the Department of Foreign international Development of the United Kingdom (UK)

While the initial approval of a transgenic product is very rigorous, the USA operates a deregulation policy that permits applications to request that a transgenic product is equivalent to the non-transgenic product. Such a product would then not be regulated or labelled. Most of the transgenic crop products in the USA market have achieved this status. Since 1990, there have been 96 approvals for deregulation comprising of alfalfa, canola, corn, cotton, flax, rose, papaya, plum, potato, rice, soybean, squash, sugarbeet, tobacco, and tomato.[15]

Those not already on the market, are likely to proceed to full commercial development in the near future. There are also 13 applications pending decision which represent the next group of GM crop varieties available in the market. These include alfalfa (1), non-browning apple (1), corn (1), cotton (1), creeping bent grass (1), cold tolerant eucalyptus (1), potato (1), and soybean (6). The most recently deregulated products are glyphosate tolerant canola, glyphosate tolerant corn and a novel F1 hybrid seed production system for corn.

With 168 events of crops approved, and 41% of the global area of transgenic crops, the United States of America is the biggest in terms of research and development as well as grower of transgenic products in the world. It is therefore not surprising that USAID is probably the biggest bilateral donor of biotechnology and consequently transgenic research in Africa.

USAID support to agricultural research is based on its Feed the Future Research Strategy 2011 which elaborates the process and the priorities areas that can be supported.[16] With regard to transgenic research, the windows of support include country lead and partnerships implementation strategies. It is within this strategic implementation process that support to CGIAR and support to research projects in partnership with American Institutions is captured.

15. David Baulcombe et al. (2014), 'GM Science Update: A Report to Council for Science and Technology,' London.
16. USAID (2011), 'Feed the Future: Global Food Security Research Strategy', USAID, Washington.

Currently the USAID is supporting 14 transgenic research activities in 23 countries mainly in Asia and Africa as shown in Annex V. In Africa, USAID is supporting about seven research activities in nine countries, to the tune of USD 15–20 million per year. All these activities are carried out in conjunction with the CGIAR centres involved in this study. The USA is an ardent proponent of transgenic research and product deployment, and it is anticipated that this level of support would continue into the future.

In the last ten years, BMGF has become a major donor, not only to transgenic research but also, to agricultural research and development particularly in Africa and Asia. To date BMGF has committed more than USD 2 billion to agricultural research and development in Africa and Asia.[17] This includes support to CGIAR of about USD 50 million per year through window 3.

With regard to transgenic research BMGF strategy focuses on optimizing nutrition outcomes from investment in Agriculture. Currently the foundation has committed nearly USD 100 million to develop and disseminate bio fortified rice, cassava, maize, beans, sweet potato, millet, maize, banana and wheat, most of which is with CGIAR centres as shown in Annex V.

Despite the hard position of Europe on GMOs, Britain through the United Kingdom aid for internation development (formerly Department of Foreign and International Development), is one of the most pro-active proponents of the application and use of transgenic research and deployment of products. The support of DFID to agricultural research and development is reflected in research for development strategy 2008 to 2013 under the themes, agriculture innovations, crops, livestock production, fisheries, aquaculture and fisheries genetics, research into use and miscellaneous headings.[18] It is within the strategy that Britain supports the CGIAR to the tune of sterling pounds 120 million from 2008 to 2013, through window 1 is reflected.

With regard to transgenic research, DFID has committed sterling pounds 30 million from 2010 to 2016 for supporting several projects as shown in Annex V, through partnership with the BMGF. The projects supported under this arrangement include C4 rice, water efficient maize for Africa, wheat rust resistance, and various activities in tropical grain legume. Indications are that DFID would continue or improve its levels of funding to transgenic research in future.

4.2 Multilateral donors

Traditional multilateral donors to agricultural research in Africa are the World Bank, African Development Bank, International Fund for Agricultural Development and the European Union. Generally, multilateral donors respond to the policies and wishes of their constituents, hence do not have strong position on transgenic research. In this study, the European Union is used as an example of multilateral donors.

The Directorate General of Health and Consumer Protection is responsible for coordination, monitoring and approval for release into the environment of genetically modified organisms into the environment, using regulation 2001/18/EC on the deliberate release into environment of GMOs and Regulation (EC) 1829/2003 concerning GM food and feed. For an application for placing on the market and cultivation of a GMO a full technical dossier of information including health and environmental risk assessment is required. The applicants submit an application for authorization to a Member State who then forwards it to the European Food Safety Authority (EFSA). EFSA performs a risk assessment and adopts a scientific opinion. Based on this opinion, the European Commission drafts a decision that it presents to the Member States for adoption. It is the responsibility of member states to carry out the necessary risk assessment and authorize field trials. The member states are responsible for making available information regarding requests for field trials in their territory and reports related to such trials to the Commission and other member states. Like most countries, European Union has zero tolerance for nonapproved transgenic products in the European

17. Bill and Melinda Gates Foundation (2013),' Agriculture Development Strategy Overview', BMGF, Seattle, USA.
18. DFID (2008), 'Research for Development Strategy,' DFID, London.

market, but once approved, the product can sell labelled like any other product. There are different requirements for approval for research and approval for release into the market.

The approval process for experimentation and commercial release of transgenic crops in the EU has more stringent regulations than conventionally bred plants. The process is slow and inefficient thereby, resulting in many multinational companies such as BASF and Monsanto withdrawing their research projects to develop transgenic crops in Europe. This has led to a reduction in experimental field trials in UK alone from 37 in 1995 to only one in 2012. It should be noted that even in the USA there is a similar stringent regulatory framework, but the approval process is more streamlined and effective.

To date there has been 120 applications for both trade and release into the environment, out of which 58 have been authorized for trade and only one for cultivation in Europe. There is therefore only one transgenic crop approved for commercial cultivation, Bt-insect-resistant maize in Europe. The total area of the crop in EU is about 129,000 ha, of which more than 90% is grown in Spain. Although less than 0.1% of the global acreage of transgenic crops is cultivated in the EU, more than 70% of EU animal protein feed requirements are imported as transgenic crop products. In 2012, Europe imported over 40 million tonnes of feed that is made from genetically modified maize and soya. Furthermore, Europe consumes a lot of cooking oil products made from genetically modified canola and soybean.

It is argued that the European commission regulates the process for transgenic products rather than regulating the product and the long time required for approval has deterred small biotechnology companies from the market and increased the monopoly of big companies. While the EU argue that its policies are based on democratic principles, it is well established that besides a small very vocal group which is anti-GMOs and another small but not so vocal group that is for GMOs, the majority of European citizens are not bothered whether food is GM or non-GM.

The European Academies Science Advisory Council (EASAC) and others have pointed out that there is no rational basis for the current stringent regulatory process. Stringent regulation of the technology would be justified if there were no benefits, if it was associated with inherent risks to the health of humans or animals or the environment, and if the technology was so poorly understood there was a high probability of unforeseen consequences. However, extensive studies over the nineteen years transgenic crops have been cultivated have failed to reveal any of these risks from transgenes of any type. Notably, even in the highly litigious USA, there have been no successful lawsuits, no product recalls, no substantiated ill effects, and no other evidence of risk from a transgenic crop product intended for human consumption since the technology was first deployed commercially in 1994.

European Union support to agricultural research is channelled through the Directors of Research Innovations and Science, for European institutions and partners; the Directorate of Development Cooperation for developing country specific and regional programs; and European Initiative for Agricultural Research and Development (EIARD) for international research. The Research, Innovations and Science directorate mainly supports European institutions but can also support joint research activities institutions in developing countries and CGIAR. By 2010, the directorate had funded over 50 research projects involving more than 400 research groups with grants of approximately Euros 200 million on GMOs, including pharmaceuticals. It is estimated that most member states are investing much more on transgenic research.

The development cooperation assistance is based on country or regional assistance strategies of the European Development Fund (EDF), framework. Currently, the framework either in place or being negotiated is EDF 11 in which Euros 2 billion has been earmarked for agricultural and rural development in Africa. The EU is supporting some transgenic research activities through the regional or national programs but the exact figure could not be established. A case in point is support for research on drought tolerance in maize and sorghum by ASARECA.

The European Union has been a long-term traditional donor of the CGIAR and is deeply involved in the reforms and the decisions of the system. The entity that represents the European Union in the CGIAR apex institutions is European Initiative for International Agricultural Research for Development (EIARD) which was established at the request of the Research Council in 1995 and approval by Council and European Parliament gained in 1997. The current EU support to the CGIAR is based on EIARD strategy 2009–2013[19] and is channelled through International Fund for Agricultural Development (IFAD) under the window three arrangements. EIARD commits Euros 50 million per year to the CGIAR focusing on support to climate risk management, low emission agriculture, linking knowledge with action, future scenarios and gender and equity.

The European Union, through the office of the Chief Scientific Advisor to the President of the European Commission is very instrumental for policy direction of member states, as it prepares briefs on scientific issues, including GMOs.

4.3 Recommendations

1. It is recommended that CGIAR centres engage more proactively with donors in Europe, including the directorate of research and innovations of the EU, and multilateral donors to support biotechnology and transgenic research for developing countries. The general fear that European countries could impose conditions for funding transgenic research for developing countries is unfounded.
2. It is recommended that CGIAR centres work with regional and national programs to mainstream support to transgenic research into their donor supported programs. Such support would be strategic for downstream transgenic research activities such as confined field trials, release approval process as well as adoption by farmers and commercialization of the products

19. EARD (2008), 'EIARD strategy 2009–2013', Brussels.

5 Summary of country analysis

5.1 Policies, legislations, and regulations

A baseline study on biotechnology research in six African countries—Kenya, Uganda, Malawi, Nigeria, and Burkina Faso, and South Africa, was carried out by FARA with support from the Syngenta Foundation in 2009.20 This study was expected to provide greater insight into the prospects of genetic engineering technology adoption and commercialization in African countries. The study gives several recommendations and conclusions that could be very useful for strategic research planning and program development by African countries at both regional and subregional level. It is anticipated that FARA will endeavour to disseminate the finding of this report, although it took a long from the time the study was carried out to the time that the report was published. The study highlights lack of science based information, on transgenic products and lack of biosafety policy and legislations as the main impediments to transgenic research as many institutions applying for research approvals could not get them on time as elaborated in Box 4.

Box 4. Key Recommendation of the FARA study report of 2011

'...inadequate diffusion of science-based information on transgenic crops at both grassroots and policymaker levels. It was reasoned that such lags were being exploited by anti-GMO non-governmental organizations such as Greenpeace, Friends of the Earth, etc. to spread negative information on transgenic products, which in turn formed the basis of the cautious approach to adoption in several African countries.'

'The lack of biosafety legislation, biotechnology policies and biosafety procedures in several countries constituted significant impediments to research institutions that wished to undertake transgenic research. Such institutions could not successfully apply for, or obtain permission for, transgenic research from regulatory authorities'.

While the study mentions the activities of anti-GMO activists and NGOs, it does not indicate this as an impediment and does not mention the fear of donor perceptions and intellectual property rights.

Since 2003, The New Partnership for African for African Development through its program of the African Biosafety Network of Experts has been providing training and public awareness in policy, legislation, regulation on biotechnology with focus on genetically modified organisms for countries in Africa.[21] During this period, the agency, with support from USAID, has carried many training workshops and facilitated short courses mainly to policymakers and biosafety regulatory agencies in most of the countries covered in this study except South Africa. The network is well known among the regulatory agencies and research scientists in the countries covered, and could be a reliable agency for interaction with policymakers.

20. Forum for Agricultural Research in Africa (FARA) (2011), 'Status of biotechnology and biosafety in sub-Saharan Africa: A FARA 2009 Study Report,' FARA Secretariat, Accra–Ghana.

21. NEPAD 2014. ABNE in Africa: Building Functional Biosafety Systems in Africa. ABNE, NEPAD, Ougadagou.

Nineteen countries out of the 54 countries in Africa have some form of biosafety legislation that can be applied to approve transgenic research activities. While this number may seem small, it would be appropriate to state that there is critical mass of countries with legal framework in Africa to partake into transgenic research. In any case without the capacity in transgenic research as is the case in most African countries, it is not reasonable to expect that most of them will have biosafety policy and legislations in place.

The status of biotechnology policy, legislation, regulations and implementing institutions in the countries covered in this study is shown in Table 3. In West Africa, Burkina Faso enacted its biosafety law in in 2003, Ghana in 2011, while in Nigeria the biosafety bill has been in parliament for the last three years. Burkina Faso is one of the three countries in Africa that has commercialized transgenic cotton and is showing the way for Africa. It is not only among the first countries in Africa to legislate biosafety framework, but also the first one to commercialize bt cotton in 2006. Currently, 70% of its cotton production is based on transgenic cotton.

Table 3. Status of biotechnology policies, legislations, regulations and implementing institutions

Country	Policy	Legislation	Regul.	Institution
Kenya	National biosafety policy 2002	Biotechnology and biosafety Act 2009	In place	National Biosafety Authority
Uganda	National biotechnology policy 2008	Biotechnology and biosafety bill 2012 in parliament	Interim	UNCST-Biosafety Committee
Ethiopia	None	Biosafety Proclamation No 655/2009	None	Ministry of Environment
Zimbabwe	National biotechnology policy 2005	The National biotechnology Authority Act (ACT 3/2006/2011 (s8)	In place	National Biotechnology Authority
Malawi	Biotechnology and biosafety policy 2008	Biosafety Act 2002	In place	Ministry of Environment and NCST, MOA, MOE.
South Africa	White paper on science and technology 1997	Genetically modified organisms act 1997 (Act no 15 of 1997), amended in 2006	In place	Ministry of Research Science and Technology
Ghana		Biosafety Act 2011	None	National Biosafety Secretariat.
Nigeria		Biosafety bill in parliament	Interim	Ministry of Environment
Burkina Faso		Revised biotechnology Act 2013	None	National Biosafety Authority
Cameroon	Science and Technology policy 2003	Biosafety *Law N° 2003/006 in 21 April 2003*	None	Ministry of Research Science and Technology
Benin	None	None	None	Ministry of Environment
Burundi	None	None	None	Ministry of Environment

The case for Burkina Faso demonstrates that with the political will, even with little scientific capacity, it is possible for a country to harness the benefits of transgenic research. Although Ghana enacted its biosafety framework in 2011, there are already several transgenic products in in CFT, and it has established fully pledged biotechnology regulatory and research institutions. Similarly, even without the biosafety legislation, Nigeria has also several transgenic products in CFTs and it has already established biosafety and biotechnology research institutions. This indicates that even without legal frameworks, there would be no major impediments in research activities where there is the critical mass of scientist and some political will. The reason why there has been such long delay in enacting the biosafety frameworks is mainly due to the power of the anti-GMO lobby groups.

However Benin lags behind in deciding on the way forward in policy direction and legislation on biotechnology as the government has been imposing moratorium on genetically modified organisms in the country. Policymakers and research managers in the country argue that they do not have enough information to formulate their policy and legislation on biotechnology and transgenic research in the country.

Most of the countries of the eastern and southern Africa subregion developed their biosafety frameworks under the United Nations Environment Program–Global Environment Facility (UNEP–GEF) project during 2001–2004. However the levels of implementation of the biosafety frameworks widely vary among countries. In the eastern and southern Africa regions, South Africa (1997), Zimbabwe (2000), Kenya (2009), Ethiopia (2009) and Malawi (2007) have enacted their biosafety laws, although except South Africa, none of the other countries have commercialized any transgenic product. Furthermore, although Uganda does not have a biosafety law, it is conducting several CFTs while countries such as Zimbabwe and Ethiopia do not have any transgenic research activities. A country like Malawi which enacted its biosafety law way back in 2007 has only one CFT on bt cotton.

The case of eastern and southern Africa countries indicate that even with legislations, there are major impediments both in research and commercialization of transgenic products, where there is no scientific capacity and no political will. The case of Zimbabwe is a clear demonstration of the lack of political will and the case of Malawi and Ethiopia is an example of the combination of the lack of political will and lack of scientific capacity. The case of South Africa is a demonstration of the power of scientific capacity and the private sector.

Among the central Africa region countries, Cameroon enacted its biosafety law in 2003 but Burundi does not have either the policy or legislation on biotechnology. The CFT trials in Cameroon are being conducted by a private company and the cotton development authority with little involvement of the NARS because of lack of capacity and also lack of political will.

Most of the countries did not have biotechnology policies to precede the legislations. In most case the legislations were backed up by the science and technology policies. Where there was a well thought out biotechnology policy, the subsequent legislation was more balanced and easier to implement. Where there was no policy, the legislations have ended up being amended several times, at the cost of delays in advancing the process of application for introduction of the products.

Subsidiary legislations in form of regulations are very useful in cases where the main legislations are weak or generic like the case in Ethiopia and Malawi. However, subsidiary legislations not been taken seriously in the past and many countries are only dependent on the main legislations.

5.2 Physical assets for transgenic research

Most of the countries sampled in this study except Malawi, Benin and Burundi have the physical infrastructure in terms of buildings for office and laboratories for biotechnology research, and subsequently transgenic research as shown in Table 4. Ghana and Nigeria have newly established national biotechnology research and development authorities complete with offices and requisite laboratories but without equipment. Cameroon has a fully pledged biotechnology research institute that can accommodate even genomics research laboratories but it is not manned and there is no equipment. Ethiopia is the process of establishing a biotechnology institute at Holleta that can accommodate even genomics research facilities but not completed and without equipment. South Africa has a fully pledged national biotechnology research institute, while Kenya and Uganda have set up molecular and transformation laboratories within their national commodity institutes and/or universities.

Table 4. Physical capacity for transgenic research in sample countries in Africa

Country	Institution	Laboratories				BSF Level		
		Mol.	Seq.	TF	BIF	1	2	3
Kenya	KALRO; universities	2	0	1	0	2	2	0
Uganda	NARO universities	2	0	1	0	1	1	0
Ethiopia	EIAR, universities	2	0	0	0	0	0	0
Malawi	Department of Agricultural Research Services and universities	1	0	0	0	1	0	0
South Africa	Biotechnology Research Institute, (ARC)	2	1	2	1	1	1	1
Zimbabwe	Department of Agricultural Research and universities	1	0	0	0	1	0	0
Ghana	NARS and universities	1	0	1	0	1	1	0
Nigeria	NARS and universities	3	0	1	0	1	1	0
Cameroon	National Biotechnology Research Institute (University of Yaoundé)	0	0	0	0	0	0	0
Burkina Faso	INRAB	1	0	0	0	1	1	0
Benin	ENIRA	1	0	0	0	1	0	0
Burundi	USABU	1	0	0	0	0	0	0

Note: Mol = Molecular, Seq = sequencing, TF = Transformation; BIF = bioinformatics platform; BSF = Biosafety facilities.

None of the countries except South Africa has any equipment for genomics research, such as sequencers or bioinformatics platforms; hence they cannot carry out research at that level. However most of them have simpler laboratories and equipment for simple plant molecular analysis and regeneration through tissue culture protocols.

The situation with livestock transgenic research in the countries in the study is pathetic. Except South Africa none of the countries is even thinking of transgenic research. There is neither the capacity nor the political will to either set up the infrastructure or build capacity in transgenic research in livestock. Policymakers perceive livestock transgenic as too complicated for the NARS to undertake. Research institutions lack the capacity even to contemplate livestock transgenic research because they are struggling to build conventional livestock breeding programs. While there may be some teaching in the universities on livestock genome and informatics, livestock transgenic research is perceived as a preserve for developed countries and farfetched for developing countries.

With regard to human capacity, there has not been a comprehensive study to establish the status and the needs assessments for competencies and numbers required for transgenic research in any of the African countries except in Kenya. The FARA study concluded that most African countries had very fragile crop or livestock biotechnology research programs that were dependent on a handful of individuals and hence limited capacity to implement research activities beyond pilot scale. Countries such as Nigeria, Ghana and Cameroon, went ahead to build elaborate physical infrastructure without both human and financial resources. Such infrastructure is now either underutilized or becoming dilapidated because of disuse. Ethiopia is in the process of establishing a national biotechnology institute, yet there is not a single transgenic research activity taking place in the country, and there is even no expertise to install the equipment that have been purchased. The numbers of scientists that are available to undertake transgenic research in the countries covered in this study are shown in Table 5.

Table 5. Human capacity for transgenic research in sample countries in Africa

	Crop geneticists				Molecular biologists				Animal geneticists				Animal mol. scientists			
	MSc and BSc		PhD		MSc/BSc		PhD		MSc/BSc		PhD		MSc/BSc		PhD	
Country	Total	Fte	Total	Fte	Total	Fte	Total	Fte	Total	Fte	Total	Fte	Total	Fte	Total	Fte
Kenya	17	4	9	3	4	2	4	1	2	0	3	0	1	0	1	0
Uganda	7	3	5	1	3	1	2	0.3	0	0	0	0	0	0	0	0
Ethiopia	12	0	5	0	2	3	0	0	4	0	4	0	2	0	0	0
Malawi	2	0	2	0	1	1	1	0.3	0	0	0	0	0	0	0	0
South Africa	10	3	8	3	10	3	6	2	3	0	3	0	2	0	2	0
Zimbabwe	3	0	3	0	2	0	1	0	0	0	0	0	0	0	0	0
Ghana	5	1	3	1	3	3	2	1	4	0	0	0	0	0	0	0
Nigeria	22	2	15	4	11	2	7	2	7	0	4	0	0	0	0	0
Cameroon	3	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0
Burkina Faso	4	2	4	2	0	2	2	1	3	0	0	0	0	0	0	0
Benin	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Burundi	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	89	15	61	14	38	17	26	7	23	0	14	0	5	o	3	0

Most of the countries in this study have the critical mass of geneticists although they may not be involved in transgenic research activities. All the countries except Ethiopia, Benin and Burundi are involved in one or more transgenic research activities with national scientists.

Except South Africa and Nigeria most of the countries do not have the critical mass of qualified molecular biologists to undertake any upstream transgenic research. Most of the staff currently involved in transgenic research have been trained either as plant pathologists or as breeders but may have gone retraining to participate in transformation, regeneration and field testing of transgenic products.

With regards to livestock biotechnology, most of the countries except, South Africa (7), Ethiopia (2) and Kenya (3), all the other countries in this study do not have animal geneticists in their national agricultural research system, that have competencies to be involved in transgenic research. There are only a few animal molecular scientists: South Africa (3) and Ethiopia (2) but none of them is involved in transgenic research because there isn't any going on.

It was not possible to establish the exact expenditure of governments on transgenic research in the countries in this study, because there are no specific budget lines for these activities. Most of the infrastructure has been established with funding from donors except in South Africa and Nigeria. Any investment on the part of the government in the other countries may be only in form training and salaries for staff.

5.3 Research projects

Between 2006 and 2009, FARA with support from the Syngenta Foundation for sustainable development carried out a baseline survey of the capacity of several countries in Africa, some of which are included in this study. Some of the findings of the study are shown in Box 5.

Cameroon, Ethiopia, South Africa, and Benin were not included in this study, although except in South Africa, there is not much biotechnology research being undertaken in the other three countries.

Currently all the countries in this study, except Ethiopia and Zimbabwe are carrying out some transgenic research activities as shown in Annex IV. South Africa is carrying out tests on 7 transgenic products, Kenya 6 products, Uganda 7 products, Burkina Faso 3 products, Nigeria 2 products and one product each in Malawi and Cameroon. All the countries except Ethiopia, Zimbabwe, Benin, and Burundi are conducting confined field trials on bt cotton. As is the case globally, most of the traits being introduced with these products are first generation transgenic products, i.e. insect resistance, disease resistance and herbicide resistance. There are also a few activities on nutrient efficient and drought tolerant traits mainly on maize and rice.

With regard to livestock transgenic research, most of the policymakers were either not aware or did not conceptualize the need for transgenic research. The NARS in all the countries also did not have any plans for transgenic research in their system in the near future. There is therefore no country either undertaking or contemplating to undertake transgenic research in livestock in the near future.

5.4 SWOT analysis

While each country has unique, strengths, weaknesses, opportunities and threats for transgenic research there are several factors that cut across all the countries included in this study.

Strengths

One of the strengths is that despite the political sensitivity of the subject of genetically modified organisms, all the policymakers and the legislature in the countries sampled are well informed about the pros and cons of transgenic products. Their failure to make prudent decision is often not because of ignorance but because of political interests and pressure from anti-GMO lobby groups. In the last 10 years, there has been considerable progress in most countries in putting in place biotechnology and biosafety polices, legislations, regulations and regulatory institutions. All the countries involved in this study have some form of research and regulatory institution with or without legislations. Only three out of the twelve countries included in this study do not have biosafety legislation in place. This being the case, one can argue that there is now the critical mass of countries with the requisite legal framework for transgenic research.

Another cross cutting strength is the political will. Except in Malawi, Zimbabwe and Benin where the political class has decided that not only transgenic but the whole of agricultural research is not a priority and they may not invest much in the near future, all the other countries have the political will to invest more in cutting edge research, including biotechnology. The main impediment is lack of resources, fear of development partners to stop their development aid, and the pressure from anti-GMO NGOs and trade related issues.

Box 5. Key finds of the FARA study report 2011

'the studies indicated that: 17 Burkinabe research institutions; 18 Ghanaian institutions; 14 Kenyan; 6 Malawian; 12 Nigerian; 16 Ugandan and 9 Africa-based CGIAR centres were introducing biotechnology tools into their research programs.'

… 'most of the research on transgenic crops was being conducted in Kenya, Burkina Faso, Uganda and Nigeria in that order. It was therefore not surprising that 42% of the biotechnology laboratories in the surveyed countries were working on molecular marker assisted plant breeding; 32% on tissue culture; **13% on GE** and 13% on fermentation research activities'.

… 'most of the transgenic research projects were concentrated on crops of importance to food security (cassava, cowpea maize and sorghum) and on livestock vaccine production.'

… 'most of the agricultural productivity challenges on which the biotechnology laboratories were working involved the control of insect pests and fungal and bacteria pathogens. There were a few studies on such abiotic stresses as drought, salinity, heat, etc.'

Weaknesses

The most serious weakness in the NARS is lack of scientific capacity, not only to carry out transgenic research but, also to respond to the many questions that arise from anti-GMO lobby groups. In all the countries except South Africa, there are not more than one or two molecular scientists who can elaborate the science of genomics and transgenic research in a convincing manner. This being a relatively new science, the NARS cannot afford to retain these scientists and once trained, they move to either international research system, or stay out of the country.

The second and related weakness is lack of funds to carry out upstream research not only in transgenic but other cutting edge sciences. Currently all the transgenic research activities in the countries involved in this study except South Africa are funded by donors, through the CGIAR centres, and a few private companies directly. Without the human capacity, it is not possible for the NARS to do proposals that can convince not only donors, but also the government to invest in transgenic research. It will therefore take very informed political decisions to invest in training and capacity building for scientists to do proposals to attract funding from both the international community and the government.

The third cross cutting and related weakness in the countries sampled in this study is lack of serious partnerships with the international agricultural research system. Except in South Africa and Kenya, there are no formal agreements between the national and the international research system, in all other countries in this study. Most of the transgenic activities that are being implemented jointly by the international and the national systems are either informal or loosely formal. The NARS play the role of desperate recipients of the funds from whatever sources through the CGIAR centres or any international organization. With this kind of arrangement, there are no mechanisms for continuity, risk management and even sustainability of the research activities in case the donors run out of funds.

In all the countries, except South Africa and Zimbabwe, there is no local private sector to engage in research and commercialization of transgenic products. There is however, a strong presence of multinational seed or agribusiness companies involved either in the ongoing testing of transgenic products, or commercialization of the already released products. This situation provides a fertile ground by the anti-GMO organizations to front the argument that transgenic products is a tool for trade dominance by the rich multinational companies at the expense of the poor small-scale farmer.

Opportunities

There are enormous opportunities for not only transgenic but also for the whole research system to contribute immensely to food security agricultural development in Africa, through science and innovations. Firstly, although food insecurity and poverty among the rural power in Africa has been declining gradually in the last 10 years, the rate of decline has been low and there is need for more focused intervention. Secondly there is a wide yield gap between the genetic potential and the small-scale farmers that needs to be closed in one way or another. Thirdly there are endemic pests, diseases, and nutritive constraints that it is not possible to address through conventional research tools other than genetic engineering. As the last frontiers of agricultural expansion and intensification, new technologies create greater awareness and pull with it adoption of and use of well-known good farming practices.

Threats

The most serious threats to transgenic research and deployment of transgenic products are the politics of anti-GMO activists and NGOs, and the fear of international business and trade related issues. Firstly transgenic products are perceived as mainly belonging to multinational companies that are merely interested in business. Policymakers and business people in Africa are therefore afraid that greater adoption of transgenic products will deny them business. The Anti-GMO organizations also argue that small-scale farmers will be exploited as they may not afford the seeds from these multinational companies. Furthermore, most African countries believe that they have no capacity to handle intellectual property issues, especially when dealing with well-resourced multi-national companies.

While the main objective of deployment of transgenic products would be food security, issues of trade are now emerging as one of the most serious threats, in three fronts. Firstly, Europe seems so skeptical about GMOs that African governments are worried that growing transgenic crops might jeopardize their much need development aid from those countries. They also fear their exports of agricultural products, including non GMOs to those countries that have zero tolerant policy on GMOs will be restricted. Furthermore since there no regional policies on GMOs, countries are afraid that growing of transgenic crops will also cause some restrictions in trading not only with GMO products but also non GMO products.

5.5 Recommendations

1. It is recommended that, as is the case for conventional breeding national performance trials (NPTS); all CFTs should be the full responsibility of either the National Research System or the private companies. This will ensure that the national governments will take the responsibility of deployment and adoption for those transgenic crops that will be in public good while the private companies will commercialize and promote those that will be registered by them. The involvement of CGIAR centres at this level should be only for backstopping and capacity building. Full responsibility of CGIAR centres on transgenic research should be up to Confined Green House Trails (CGHTs).
2. It is recommended that issues of intellectual property rights, and trade be elaborated at the event selection stage, and continue to be part and parcel of the communication package of any transgenic research activity. AATF should be included whenever these issues are up for discussion.
3. It is recommended that Crop based centres should focus on a few countries that are ready or near ready with policies, legislations, regulations, highly willing and with the critical mass of scientists to carry out and supervise controlled field trials and take responsibility for deployment of the technology. As a start, two countries in eastern Africa (Kenya, Uganda), three countries in West Africa (Ghana, Nigeria and Burkina Faso) and two countries in southern Africa (South Africa, Zimbabwe or Malawi) could be the focus in the next 10 years. The other countries should be assisted to develop a regional approach to adopt from these countries.
4. It is recommended that ILRI selects two or three countries in Africa to start a program on building livestock biotechnology research capacity. South Africa, Kenya and Nigeria could be good candidates to start with. These would then be the countries that would participate in transgenic research activities.

6 Benchmarking with India

6.1 Introduction

In many ways India is a country of contrasts, in social, economic and scientific standing. For instance, 11.8% (148 million) of the Indian population lives under the absolute poverty line but manages to coexist with a growing wealthy class. The number has declined rapidly from 37% in 2003, and is set to decline even further as the country implements more social welfare programs. Low input subsistence agriculture coexists with high-tech clusters of information and communication technologies with widespread farming of transgenic crops. Services and Industry have grown steadily to become the drivers of the economy at 66.1% and 17% respectively. The contribution of GDP has decline and currently stands at only 16.7%.

Biotechnology is one of the most modern and developed sectors of the Indian economy, and it has been one of the engines of the present prosperity of cities such as Hyderabad and Bangalore, as well as the Mumbai/Pune area. It is not regarded only as a private profiting activity, but also as a tool to foster national development. India singled out biotechnology as a useful means to meet the health and agriculture needs of the Indian population way back in its 1985–90 development plan. Since then, technology in general, and biotechnology in particular, have been at the centre stage of Indian national development strategy.

Despite the long experience and so much research only eleven events—six on cotton and five on soybean have been approved for commercialization in India. Bt cotton is now widely grown in the country and has almost replaced conventional cotton. India is now cultivating over 11 million hectares and is the second largest Bt cotton grower in the World.

India is also a major consumer of transgenic products in the form of animal feed and oil imports from the United States, of America, Brazil and Canada. In 2013 India imported over 2 million tonnes of soybean oil from Brazil and Canada where most of the soybean is now transgenic.[22]

6.2 Institutional development and investment

The process for application and building of biotechnology research in India dates back to 1982 with the creation of the National Biotechnology Board as a small division within the Department of Science and Technology devoted to the management of biotechnology. In 1983 the department drafted and issued the *Long Term Plan in Biotechnology for India*, which mapped the priorities in that field for the years to come. Four years later, in 1986, a Department of Biotechnology was founded within the Ministry of Science and Technology.

Since then biotechnology is regarded as fundamental for the development in India. In 2001 the vision statement on biotechnology—'attaining new heights in biotechnology research, shaping biotechnology into a premier precision

22. ISAAA (2013), Global Status of Commercialized Biotech/GM Crops: 2013, ISAA Brief 46. ISAA, NY.

tool of the future for creation of wealth and ensuring social justice –specially for the welfare of the poor',[23] was an indication of the importance that was attached to biotechnology by the Indian Government.

Since the establishment of the department India has invested heavily in biotechnology research. It is estimated that in the last 15 years, India has been investing approximately USD 200 million of public resources on biotechnology research.

6.3 Transgenic research capacity

Since 1986, India has built a formidable capacity of human resource and state of the art infrastructure for research in transgenic and related research. The country has world class facilities for molecular biology DNA sequencing, genetic engineering, bioinformatics platforms, and biosafety containments to undertake any level of genomics proteomics, genetic engineering, and transgenesis. The facilities are generally shared by both the public and private research laboratories at a cost comparable to that of developed countries. There are about 200 laboratories with state of-the-art equipment and facilities for DNA research, in public sector and even more in private sector.

Currently (2014) there are fifty universities, 45 research institutions and 140 private companies carrying out transgenic research in one way or another on 36 crops for 18 traits.[24] There is a fully fledged Institute of Plant Genome Research that is mandated to ensure that India is at the top of the world in accumulation of genome and proteomics knowledge and information. In additions to all kinds of equipment and facilities in the universities and private sector, there are high throughput DNA sequencing facilities in four public institutions. National containments are provided at the National Biotechnology and Plant Genetics Research Center while plant gene repository is provided at the National Institutes for Plant Genetics Resources. The PTTC at ICRISAT provides the facilities for transformation and testing of transgenic products. Down the value chain the National Agri-food Biotechnology Institute and bioprocessing units are provided at the Agri-food biotech park at Mohali-Punjab.

With regard to livestock, India has also made tremendous progress in some areas of biotechnology such as animal feed development and recombinant vaccines. Most of the public funded animal transgenic research is carried out in the National Institute of Animal Biotechnology. As is the case in most countries, transgenic research in livestock in India is limited. The institute has a program on transgenic technology, whose research activities include production of pharmaceuticals and bioactive molecules; and safety and quality of transgenic livestock and livestock products. Efforts have made towards research in large farm animals for expression of new genes and production of novel protein based on mice but there is no documented transgenic animal on trial.

It is not possible to enumerate the number of transgenic research projects going on in the private sector and the universities, and even in the public intuitions. Table 6 below is sample of some transgenic activities going on in the public institutions. It is apparent that India has a strong focus on transgenic food crops, indicating the priority for food security. Most of the traits being targeted are those that were not easy or possible to confer using convectional breeding process. These include, insect resistance, disease resistance, drought tolerance, nutrition improvement, and some special qualities preferred by the industry.

23. Rao S.R. (2013), 'Indian Biotechnology Development in Public and Private Sector, Status and Opportunities', Department of Biotechnology, India.
24. Rao, S.R. (2014), 'Status of GM crops in India: Department of Biotechnology, Ministry of science and technology, India.

Table 6. Sample of ongoing crop and traits transgenic research in India

Crop	Institutions	Traits
Rice	IARC, Mahyco and TNAU,IRRI	Tolerance to drought, salinity, tango virus, gall midge, bacterial leaf bright and bio-fortification
Wheat	Various	quality, heat tolerance and bio-fortification; leaf and stripe rust, karnal burnt and Powderly mildew resistance
Cotton	Various	fibre strength, oil content and insect,
Maize	Various	Quality protein and bio-fortification
Brinjals	IARC, Mahyco	fruit and short borer resistance
Mustard	Various	seed yield, oil content, low glucosonilate, an aphid resistance
Soybean	Various	yellow mosaic resistance
Chickpea	ICRISAT, AAU	pod borer resistance, drought tolerance
Sorghum	NRCS, ICRISAT	shoot fly and stem borer resistance
Pigeonpea	ICRISAT, IIPR	Podborer resistance, bio-fortification for pro-vitamin A
Castor	DOR	Insect resistance
Tomato	IARC	Virus and insect resistance
Potato	CPR	Leaf blight resistance

Note: NRCS = national research centre for sorghum, TNAU = Tamil Nadu Agricultural University. DOR = Directorate of Oilseed Research, CPR = Centre for Potato Research; IIPR = Indian Institute of Plant Resources; AAU. Arangabad Agricultural University

Generally India has excessive human resources in any of the contemporary areas of scientific research and innovations. It is estimated that India has over 1000 highly qualified scientists in various disciplines of biotechnology, including transgenic research. It has however not been possible to get accurate statistics of how many scientists are carrying transgenic research in the multiplicity of institutions that undertake biotechnology research in the country.

6.4 Regulatory framework

The Indian legislative framework that includes rules, regulations and procedures for handling of the genetically modified organisms and rDNA products is the Environment (Protection) Act (EPA) of 1986. In 1990 a set of biosafety rDNA guidelines were issued covering genetically engineered organisms, genetic transformation of plants and animals, mechanism of implementation of biosafety guidelines, containment facilities at lab level under three risk groups. The rules then come into force 1993 to cover manufacture, use/import/export; and storage of hazardous micro-organisms, genetically engineered organisms or cells.

Since then biosafety guidelines have been revised several times to match with the newer aspects of technology. In 1998 revised guidelines for research in transgenic plants and guidelines for toxicity and allergenicity for evaluation of transgenic seeds, plants and plant parts were issued and came into force immediately. These were meant to give thrust and importance of hastening the process of acquisition of transgenic products including Bt gene in cotton which was given approval for commercial release in March 2002.

In India regulatory legislations, rules and procedures are generally compliance friendly. The majority of the agencies that enact rules and control activities in the biotechnology are in four ministries of the central government. The Ministry of Science and Technology controls the Department of Science and Technology, the Department of Scientific and Industrial Research and the Department of Biotechnology. The Ministry of Health governs the Indian Council of Medical Research. The Ministry of Agriculture controls Indian Council of Agriculture Research, and the Department of Scientific and Industrial Research funds the Council of Scientific and Industrial Research which also funds biotechnology research.

A series of committees set up a multi-tiered regulatory framework aimed at ensuring the biosafety of genetically engineered organisms in India. These agencies are the Review Committee on Genetic Manipulation, the Genetic Engineering Approval Committee, the Recombinant DNA Advisory Committee, the Institutional Biosafety Committee, the State Biotechnology Coordination Committee and the District Level Biosafety Committees.

The multiplicity of regulatory agencies and the complex approval procedures are an impediment to the functioning of the Indian biotechnology sector. It is for this reason that, a new legislation for the establishment of a single-window regulatory agency has been proposed and is pending in parliament. If created the Biotechnology Regulatory Authority of India will regulate the research, manufacture, importation, and use of genetically engineered organisms and products derived thereof.

In India there is enough expertise in technology and risk assessment of genetically modified plants for safety to environment as well as human and animal health. Keeping up with the recent trends/public perceptions on genetically modified foods, appropriate measures and mechanisms are being evolved to label the same within the scope of CODEX alimentarius. Genetically modified products detection and analytical food safety laboratories have been established to facilitate generation of scientific data. Similarly, containment facilities at the biosafety levels three and four are also available for both research and *in vivo* evaluations.

6.5 Technology transfer

To facilitate the transfer and commercialization of transgenic and other biotechnology products the Indian Government established the Biotechnology Consortium of India Limited in 1990, to act as an agency for forging effective linkages between research, financial and industrial institutions and the policymaking framework at the government level. So far more than 60 technologies and research leads from the government funded R&D projects have been transferred to Indian industries for scale up, validation and commercialization. Some of these products such as leprosy vaccine, HIV and hepatitis diagnostic kits, natural streptokinase, veterinary diagnostics, etc. are already in the market and some others are in the pipeline. The same process is applied for crop transgenic products.

To encourage the institutions to file patent applications on their innovations, and to motivate them to transfer their technologies for commercialization, and to reward their inventors, the institutions are permitted to retain the benefits and earnings arising out of the IPR. The IPR generated through joint research by institutions and industries can be owned jointly by them as may be mutually agreed to by them. The institutions are required to set aside 25% of such earnings into a fund called Patent Facilitating Fund to be utilized by the institution for updating the innovations, for filing new patent applications, protecting their rights against infringements, for creating awareness and building competency on IPR and related issues.

6.6 Recommendations

India's experience and progress in transgenic research provides very useful lessons for African Countries. Like in Africa, despite tremendous experience there is only one crop—Bt cotton that has been released in India, but there are several crops in the pipeline. However, while there is been some resistance in Africa, adoption of Bt cotton has spread widely within a very short period in India. In addition, India is a major importer of transgenic food and feed from other countries.

Unlike Africa, India has an immense human and physical capacity in transgenic research accumulated over a long period of time. India is also investing heavily on more transgenic research to position itself to be a major global player.

Like in Africa, there is a very strong anti-GMO lobby groups with external funding that has mounted a strong campaign against deployment of transgenic products. The groups have gone as far as taking public institutions to courts to prevent them from releasing transgenic products. By the time of this study, there were several cases in courts, and some of them in the Supreme Court, to stop public and private institutions from releasing transgenic product. Such cases take a long time to determine. However the research system in India is generally not deterred by the campaign and the cases.

1 It is recommended that African countries work out a South–South Cooperation program on Science and Technology that would include and emphasize biotechnology and consequently transgenic research. In such an arrangement, the CGIAR centres will provide backstopping and bridging with the NARS in the thematic areas of their competencies.

7 Country analysis

7.1 Uganda

The National Agricultural Research System in Uganda comprises of mainly the National Agricultural Research Organization (NARO) and the universities that have Departments or Faculties of Agriculture, Livestock and Veterinary Medicine. NARO comprises six National Agricultural Research Institutes and eight Zonal Agricultural Research and Development Institutes. The national institutes carry out strategic research of national importance related to crops, fisheries, forestry, livestock, and semiarid agriculture, and Natural Resources. Transgenic research in NARO is therefore carried out in some of the national centres.

Currently, the National Crops Research Institute is involved in collaborative transgenic research with several international agricultural research centres, but there is no transgenic research in the Livestock Resources Research Centre.

Institutions of higher education involved with agricultural research are Makerere University, the Institute of Environment and Natural Resources, and Nyabyeya Forestry College. The role of other agencies in public agricultural research in Uganda is small and the only nonprofit agency identified as conducting agricultural research is the Uganda Coffee Development Authority which is also very small.

Policies and legislations

The national biotechnology and biosafety policy for Uganda was released in April 2008 by the Ministry of Finance, planning and Economic Development. The content, as is the case in most policies is rather generic and does not provide any details that can have any implications to transgenic research. The policy places the national focal point for biosafety regulation in the Ministry of Environment and the competent authority as the Uganda National Council for Science and Technology. This council is required to house the secretariat and the National Biosafety Committee. Institutions that carry out research are identified as other lead agencies.

Uganda's structures uses existing institutions and avoids creation of additional institutions and bureaucratic structures. However there is already bureaucracy in the system and the process of applications for approval and commercialization of transgenic products take a relatively long time.

Uganda has not yet promulgated its biosafety law. The national biosafety bill was approved by the Cabinet in October 2012 and has been in parliament for debate since then. By the time of this survey the bill had been referred back from parliament to the parliamentary committee on agriculture for public debate. However Uganda uses the existing institutions for approval of transgenic research and testing.

While there is much debate and activities in crop biotechnology research, there is no awareness that there is livestock biotechnology research. The policy and law makers argue that livestock keeping in Uganda is so traditional that it does not need transgenic research yet. Furthermore they believe that improvement in livestock productivity would be targeting the export market and they are not ready to make the case for transgenic products in the countries that are potential market for livestock products.

Research capacity

Uganda has reasonable physical capacity within its public research institutions and universities to carry out its requisite agricultural research activities. For transgenic research, the country with support of donors has established some capacity within NARO and universities for transformation, confined field and laboratory trials. There may however not be adequate capacity for regulatory and intellectual property issues.

With regard to physical capacity Uganda does not have a dedicated biotechnology research institute, and transgenic research activities are implemented within NARO or the universities. There are however 3 molecular laboratories two biosafety level 1 and one biosafety level 2 greenhouses which have been put up with the support of donors.

In the last decade Uganda has built a considerable capacity in human resources in agricultural research. By 2010 the number of research scientists in Uganda stood at 309 fte,[25] which can be said to be within the critical mass required for the adaptive research needs for the country for now. While this capacity has been in fluctuation and has generally not increased in NARO, human capacity in the institutions of higher education in Uganda has increased tremendously in the last 15 years. Currently these institutions account for 33% of the scientists in agricultural research and the distribution of staff by commodity is about 28.5 in crops and 71.5 in livestock research.

In NARO crops research takes about 70.2%, livestock 6.1%, while others account for 23.6% of the research capacity. Agricultural research is therefore strongly inclined in favour of crops and both livestock and natural resources research are disadvantaged.

There is a total of 4.3 fte research scientists involved with transgenic research in Uganda, with most of them from NARO and Kampala University. There is however a pool of scientists that can undertake transgenic research especially at downstream level as shown in Table 2.

The Department of Crop Science and Animal Science both have some capacity in biotechnology research but mainly in teaching and some few research activities apply biotechnology tools but not in transgenic research. There is however no transgenic livestock research that could be traced even in the universities.

Uganda has also increased funding to agricultural research considerably in the last 15 years. Currently public investment in agricultural research is nearly about USD 89 million (PPP 2005 price), per annum largely as a result of donor funding mainly from the World Bank and proportional funding from government. NARO accounted for 73%, the universities 25% while other public institutions 2% of this investment. With little human resource capital in livestock research in NARO, this proportion of investment indicates that little proportion of investment is made in Livestock research.

Except for in kind support in terms of physical infrastructure and staff remuneration, the Government of Uganda has no budgetary allocation for biotechnology or transgenic research. All research activities are funded by bilateral or philanthropic donors.

Although Uganda does not have a biosafety law, it has been conducting confined field trials (CFTs) on banana (*Musa* spp.) and cotton (*Gossypium hirsutum*) since 2007. Currently, there are the following transgenic research activities ongoing in Uganda with details in annex IV:

1. Introduction of insect resistant cotton, which is in confined field trials and expected to release some varieties by 2016.
2. WEMA transgenic drought tolerant maize, which is in confined field trials.
3. WEMA transgenic insect resistant maize, which is in confined field trials.

25. Kathleen Flaherty et al. (2010). Recent developments in Agricultural research in Uganda; AST, IFPRI, Washington.

4 Testing of cassava mosaic resistant cassava, which is in confined field trials and is expected to release some transgenic varieties by 2017.

5 Xanthomonas wilt resistant banana that is in confined field trials and expected to be released by 2016.

6 Parasitic nematode and weevil resistant banana that is at confined field trials stage.

7 Iron and vitamin A fortified Banana that is at the confined field trials stage.

8 Weevil resistant sweet potato that is in the stage of confined greenhouse trials.

In the last 10 years, despite the very vocal anti-GMO campaign in the country, Uganda has attracted several transgenic research activities because of the expeditious approval process, critical mass of research capacity and the support of the political leaders.

SWOT analysis

In Uganda, the policy and law makers are well informed about the pros and cons of biotechnology and transgenic research, to the extent that they strongly support the whole process of research and application. It is however paradoxical that while the policy and law makers are so well informed, there is no budgetary support to the whole process of biotechnology research. There is also the critical mass of research scientist to carry out field trials but not genetic engineering for any desired traits. Development partners are aware of this strength and have provided significant financial and knowledge support systems.

There is however such a vocal anti-GMO civil society and non-governmental organizations that even the policy and law makers are afraid. The public and the farmers especially in the rural areas are poorly informed about the debate on biotechnology, hence they quickly fall prey to anti-GMO lobby groups. The media is not analytical and tends to convey the popular views. There is no structure in the communication channels of the institutions involved in biotechnology, exposing the whole process to misuse and confusion.

With most of the farming being smallholder, there is hardly any local private sector organization that can express views on transgenic research. The only private sector that is involved is the multinational organizations in the seed system. These are the same organization involved in transgenic research in collaboration with international, and the national research system, hence creating room for suspicion.

With the multiplicity of institutions especially in the research and regulatory framework, and lack of local capacity to handle the stewardship of transgenic products, there are threats of misuse of intellectual property rights at the expense of farmers. There is no coordination of biotechnology research hence institutions are competing for resources and donors and private companies for control. Furthermore there is not adequate analysis of the threats on trade issues.

However, Uganda has serious food security and nutrition issue and so many production constraints that it provides great opportunities and the need for transgenic research. Furthermore with the critical mass of research scientists there is good opportunity for strong partnerships with the local scientists in the frontline.

Table 7. SWOT analysis for transgenic research in Uganda

Strengths	Weaknesses
1. Strong political will	1. Uninformed public particularly farmers
2. Well informed policy and law makers	2. Weak private sector
3. Critical mass of human resources	3. Unstructured communication channels
4. Critical mass of physical capacity	4. Weak partnership among the centres, NARS, and SRO
5. Support from donors	
Opportunities	Threats
1. Food and nutrition deficit	1. Very active and vocal anti-GMO organizations
2. Production constraints for transgenic research	2. Intellectual property rights and trade related issues
3. Fast growing human capacity in NARS, SROs	3. Competition of resources, both human and financial
4. High potential for increasing productivity	4. Competition of development partners
	5. Competition of the Private sector companies to demonstrate their products

7.2 Ethiopia

The National Research System of Ethiopia comprises of the Ethiopian Institute of Agricultural Research (EIAR) as a federal organization, regional research institutes and the universities. There are seven regional agricultural research institutes located in various administrative regions of the country to undertake research that is relevant for those regions.

Institutions of higher education that are involved in agricultural research are: Haramaya University (formerly Alemaya University of Agriculture), Mekele University's College of Dry land, Agriculture and Natural Resources and College of Veterinary Sciences, and the, Faculty of Veterinary Medicine at Addis Ababa University, which conducts veterinary medicine research. The involvement of agricultural research by nonprofit and for profit organizations in Ethiopia is minimal.

The Ethiopian Government is establishing a fully pledged biotechnology research institute at Holleta in preparation to undertake biotechnology research once the legislation is amended.

Policies and legislations

Currently, there is no stand-alone policy on biotechnology in Ethiopia. It is deemed that biotechnology is part and parcel of Science and Technology, hence, policy issues should be captured in the respective science and technology policies.

Ethiopia passed its biosafety law vide Biosafety Proclamation No 655/2009. This law has been deemed too restrictive and is in the process of being amended. Currently, there are no legal bodies for regulation of transgenic research in Ethiopia but the proclamation is implemented by the Ministry of Environment.

Research capacity

Ethiopia has well-established infrastructure in terms of offices, laboratories and other facilities for agricultural research within its public research institutions and the universities to carry out the agricultural research that is required in the country. In fact most of the laboratories are not well equipped and grossly underutilized. For transgenic research, the biotechnology research institute being established at Holleta is expected to be equipped with state of the art facilities for tissue culture, transformation and genomic research. There are however currently no biosafety facilities because there is no transgenic research that is expected to be going on in the country.

Ethiopia has relatively strong human capacity and has made reasonable investment in agricultural research. There is a total of 1318 FTE research scientists with EIAR accounting for 582 FTE while regional institutes employ about 613 fte.[26] The institutions of higher education have over 110 fte research scientists for agricultural research. Ethiopia has therefore the capacity and the potential to quickly mobilize human capacity for transgenic research if the policy and legislative provisions are put in place.

Crops research account for 60% of this capacity while livestock accounts for only 10%, which is an indication that livestock research is highly disadvantaged in Ethiopia and mobilizing human research capacity for transgenic research in livestock is not currently possible. Forestry research accounts for about 10% and fisheries 5% and the rest going into others.

In Ethiopia, much of the research expenditure accounting for about 50% is by the national research institute. The seven regional agricultural research institutes account for 38% of expenditure and the eight higher education institutions take 12% of the research budget.[27] Funding sources for agricultural research in Ethiopia are the national government, multi-and bilateral donors and development banks. This implies that Ethiopia has the capacity to quickly mobilize financial resources for biotechnology and transgenic research if and when it deems it appropriate.

The proportion of expenditure in commodities is similar to that in human resources, with crops accounting for about 50% livestock 10% and the rest going into others. Despite the existence of a biotechnology research centre, there is no financial resources allocated for transgenic research in Ethiopia, probably because the law is still too restrictive.

In Ethiopia there is a pool of geneticists and molecular biologists as shown in Table 5 that can undertake transgenic research once the policy and legislative environments are conducive. With 12 geneticists and 5 molecular biologists in the system, there is no risk of the lack of human capacity to initiate transgenic research in the country.

SWOT analysis

Ethiopia has a relatively strong political will and well informed policy and law makers in the pros and cons of biotechnology and transgenic research. There is a strong will among scientists to use the biotechnology tools for contemporary research in the country. However, the lack of strategic and policy direction has made it impossible for the national research system to carry out meaningful biotechnology and consequently transgenic research. There is no critical mass of human and physical capacity for transgenic research except for the biotechnology centres which is now being established at Holleta. There is also no financial resources allocated for transgenic research. Development partners also dare not take part in transgenic research with such restrictive policy and legislation regime. Consequently anti-GMO lobby groups have found a fertile ground for their activities and have made it very difficult for the law makers to take decisions on the amendments of the biosafety proclamation.

With the serious food deficit and severe productions constraints, there are great opportunities for transgenic research in Ethiopia. Furthermore, there is human capacity in related disciplines that can be quickly tapped for transgenic research and latent donor support that can be quickly unlocked if policy and legislation environment improves. There are however threats of anti-GMO campaign groups due to lack of capacity to handle intellectual property and trade related issues and the slow decision-making process in the government.

26. Kathleen Flaherty et al. (2010), Recent Developments in Agricultural Research in Ethiopia, AST, IFPRI, Washington.

Table 8. SWOT analysis for transgenic research in Ethiopia

Strengths	Weaknesses
1. Moderate political will	1. Uninformed public particularly farmers
2. Informed policy and law makers	2. Weak private sector
3. Staff that can be deployed in transgenic research	3. Weak partnership among the CG centres, NARS, and SRO
	4. Lack of critical mass of physical capacity
	5. Lack of support from development partners
Opportunities	Threats
1. Food and nutrition deficit	1. Strong anti-GMO campaign NGOs
3. Growing human capacity in NARS,	2. Intellectual property rights and trade issues
3. High potential for increasing productivity	3. Political indecisiveness

7.3 Malawi

The Department of Agricultural Research Services (DARS) which is part of the Ministry of Agriculture, Irrigation, and Food Security (MAIFS) is Malawi's main agricultural research institution in the country. DARS is responsible for crop and livestock research, with the exclusion of tobacco, tea, and sugarcane. It comprises of three main stations, one at Chitedze responsible for field crops, livestock, natural resources, and farm machinery, the second at Bvumbwe responsible for horticulture and crop protection and the third at Lunyungwa for all crops in the region. There are also nine substations for field testing. DARs has been re-organized several times in the last 20 years, and its headquarters was moved from the Ministry Headquarters to an old building at Chitedze research station.

The Central Veterinary Laboratory which also falls under the responsibility of MAIFS, is a national referral veterinary laboratory, in conjunction with two regional and nine district laboratories. The Forestry Research Institute of Malawi and the Fisheries Research Unit both fall under the Ministry of Forestry and Environmental Affairs.

Agricultural Research and Extension Trust, established in 1995 through a merger of the Tobacco Research Institute of Malawi, and the Estate Extension Service Trust, under the Tobacco Association of Malawi also carry out some agricultural research.

Bunda College of Agriculture is the only higher-education agency in Malawi involved in agricultural research. The university conducts some research on crops, livestock, fisheries, natural resources, food processing and storage, economics, and agroforestry.

Policies and legislations

Malawi has no stand-alone policy or legislation on agricultural research. Agricultural research is covered within the National Council for Science and technology policy and acts. However the country enacted its biotechnology and biosafety law to facilitate acquisition of genetically modified maize and food aid in 2002. Later on in 2008, the country realized that it needed regulations and policy to go along with the act. National biosafety regulations were done in 2007 and national biosafety policy in 2008.

The competent authority for the national biosafety act is the Ministry of Environment and Climate Change, which house the National Biosafety Committee. There are national and institutional structures in the form of biosafety committees for regulation of research and deployment of transgenic products but there are hardly any physical and financial resources as well as human capacity for implementation. There is therefore no paper trail on approvals and the inspectors in place for monitoring the field trials.

Research capacity

From mid-1980s to the 1990s the government of Malawi embarked on major investment in agricultural research through a loan from the World Bank, the National Agricultural Research Program and the Agricultural Sector Program, and grants from several other donors. During this period, some physical infrastructure including offices and laboratories were established for the NARS. The level of investment in research and development during this period was as much as 22 million USD (PPP 2005 price) per annum.[27] Donor support was terminated in 2000 due to various political and mismanagement issues and the government ejected its own funding in 2000/2001 but could not sustain the investments in the following years. By 2001, the level of funding went to as low as USD 13 million per annum and continues to decline.

Unfortunately the gains made during this period have since been eroded, because of shortfall in funding. The situation of agricultural research in Malawi is currently in a desperate situation. Physical facilities are becoming dilapidated, and staff morale is very low. There is no physical capacity that can be said to be available for transgenic research and practically no transgenic research in the country and the government has any plans to put them up in the near future.

The human capacity of agricultural research in Malawi has declined steadily over the last 20 years, falling from 170 to 146 fte between 1996 and 2001 and currently stands at less than 120. Losses resulted from staff departures, because of the low salary levels at MAIFS agencies and normal attrition without replacement.

There is only one scientist undertaking PhD studies in molecular biology who can be said to be available for transgenic research in DARs. There are also two molecular biologists in the university who are spearheading the CFTs on Bt cotton in addition to the lecturing workload.

There is no scientist involved with livestock transgenic research and there is no indication of anyone trained to carry out this type of research in the country.

SWOT analysis

In Malawi, the political class and policymakers are very much aware of the benefits of transgenic agricultural research and subsequent application of well tested products. There is also a strong will of research scientists to carry out some transgenic research to address critical production constraints. However, the country lacks in financial, human and physical capacity, purely because, having been abandoned by donors, it cannot afford. The private sector does not see any potential of application of transgenic products because farmers cannot afford even the application of fertilizers and improved seeds.

If the situation changes and development partners return to assist the country, there is great opportunity for application of transgenic products, to improve the very low agricultural productivity and food security situation in the country. However with such low human capacity, there is serious threat for misuse of intellectual property. Furthermore, the country is in dire fear of the consequences and the cost of transgenic products for regional and international trade.

27. Beintema et al. (2004), 'Agricultural science technology indicators'. Country Brief 22, IFPRI, Washington.

Table 9. SWOT analysis for transgenic research in Malawi

Strengths	Weakness
1. Well informed law makers	1. Lack of human, and physical capacity
2. Well informed policymakers	2. Lack of donor support
3. Strong will of agricultural research scientists	3. Weak private sector
	4. Weak partnerships among the CG centres, NARS, and SRO
Opportunities	Threats
1. Food and nutrition deficit	1. Anti-GMO campaign groups
2. Production constraints for Transgenic Research	2. Intellectual property rights and trade issues
3. High potential for increasing productivity	

Political economy of transgenic research in Malawi

Malawi is one of the world's poorest countries ranking 171 out of 187 countries on the UNDP's 2011 human development index. Although agriculture contributes 36% to the GDP of Malawi and 87% of the population depends on the sector, agricultural research is not considered to be a priority in the context of other competing needs. This is evidenced by the fact that there is no clear government policy on agricultural research system, the decline in funding and failure to build human and physical capacity. Furthermore, Malawi is relatively sparsely populated and there is ample land for its predominantly subsistence rain-fed agriculture. It is therefore a general perception of the government, that a lot can be achieved with just better agricultural extension and advisory services, with minimal investment in research.

With predominance of subsistence agriculture with low input, agricultural productivity in Malawi is one of the lowest in the world. The Government of Malawi attempted to revamp this productivity through heavy fertilizers subsidy between 2003 and 2010 with donor support but this could not be sustained and has since been abandoned. Through this subsidy, the Government of Malawi demonstrated that agricultural productivity can be more than trebled by inputs only, hence the no need for research. Through this fertilizer subsidy, Malawi was able to produce a lot of surplus maize and began to export to neighbouring countries.

With regard to transgenic products, countries of the southern African region have taken a very restrictive political position. While there is no clear legislative restriction, the general position of the southern African countries is that they will not grow transgenic crops. Since Malawi perceives its increase in productivity would be for the regional market, transgenic crops could be a threat for its region trade. Furthermore, with restrictive measures in neighbouring countries, it perceives that transgenic crop will increase its cost of production, hence make it uncompetitive in the region.

7.4 Zimbabwe

The main agricultural institution for the National Agricultural Research System is the Department of Research and Specialized Services (DR&SS), under the Ministry of Agriculture, Mechanization and Irrigation Development. DR&SS was established in 1948, but has been reorganized and renamed several times. In 2001, the department was merged with the former Agricultural Technical and Extension Services Department to become the Department of Agricultural Research and Extension. In 2007, the Department of Agricultural Research for Development was formed from the research arm in order to accommodate new developments in the sector. In 2009, the department of research was again reverted to its earlier name of DRS&SS.

The department manages three commodity based institutes—horticulture, coffee and cotton and two factor research institutes—the plant protection, and the chemistry and soils research institutes, and four research stations focusing on animal research. Fisheries research was also brought under the department in 1990 from the national parks and wildlife management.

Other agricultural research agencies include: the Tobacco Research Board, the Department of Veterinary and Laboratory services, the Forestry Research and Training Division, and the Institutes of Agricultural Engineering. Four not for profit agencies, viz: the Agricultural Research Trust for oilseed Producers Association; the Commercial Grain Producers Association, and the African Institute for Agrarian Studies and the Ruzivo Trust also conduct agricultural research cutting across commodities, livestock and natural resources.

With regard to higher education, the University of Zimbabwe's Agriculture Department, and Biological Sciences Department carry out some research in crops, livestock and natural resources.

SeedCo which was started as a public seed company but later privatized is the main for profit private company that carries out research on seed systems in Zimbabwe. Since 2007, several other private seed companies that have skeleton human resources in agricultural research have been established. These are however insignificant in contribution to agricultural research capacity.

Policies and legislation

Biotechnology policy in Zimbabwe is contained in the national biotechnology policy released in 2005 but also elaborated in the Science and Technology, Innovations Policy of March 2012. The policy is a very generic document and contains all the elements that can be said to be in support of transgenic research and even deployment of the products.

The National Biotechnology Authority Act (ACT 3/2006/2011 (s8) was passed in 2006 and amended in 2011. The act provided for the establishment of the National Biosafety Authority, Biotechnology Fund, biosafety committees and appointment of inspectors.

Since then, the National Biotechnology Authority has been established and fully operational. The establishment of specialized biosafety committees and the appointment of inspectors have not been implemented. Furthermore, the establishment of the biotechnology fund is yet to be realized.

While there is the policy, the legislation and the biosafety authority, there is yet to be regulations to govern the industry. The authority maintains that there is no need for regulation because the act is comprehensive enough to be implemented without the need for supplementary legislation.

Research capacity

In the 1980s and 1990s Zimbabwe was viewed as a success case for a longstanding agricultural research system. However since the year 2000 economic decline brought about by land reforms, and the consequent donor sanctions, the government has been unable to finance agricultural research and it is only virtually maintaining the salaries of the staff that are still in the system.

In the last 15 years, human, physical, and financial capacity for research in Zimbabwe has been seriously eroded. In the public institutions, the number of scientists declined from 114 fte, in 2003 to 92 in 2008 fte and currently to about 66 fte.[28] The main reason for the decline is low remuneration, and lack of operational resources. There has been a moderate increase in the number of scientists in institutions of higher education where the numbers have increased

28. Kathleen Flaherty et al. (2011), 'Recent Developments in Agricultural research in Zimbabwe' AST, IFPRI Washington.

from 30 fte in 2003 to 40 fte in 2008 and currently stand at about 48 fte. The private sector also has registered a slight increase from 8 fte in 2003 to 10 fte in 2008 and currently at 13 fte.

Currently, there is no research scientist dedicated to transgenic research in public institutions. However there are two molecular scientists in the institutions of higher education who are fully engaged in teaching. There is one molecular scientist at PhD level who is fully engaged in management matters.

Investment in research in Zimbabwe has declined drastically over the last 10 years. Overall fund for research has declined from USD 9 million (ppp 2005 price) per annum in 1992 to USD 4.3 million, in 2008 and currently stands at about USD 1.7 million mainly for salaries of the remaining staff and minimal operation costs. This decline has occurred across the board in public institutions, and institutions of higher education.

The state of physical capacity for research has also declined to the extent that buildings are becoming dilapidated, laboratories are idle and equipment is wearing out and going into disuse. Currently, there is no physical infrastructure for any transgenic research in Zimbabwe.

SWOT analysis

Currently, Zimbabwe's agricultural research system can be said to be surviving from the past glory of the 1970 to 1990s, when it had one of the most well developed agricultural research system in Africa. It still has the infrastructure for research that was established at that time but is now becoming dilapidated. Zimbabwe's strength can also be found in its well established legal framework, strong private sector and the will of the scientists to keep on.

The greatest weakness of Zimbabwe's agricultural research system is lack of funding, and subsequent loss of human capacity and dilapidation of physical assets. With no donor support, the system is now international abandoned not only in terms of funding but also human capacity development and keeping abreast of changes in technology and innovations. Research institutions are uncoordinated and potential for partnerships are limited. It is not even possible to discern communication channels and engagement with the public and media.

There is therefore the threat of scientific isolation, mishandling of intellectual property rights, and lack of strategy to handle regional and international trade of products from transgenic research. With the land reforms that have brought in many more small-scale farming, agricultural productivity has declined in Zimbabwe and food insecurity is on the increase. This can now be viewed as an opportunity for the international fraternity of agricultural research to bring in appropriate technology to revive agricultural productivity and hence from security in the country. This will however require a different approach in the context of a very complex political economy in the country.

Table 10. SWOT analysis for transgenic research in Zimbabwe

Strengths	Weakness
1. Policy and legal framework	1. Lack of human and physical capacity
2. Well established institutions	2. Lack of donor support
3. Strong Private sector	3. Uncoordinated institutions
4. Strong will of agricultural research scientists	4. Weak partnership among the CG centres, NARS, and SRO
Opportunities	Threats
1. Food and nutrition deficit	1. Intellectual property rights and trade issues
2. Production constraints for transgenic research	
3. Potential for increasing productivity	

The current status of agricultural research and development, and consequently transgenic research in Zimbabwe is a result of the recent political position in the country. In 2003, the Government of Zimbabwe embarked on very aggressive and internationally unpopular land reforms that sort to forcibly take land from the whites and give it to Africans. These reforms have caused the most drastic economic meltdown of the country. Since the government started to introduce the reforms in 2003, donors not only stopped aid but also imposed sanctions on goods and services from Zimbabwe. By 2008 the country had performed so badly that it abandoned its currency and went to using US dollars for all its monitory transactions.

Under these reforms many large-scale highly productive farms were subdivided and allocated to small-scale farmers, with low technical knowhow. Consequently agricultural productivity for all crops declined drastically. For example the yield of maize declined from an average of 7.8 to as low as 1.5 t/ha.

The fall of the economy brought down with it the institutions and agricultural research institutions were not spared. The once vibrant research system has now been reduced to a shell with only a few staff waiting for their salaries at the end of the month. With no funding for agricultural research in general, there would then not be expected to be any research on biotechnology or transgenic.

In Zimbabwe, it is public knowledge that there is massive cross border trade through which transgenic products such as genetically modified maize, and oils from South Africa find their way to the local market. The politicians and the public admit that they are consuming a lot of genetically modified food. However the government positions is that it is not opposed to transgenic research but it is not ready to commercialize or approve commercialization of any genetic products. One of the main reasons given for this position is that the scientists have not convinced the government that there is need or such products and whether the government is ready to manage and steward such products. It is also argued that the rest of the countries, except South Africa do not allow commercialization and consumption of the same, hence if one country goes its way, it will find it very difficult to participate in regional trade.

The main underlying reason for such confusing position by the government is that on many occasions the President of Zimbabwe has stated that there is no need for biotechnology and transgenic products in the country.

7.5 South Africa

In South Africa the Department of Science and Technology is responsible for all science and technology research policy and basic research capacity. The line departments take responsibility for applied research functions related to their services. However there is no clear distinction between basic and applied research, hence most line departments also carry out most the basic research.

The main agricultural research organization in South Africa is the Agricultural Research Council (ARC). It comprises of 11 research institutes, seven of them working on crops, two on livestock and two on natural resources spread throughout the country. ARC has an exemplary management structure comprising of President/CEO, the ARC Council and an Executive management team.

There are six other public not for profit entities that carry out agricultural research on policy, marine, food biology and chemical technologies, forestry and forest products; and oceanic research which are related to agricultural research.

Nine provincial departments of agriculture also have the mandate to conduct research on issues relevant to their respective provinces, but their research capacity is dismal. The South African Sugarcane Research Institute a division of the South African Sugar Association carries out research on Sugar.

Within the universities and higher education entities, there are several departments, schools, and faculties of agriculture and related sciences that also under some agricultural research. There are also a couple of private companies conducting some type of agricultural R&D in South Africa.

Policies and legislations

There is no stand-alone biotechnology policy document in South Africa, but there are science and technology policy papers that are adequate to guide biotechnology research. The White paper on science and technology 1996 titled 'preparing for the 21st century' give the policy directions for biotechnology and subsequently transgenic research in South Africa. In addition South Africa has a comprehensive national biotechnology strategy that also contains policy directions for biotechnology and subsequently transgenic research in the country.

With regard to legislation, transgenic research in South Africa is covered in the Genetically Modified Organisms Act, 1997 (Act No. 15 of 1997), amended in 2006. The act was passed in 1997 and became fully implemented in 1999 and the amendments were implemented in 2010.

The Act provides for a Registrar, two regulatory bodies, i.e. Regulatory Committee and Executive Council as well as inspectors. In addition, there is the Biosafety Directorate in the Department of Agriculture, Forestry and Fisheries that is supposed to facilitate the implementation of the Act and the South African, Biosafety Clearing House, which acts as a platform for exchanges of information on living genetically modified organisms.

There are various regulations application for every stage in research, deployment and use of transgenic organism. With regard to research, there are no restriction charges but application for research and deployment can take as long as two years.

Research capacity

South Africa is probably the only country in Africa that can be said to have the state of the art physical facilities in terms of infrastructure, equipment and modern technology platforms for agricultural research that is comparable to some developed countries. These facilities are found not only in public institutions but also the private sector.

With regard to transgenic research, South Africa has a fully-fledged biotechnology research institute at Onderstepoot. The institute houses several molecular laboratories, transformation laboratories supported by bioinformatics platform and modern sequencers. The institute manages three biosafety level 2 containments, 1 biosafety level-3 containment and is in the process of building level-4 containment, which could be the only one in sub-Saharan Africa.

The institute has therefore the requisite physical capacity to undertake the whole continuum of transgenic research from genomics, engineering to deployment and commercialization.

Funding for agricultural research in South African public institutions is almost entirely (95) from government and sale of services/commodities. The level of funding has been stable at about 2% of GDP over the last 10 years. Some research institutions such as ARC are well funded to the extent that they report annual budget surplus in most years.

It was not possible to estimate how much the country is spending on transgenic research as the cost is not disaggregated to that level. Furthermore, there are so many public and not for profit organizations involved in transgenic research that a process to determine the levels of funding would require much more time and resources than this study could afford.

South Africa has one of the strongest human capacities, of agricultural research system in Africa. In the last fifteen years the total number of research scientists increased to as high as 1091 fte in 1996 but declined to 784 fte by 2008,[29] but started to rebound and currently stands at 835 fte. The professional qualifications of scientific staff in South Africa are generally high with ARC having 37% with PhD, 48% with masters; and universities with 75% with PhD and 20% with masters degrees.

29. Kathleen Flaherty, Frikie Liebenberg, and Joan Kersten (2010), 'South Africa—Recent Development in Public Agricultural ASTI, IFPRI, 2010, Washington.

The allocation of research scientists by commodity is quite well balanced. In ARC, 45% of the scientists are in crops and related research, 38% in livestock research and 17% in natural resources and post-harvest technologies. In the non-ARC government agencies, about 50% of the scientists are dealing with fisheries research, 35% on forestry and the rest on others.

For transgenic research, South Africa has both the physical capacity and a pool of well qualified scientists within its public institutions to undertake the whole continuum of transgenic as shown in Table 5. The ARC has set up a fully pledged biotechnology centre with the modern sequencers, bioinformatics platforms, and other necessary equipment for biotechnology research ranging from genomics to transformation and regeneration.

Currently the country is undertaking seven transgenic research activities at different stages of research as shown in Table 11. Most of the gene constructs being tried in South Africa are from the private sector but the ARC being a public institution has the full control of the intellectual property rights.

Table 11. Transgenic research projects in South Africa

Activity	Institutions	Crop	Trait	Event	Status
1. Bio fortified cassava	ARC, IIC	Cassava, *Manihot esculenta*	Starch enhancement	TMS60444	Proof of concept
2. Insect and herbicide tolerant Cotton	ARC, IIC	Cotton, *Gossypium hirsutum*	Insect/herbicide tolerance	9 events	CFT
3. Virus resistant potato for South Africa	ARC, G2 Spunta	*Potato (Solanum tuberosum)*	Insect resistance	ARC-OVI	CFT
4. Alternative sugarcane for South Africa	ARC, SASRI	Sugarcane, *Saccharum officinarum*	Alternative sugar	NCo310	CFT
5. Drought tolerant wheat for South Africa	ARC, AGERI,	*Wheat (Triticum durum)*	Drought tolerance	HVA1	CFT
6. Bio-fortified sorghum for Africa	ARC AHBFI, pioneer	Sorghum, *Sorghum bicolor*	Nutritional enhancement		CGHT
7. Insect and disease tolerant maize for South Africa	ARC Syngenta	Maize, *Zea mays*	Insect /herbicide resistance	GA21 MIR162 BT11xGA21	CFT

SWOT analysis

South Africa has enormous strengths, not only to carry out transgenic research, but also in agricultural research in totality. The physical capacity transcends from state of the art laboratories to sequencing and bioinformatics platforms. The human capacity is found in private and public organizations and funding is relatively stable.

There are therefore very ripe opportunities for the South Africa agricultural research system to be not only a partner in transgenic research but also a hub for the southern African countries. In view of its strong private sector, the country is in the lead in the commercialization of transgenic products not only in Africa but also globally.

The main weakness in South African agricultural research system is the coordination within government departments and the private sector. The various public organizations are strong enough to compete for power and resources. For example staff moves between universities and agricultural research institutions mainly for better pay and recognition with risks of the research activities in their former institutions being abandoned.

As a relatively well developed country with a predominance of large-scale farming South Africa does not have adequate experience with small-scale farming enterprises. While this does not have any significance in the relevance of transgenic research, there is the weakness of perception. It has also been observed that South Africa does not generally come out to champion the Africa Agenda.

The most important threat to transgenic research and deployment is competition between the private sector bodies and also with public bodies. It has been noted that some of the large private sector companies would go to quite some extent to prevent the deployment of public sector invention purely to protect its business. Other threats include inadequate capacity to handle emerging issues of trade with regard to transgenic products, due to the fast changing conditions and the volatility of policies and conditions of trade in the region.

Table 12. SWOT analysis for transgenic research in South Africa

Strengths	Weakness
1. Critical mass of human and physical capacity	1. inadequate knowledge of small holder farming
2. Well-funded research system	2. Not pro-active in presenting Africa Agenda
3. Policy and Legal framework	3. Weak coordination between public and private sector research
4. Well established institutions	
5. Strong Private sector	
Opportunities	Threats
1. Africa and regional leadership	1. Competition with the private sector
2. To be a model of NARS/CGIAR centres partnership	2. Inadequate capacity to handle emerging issues of trade
3. unique setting of 'small'-scale farmers	3. Fear of regional and international trade issues

7.6 Kenya

National Agricultural Research system in Kenya comprises of the recently established Kenya Agricultural and Livestock Research Organization (KALRO), and the several universities with faculties in agriculture and livestock. KALRO which is the largest institution for agricultural research comprises of the former Kenya Agricultural Research Institute and commodity funded research foundation for coffee, tea, and sugarcane. KALRO has now over 33 centres spread throughout the country some with national and others with regional (agro-ecological based) mandates. Transgenic research in KALRO is carried out within commodities but coordinated in the Biotechnology Research Centre based in Nairobi. Various universities also carried out some transgenic research in collaboration with International Research Institutions but they are mainly involved in training.

Policies and legislations

Kenya developed and released the biotechnology policy in 2006 and enacted its Biosafety Act in 2009 to regulate agricultural biotechnology. This paved the way for the establishment of the National Biosafety Authority in 2010 and setting the legal framework for the institutional biosafety committees and the biosafety inspector. This was followed by the publication of implementing regulations in August 2011, paving the way for commercialization of GM crops.

The National Biosafety Authority has the mandate to act as the coordinating institution on matters relating to the safe development, transfer, handling and use of genetically modified organisms. The Board of Management that was appointed in April 2010 and is composed of representatives from relevant government ministries, supporting regulatory agencies, scientists, farmers, private sector and consumer organizations.

In late 2012, the Kenya Government through the Ministry of Health pronounced a ban on importation of GMO food products into Kenya. This ban was premised upon the finding of the Seralini paper,[30] which generated a lot of debate and has subsequently been found to be incorrect and withdrawn. In June 2013 the government appointed a committee to collate information and advise the government on the lifting of the ban.

Kenya has therefore fully established policy, legal and regulatory and institutional to partake in genetic research, deployment and commercialization of transgenic products. It however suffers the pressure of strong environmentalists and anti-GMO campaign groups that thrive in the country to the extent that it has not been able to commercialize any transgenic crop.

30. Gilles –Eric Seraline et al. (2012), 'Long-term Toxicity of Roundup Herbicide and Roundup Tolerant Genetically Modified Maize; Food and Chemical', Toxicology Journal, Elsevier.

Research capacity

Kenya is well endowed with both physical and human capacity for agricultural research. The physical infrastructure for research including offices and laboratories are well established in the public research institutions and in some cases underutilized. These are complimented by the presence of the several international agricultural research institutions in the country.

For transgenic research, there are several molecular laboratories within the public funded research institutions that can be said to be sufficient for basic training and testing of transgenic products. There are also adequate biosafety containment facilities for deployment products. There is however no genomic research facilities for upstream transgenic research within the NARS. The existence of BecA/ ILRI hub in the country renders these facilities at national level unnecessary.

With regard to human resources Kenya has a total human capacity of over, 1110 fte of scientific staff of which 53% are in KALRO, 20% in other public funded institutions, 23% higher education and 4% in nonprofit organizations.[31] The allocation of human resources is 38% on crops, 18% on livestock, 12% on natural resources and 8% on forestry and 6% on fisheries. The levels of education are 35% at PhD level, 50% at Masters and the rest at BSc levels. The universities have higher levels of qualification with about 60% with PhD and the rest with master's qualifications.

For transgenic research there is a total of 8 molecular biologists in public institutions with master's degree and above qualification but only 3 fte are involved in transgenic research. These are quite few in relation to the total number of scientists and the number of activities that are being carried out in the country. There is however potential to deploy the capacity that is within the universities in case of an upsurge of requirement for transgenic research. While there is still need for human capacity for upstream research, there is quite reasonable capacity to undertake downstream transgenic research such as breeding, backcrossing and controlled field trials.

With regard to livestock research, there is no indication of any human capacity on transgenic research even for the purpose of vetting and deployment.

Kenya is also well resourced in terms of funding for agricultural research compared to other African countries. In the last five years, Kenya has been spending well over USD 155 million (ppp 2005 price) per year for agricultural research and development. It is however not possible to determine the allocation of funds for the different commodities and programs.

While the government has been funding staff salaries and related costs, over the years, the country has been highly dependent on donors for funding the operations of its research programs. Over 95% of the funding for all research operations and capital investment is from donors. The main donors for Kenyan agricultural research are the World Bank and the European Union. Other sources of funds include grants from philanthropic organizations and collaborating international organizations.

The following are the transgenic research activities ongoing in Kenya:

1. Introduction of insect resistant (bt) cotton, which is in multilocation field trials and expected to be released in 2015;
2. WEMA Insect resistant maize which is in CFTs;
3. WEMA drought tolerant maize which is at CFTs stage;
4. Nitrogen use efficient maize which is in the lab stage
5. Development of cassava mosaic resistant in cassava which is at CFT;
6. Virus resistant potato for Kenya which is also at CFT stage;

31. Kathleen Fraherty et al. (2010), 'Kenya: Recent development in Public Agricultural Research', ASTI, IFPRI, Washington.

7 Protein, iron and vitamin A fortified cassava at the stage of CFT; and

8 Bio fortified sorghum for Africa, which is in CFT stage.

All the events in the trials are either from the private sector or public international organizations and funded by the collaborating partners. With such human capacity and financial resources, there is no explanation as to why both the government and the multilateral donors are not financing transgenic research in the country.

SWOT analysis

In Kenya, there is well established biosafety policy and legislation, as well as institutions in since 2006. There is large flow of information to the public, the policymakers and national agricultural research and development systems, because of the presence of many international and regional organizations. The policymakers and the law makers are well informed of the pros and cons of transgenic products and the risks of failure to invest in knowledge and innovations systems. The NARS are strong enough to withstand the pressure and negative energy of the anti-GMO activists and NGOs.

There is however no infrastructure and human capacity to undertake upstream transgenic research for the needs of the country. Furthermore, despite two of them being headquartered in the country, partnerships with the CGIAR centres are not legally bidding or elaborate enough to deliver some tangible results. With so many regional and international organizations, communication with the government and the media is so unstructured that there is a risk of dissipation of energies and competition for resources and attribution of results. Every institution is struggling to show to its donors that it is having an impact. As a result, the policymakers are torn between organizations and take long to make decisions.

There are however immense opportunities for transgenic research to have an impact in food and nutrition security as the country is far from achieving its development targets. Furthermore with the fast growing urban population, the demand for nutritious food is increasing in such a rate that conventional breeding may not cope in providing the solutions. Climate change is also having such an impact in the country, because of its equatorial location that there is need to apply more climate smart agricultural development solutions.

The main threats of transgenic research and product deployment in the country is anti-GMO activists and NGOs; and the fear the of the trade restriction. With so many international organizations based in Nairobi, Kenya provides fertile ground for activists and anti-GMO lobby groups. Furthermore, as a country whose foreign exchange is from agriculture, it would take any threat on trade and donors seriously.

While Kenya has made significant progress in building the human and physical capacity, in the last two years, the Ministry of Health unilaterally imposed a ban on genetically modified organisms through a ministerial statement, without due regard for the biosafety law, the biosafety authority, or technical advice from the competent authority. The anti-GMO activists have taken advantage of this situation to campaign so much that despite the positive statement from the politicians the government has been very cautious and indecisive. This is probably the most serious threat of progress in transgenic research in the country at the moment.

Table 13. SWOT analysis for transgenic research in Kenya

Strengths	Weakness
1. Policy and legal framework	1. Lack of human and physical capacity for upstream transgenic research
2. Well established biosafety institutions	2. Competition for resources and attribution
3. Well informed policy and law makers	3. Unstructured communication channels
4. Strong will of agricultural research scientists	4. Weak partnership among the CG centres, NARS, and SRO
Opportunities	Threats
1. Food and nutrition deficit	1. Anti-GMO campaign groups
2. Intrinsic constraints for transgenic Research	2. Intellectual property rights and trade issues
3. Enterprising human capital	3. Regional and international trade related Issues
	4. Political indecisiveness epitomized by the ban on food imports

7.7 Ghana

In Ghana the national agricultural research system comprises of the institutes of agricultural Council for Scientific and Industrial Research (CSIR), universities, and commodity funded organizations. CSIR accounts for more than two thirds of the research capacity in the country. It comprises of 13 research institutes of which nine carry out activities in agricultural research. The agricultural research institutes are categorized into: Crops, Animal, food, soil, water, forestry, savannah, and oil palm institutes.

There are about 15 higher education agencies that conduct some agricultural research accounting for about 20% of the research capacity. However most universities have a high teaching workload hence they do not carry much research.

Other government organizations that conduct agricultural research are the Cocoa Research Institute of Ghana; the Biotechnology and Nuclear Agricultural Research Institute and the Marine Fisheries Research, which account for about 15% of the research capacity of the country.

Policies and legislations

In Ghana biotechnology policy issues are contained in the National Science, Technology and Innovations policy of 2009. The policy supports promotion and application of new technologies, including safe application of biotechnology for increasing productivity as well as building capacity for the same.

Ghana promulgated the biosafety law in December 2011 vide Biosafety Act 831. The Act provides for establishment of Biosafety Authority, Biosafety Committees and Inspectors. The act is adequately comprehensive for application of research and commercialization of transgenic products. There are no subsidiary legislations in the form of regulations but the Act contains regulations that are currently used for approval of applications for transgenic research. While the country is in the process of establishing the institutions for implementation of the act, several applications have already been approved for research. According to the CSIR, there are no delays in approval of requests for research in transgenic research.

Ghana is in the process of establishing a fully pledged Biosafety regulatory system. Currently, there are transitional institutions that are making sound regulatory decisions on applications for activities regulated under the Biosafety Act 2011. However the absence of a National Biosafety Authority (NBA) is an issue of concern for many stakeholders in biotechnology applications.

Research capacity

Ghana has generally well established physical infrastructure in terms of offices and laboratories for its portfolio of agricultural research activities in the public funded organizations and the universities. For transgenic research there is a semi-autonomous institute of biotechnology research with new infrastructure for offices, and laboratories but with no operational funds and equipment. There are several molecular laboratories within the public funded research institutions that can be said to be sufficient for basic training and testing of transgenic products. There are also adequate biosafety containment facilities for deployment of products within the country. Like in many other African countries there are however no genomic research facilities and transformation laboratories for upstream transgenic research within the NARS.

The human capacity of agricultural research in Ghana is relatively optimal. As in 2008 there were 27 public and not for profit agencies involved in agricultural research in Ghana all employing a total of 572 fte research scientists.[32] The Council for Scientific and Industrial Research (CSIR) which accounts for two thirds of the research capacity had 365 fte while the institutions of higher education accounted for 19% and other public institutions accounted for 14% respectively.

Crops and crop related research accounts for 90.3% while livestock accounts for only 9.7% of this capacity. Within CSIR crops research accounted for 70% while livestock accounted for 30% of the human capacity. In institutions of higher education, crops and crop related research accounted for 94.4% while livestock accounted for 5.5%. This implies that livestock research is relatively disadvantaged in Ghana.

Like most countries in this study, human capacity for transgenic research is relatively low in Ghana. Currently there are 3 crop molecular biologists and 4 crop geneticists involved in transgenic research in the country. These scientists are involved in downstream activities as there is no physical infrastructure or equipment to undertake upstream transgenic research.

No physical or human capacity exists for livestock biotechnology or transgenic research.

Investment in agricultural research in Ghana has increased in the last 10 years from about USD 41 million (ppp 2005 price) in 2001 to USD 95 million by 2011. However most of this expenditure has gone into salaries whose proportion stands at 87% of the total expenditure. Expenditure on agricultural research could not be apportioned to commodities as payments are made centrally by government.

CSIR which is the main public funded research institution is not allocated any budget for operation by central government but it is expected raise funds through their services or grants. Funds raised through sale of services are not adequate to carry out any meaningful research activities. In 2012 the central government took a deliberate decision to fund only salaries so that it can retain competent scientists and wait to fund operations later. Consequently, no operational funding exists from the government for transgenic research.

Despite the lack of human capacity and funding, Ghana is among the countries that are conducting several field trials in transgenic research. Currently there are confined field trials in: (i) Insect resistance Bt cowpea; ii) High protein Sweet Potato; (iii) N-use efficiency, Water –use efficiency, and Salt Tolerant Rice; and (iv) multilocational field trials of Bt Cotton. While these are on trial, there is no laid down procedure for stewardship and deployment of these products after the field trials. In the absence of such procedures, farmers in the northern part of the country have already grown transgenic Bt cotton from Burkina Faso where it is being grown extensively.

32. Kathleen Flaherty et al. (2010), 'Ghana—Recent Developments in Public Agricultural Research; ISTA, IFPRI, Washington.

SWOT analysis

The passage of biosafety legislation in Ghana in 2011 created a major impetus for transgenic research in the country. There is now a strong political will and well informed policy and law makers, and the process of establishment of institutions are well under way.

While there is considerable investment in staff salaries the lack of human and physical capacity as well as financial resources for operations is a very serious weakness not only for transgenic research but also for the whole of agricultural research in Ghana. It is not clear why the development partners are also participating in funding for the high salaries and not for operations.

Research activities for transgenic research also appear to be uncoordinated as they scramble for the little resources from philanthropic organizations and private companies that are supporting deployment of transgenic products. There is no indication of coordination activities among the CGIAR centres that are working in collaboration with the national system to conduct the recent confined field trials. Such weakness creates a situation of risks of failure of stewardship and deployment of the products that are being tested.

Like many of the African countries, there are opportunities for transgenic research, given the food and nutrition insecurity and endemic production constraints. The growing national research system and creation of biotechnology research institutions also proved a good opportunity for transgenic research. Issues of intellectual property rights and trade remain a major threat for this research.

Table 14. SWOT analysis for transgenic research in Ghana

Strengths	Weakness
1. Policy and legal framework	1. Lack of human capacity and equipment
2. Biosafety institutions	2. Lack of donor support
3. Well informed policy and law makers	3. Unstructured communication channels
4. Strong will of agricultural research scientists	4. Weak partnership among the CG centres, NARS, and SRO
Opportunities	Threats
1. Food and nutrition deficit	1. Intellectual property rights and trade issues
2. Production constraints for transgenic research	2. Competition of private sector
3. Growing national research capacity	3. Anti-GM campaign and lobby groups
4. High potential for increasing productivity	

7.8 Nigeria

The National Agricultural research system in Nigeria comprises of the institutes of the Agricultural Research Council of Nigeria (ARCN) institutions of higher education known as federal agricultural colleges, and other public institutions. ARCN, created in 2006, coordinates 15 national agricultural research institutes, of which seven deal with various crop, two deals with livestock, one on forestry, one on fisheries and the others won issues that cut across commodities. ARCN falls under the administration of the Federal Ministry of Agriculture and Rural Development and has a relatively organization, it is still struggling with issues of implementation and reforms.

Seven other government agencies that conduct agricultural research are Federal Institute of Industrial Research, Oshodi; the Forestry Research Institute of Nigeria; the National Centre for Genetic Research and Biotechnology; the National Research Institute of Chemical Technology; the Nigerian Institute of Social and Economic Research; the National Institute for Trypanosomiasis Research; and the Projects Development Institute. These institutions fall under the administration of respective line federal ministries.

Nigeria has a fully-fledged National Biotechnology Development Agency to coordinate and advise the government on the priorities for research and development using biotechnology tools. However, since its establishment in 2002, the agency has not carried out any meaningful research. Transgenic research is part of each specific commodity institution.

Policies and legislations

Nigeria released its national biotechnology policy way back in 2001, under the auspices of the Federal Ministry of Science and Technology and, in the same year established the National Biotechnology Development Agency (NABDA). The policy is generic but provides statements that were adequate for the development of legislations and regulations. In 2009, the country with support from USAID and AATF drafted a bill which was passed by cabinet the same year. The bill provides for the establishment of a biosafety department within the National Biodiversity Management Agency. This is a departure from similar legislation in other countries that provide for the establishment of autonomous or semi-autonomous biosafety authority under the auspices of the Ministry of Research Science and Technology or equivalent. The bill also provides for establishment of biosafety committees at institutional and technical level and the appointment of biosafety inspectors as is the case in other countries.

Since 2009, the bill has been undergoing parliamentary debate and approval process in both the parliament and the senate. It is anticipated that the bill will be passed into law before the end of this year.

Research capacity

As a large country with a population of 174 million people, and an agricultural sector that contributes 41% of the GDP, Nigeria has a huge physical infrastructure for agricultural research. There is excess physical capacity for office and laboratories space in the public institutions but there is hardly any equipment for transgenic research.

With regard to human capacity Nigeria has the largest national agricultural research system in Africa. By 2008 there were 2 062 fte scientists in public institutions, with ARCN comprising of 43%, institutions of higher education, 41% and other public agencies 16%.[33] On the basis of commodities, crops and related research accounts for 63% while livestock research accounts for 37% of this research capacity.

The ARCN institutions are biased towards crops accounting for 73% and livestock 26% while in institutions of higher education, crops research accounts for 44% and livestock 56% of the research capacity.

The human resource capacity of Nigeria is relatively well qualified to undertake the research requirement for the country. By 2010, 35% of scientists had PhD qualification, 40% Masters and the rest BSc degrees. With such a pool of human resources, it would be anticipated that Nigeria can easily mobilize expertise in biotechnology and consequently transgenic research as and when required.

However, due to lack of legislative framework, political will and low investment in biotechnology, the human capacity for transgenic research is meagre. There are scientists within the public institutions but only a few are involved in transgenic research. There are over 40 crop geneticists and over 19 molecular biologists but only 3 geneticists and 2 molecular biologists are involved in transgenic research in the country. Even without the biotechnology legislation, a few transgenic research activities have been approved and are currently being carried out in Nigeria. These include: i) insect resistant cowpea; ii) disease resistant bananas; iii) protein and iron rich cassava; and iv) nutrient use, water use efficient and salt tolerant rice (see details in annex v).

By virtue of its size of the national agricultural research system, in Nigeria has the highest investment in agricultural research in Africa. By 2008, Nigeria was spending, USD (pp 2005 price) 392 million per annum on agricultural research and development. Agricultural research is generally funded by government with some support albeit small from donors. With such a large budget for agricultural research it would be expected that some funds would be allocated for biotechnology and subsequently transgenic research. However, except for the maintenance and payment of salaries of staff, currently, there is no allocation of funds by the government of Nigeria for Biotechnology or transgenic research.

33. Kathleen Fraherty et al. (2010), 'Nigeria—Recent Developments in Public Agricultural Research', ASTI, IFPR Washington.

SWOT analysis

Nigeria has immense human capacity for agricultural research compared to other African countries. It also enjoys financial resources from the public funds for research, including transgenic research. This is a major strength for Nigeria as country that remains unutilized. In addition the policy and law makers are well informed on issues of biotechnology and transgenic research generally, but the delays in the legislation process has also caused delays in decision-making within the government structures. The country has started the process of establishing biotechnology and transgenic research institutions and programs as well as establishment of a biosafety regulatory system.

The bureaucracy in the decision-making process in the government structure is the most serious weakness of the entire research system including therefore transgenic research. ARCN which was created some eight years ago is still engaged in establishment and putting the structure in place. Furthermore there is no clear indication of the role of the biotechnology centre *vis-a-vis* the research institutions on the mandates and responsibilities of biotechnology and transgenic research. With such confusion, while the physical infrastructure is in place and the research and biosafety institutions have been formed, they remain weak and lacking in human capacity and scientific equipment.

Like most African countries there is good opportunity for transgenic research to contribute to the food and nutrition security in Nigeria. As one of the major consumers of cassava and rice which have low nutritive value, transgenic research has great potential to improve both the food security and nutritional food value in the country. The existing human capacity and the growing national agricultural research system also provides opportunities for transgenic research.

There is however strong threat of the anti-GMO campaign groups which are very active and spending a lot of resources to influence not only the public put also the policymakers in the country. It is probably the influence of these groups that is causing the long delay for the parliament to pass the biotechnology bill. In addition, like most African countries, Nigeria may not have the capacity to handle intellectual property and trade issues that may arise on commercialization of transgenic products.

Table 15. SWOT analysis for transgenic research in Nigeria

Strengths	Weakness
1. Human, and financial capacity	1. Bureaucracy in decision-making in government structure
2. Interim biosafety institutions	2. Lack of equipment
3. Well informed policy and law makers	3. Weak biotechnology institutions
4. Highly proactive leadership at the policy level	4. Delays in promulgation of biosafety law
Opportunities	Threats
1. Food and nutrition deficit	1. Anti-GMO campaign groups
2. Production constraints for transgenic Research	2. Inadequate capacity to handle intellectual property rights
3. Growing national research system	3. Inadequate capacity to handle emerging issues of trade
4. High potential for increasing productivity	4. Competition of private sector

7.9 Benin

The National Agricultural Research System in Benin comprises of the National Agricultural Research Institute of Benin (INRAB), the universities with agriculture departments, and a few not for profit organizations. INRAB which was established in 1992 is under the supervision of the Ministry of Agriculture and Livestock Development. It constitutes about 60% of the agricultural research system in the country. The institute comprises of the headquarters in Cotonou and six agricultural research centres that are dispersed throughout the country. There is no dedicated infrastructure for biotechnology or transgenic research in Benin.

Policies and legislations

Benin does not have any biotechnology policy or legislation on biotechnology. In 2003, the government issued a moratorium on genetically modified organisms that was supposed to last up to 2008, but was extended from 2009 to March 2014. Currently the moratorium has expired and the government is in the process of national consultations to decide on the way forward. Policymakers and the leaders in the NARs are not keen to make any decision on either transgenic research in the country.

Research capacity

Like other countries in in sub-Saharan Africa, human research capacity in Benin has been declining over the last 20 years. By 2008, the total human capacity declined from 120 fte in 2000 to 115 fte in 2008 due to attrition and the employment freeze in INRAB[34] and currently stands at only 111 fte. The main agricultural research institutions—INRAB employed 65 fte in 2008 and currently stands at 61 fte researchers. However in the institutions of higher education and the number of research scientists has grown from barely 23% in 2000 to 43% by 2012. Currently, the University of d'Abomey Calavi has about 46 fte while the university of Parakau has 4 fte involved in agricultural training and research.

Much of the focus is on crops, comprising of 67% of the fte while livestock accounts for 33% of fte. A large proportion of the research capacity—9.7% in the INRAB and 38% in the universities are carrying out research in cassava. Oil palm and rice also received significant attention with an allocation of 11% of fte and 10% in INRAB, and 38% of fte and 28% fte in the universities.

Funding for agricultural research, is highly dependent on donors—who contribute about 60% of the budget of research in INRAB, while the government and internally generated revenue funds the balance mainly on salaries. There is little funding for research activities in the universities.

There is no biotechnology or transgenic research in Benin. There are however 6 crop geneticists, 1 molecular biologist and 2 animal geneticists in INRAB, 8 geneticists and 3 molecular biologists at the university that have competencies for transgenic research.

SWOT analysis

With the ban of genetically modified organisms in Benin, while policymakers are well informed about the pros and cons of transgenic research, it is only scientists, who express the wish to join their colleagues in the research fraternity in transgenic research. There is a general lack of human and physical capacity, as well as donor support as none is willing even to discuss possibilities of transgenic research in the country. While there are opportunities to address important production constraints and high potential of increasing agricultural productivity, there is no capacity to handle intellectual property rights and trade issues that may arise on adoption of transgenic products. The anti-GMO campaign groups and activists have taken advantage of this situation to the extent that some of the leadership in research institutions are contemplating advising the government that Benin should be a transgenic free country.

34. Gert-Jan Stands and Jonas Hinvi (2010), 'Benin: Recent Developments in Agricultural Research, Country Note, ASTI, IFPRI, Washington.

Table 16. SWOT analysis for transgenic research in Benin

Strengths	Weakness
1. Well informed scientists and policymakers	1. Lack of human and physical capacity
2. Strong will of scientists	2. Lack of donor support
	3. Lack of political will
Opportunities	Threats
1. Food and nutrition deficit	1. Intellectual property rights and trade issues
2. Production constraints for transgenic research	2. Anti-GMO activists and NGO
3. High potential for increasing productivity	

7.10 Burkina Faso

Most of the agricultural research in Burkina Faso is carried out within the auspices of the Environment and Agriculture Research Institutes (INERA). The institute was established in 1996, under the Ministry of Secondary, Higher education and scientific research, and accounts for nearly 85% of the human and financial resources. It comprises of the environment and agricultural research and training centre situated at Kamboinse and five other regional agricultural and environmental research centres located in the five agro-ecological zones of the country.

There are other five relatively smaller public institutions that carry out agricultural related research that take up about 10% of the human and financial resources while the University of Ouagadougou takes up to 8% of the resources.

Policies and legislations

Burkina Faso does not have a stand-alone biotechnology policy but it was among the first countries to legislate the application of transgenic products when it enacted its biosafety law in 2003. Immediately, thereafter, the country put in place the requisite institutions in place and by 2006 approved the commercialization of bt cotton. The national biosafety authority has demonstrated the capacity not only to approve but also to supervise the commercialization of transgenic crops in the country. There are also institutional biosafety committees that provide the technical information that is required for approval and supervision of cultivation of transgenic crops.

Research capacity

Burkina Faso has some basic physical infrastructure, within INERA, and the universities in terms of offices and laboratories, to undertake downstream transgenic research. However like most other countries in sub-Saharan Africa, there is no capacity to undertake upstream transgenic research such as transformation and genomics.

With regard to human resources, the total number of research scientists in Burkina Faso by 2008 was 240 fte researchers of which more than 50% had PhD and virtually all the rest with master's qualification.[35] Generally the staff allocation by main themes is 26% in crop research 22% on natural resources, 17% forestry, 12% on livestock research and 23% others.

Although still not adequate, Burkina Faso has made considerable efforts to establish human capacity for biotechnology and consequently, transgenic research within it public institutions. Currently, there are four crop geneticists and 3 crop molecular biologists undertaking transgenic research activities in the country. There is however neither the physical nor the human capacity to undertake upstream transgenic research.

35. Gert-Jan Stands et al. (2010), 'Burkina Faso Recent Development in Agriculture', ASTI, IFPRI, Washington.

Agricultural research in Burkina Faso is funded by the government with heavy support from donors, mainly the World Bank, and African Development Bank, for infrastructure and operations. In 2008, public investment in agricultural research was USD 19.9 (ppp 2005 price) but had declined to USD 15 million by 2012.

As one of the pioneer countries in cultivation of Bt cotton, and with a proven regulatory framework Burkina Faso has attracted several donors and private sector for transgenic research. Currently, there is considerable financial support from both bilateral and philanthropic donors for various transgenic research, in the country.

Five transgenic events have been approved in Burkina Faso. In addition to the already commercialized Bt cotton, herbicide tolerant cotton (roundup ready flex) and insect resistant cowpea are under trials. Despite the cost of seed, 70% of the cotton grown in the country is already bt cotton. The deployment and commercialization of bt cotton in the country has served to support capacity building for transgenic research as well as to establishing the capacity to deal with the intellectual property rights and trade related issues. Burkina Faso is therefore viewed as a pioneer country with respect to transgenic research and deployment.

The country is involved in a transgenic fungus (*Metarhizium robertsii)* controlling the malaria mosquito, *Anopheles gambiae* and another GM mosquito project, which will use genetic modification of the male mosquitoes to make them sterile.

SWOT analysis

The provision of legal and regulatory frameworks for transgenic products and commercialization of bt cotton gives Burkina Faso an advantage over other Africa countries. The research system and the policymakers are well informed of the pros and cons of transgenic research, and there is a general acceptance of transgenic products by the public. There is however a need for human and financial resources so that the country can build capacity for upstream transgenic research activities such as marker selection and transformation. Furthermore there is still no framework for partnerships between the NARS and the CGIAR centres or the private sector creating a situation of competition and institutional vulnerability on the basis of resources.

Burkina Faso is located on the desert margins and is prone to drought, high infestation of crop pests, and incidences of crop diseases. This poses greater threats of food and nutritional security that are endemic and cannot be resolved using conventional breeding tools. There are therefore, more opportunities for transgenic research to contribute to increase in crop productivity, as it has been proven with bt cotton, hence food security in the country.

Table 17. SWOT analysis for transgenic research in Burkina Faso

Strengths	Weakness
1. Policy and Legal framework in place	1. Inadequate human and financial resources
2. Well established biosafety institutions	2. Weak partnerships with CGIAR centres
3. Well informed policy and law makers	3. Weak private sector
4. Strong will of agricultural research scientists	
Opportunities	Threats
1. Food and nutrition deficit	1. Activities of anti-GMO campaign groups
2. Production constraints for transgenic research	2. Competition of multinational companies
3. High potential for increasing productivity	
4. Need for climate smart transgenic products	

7.11 Cameroon

The National Agricultural Research System in Cameroon comprises of the Institute of Agricultural Research and Development (IRAD) established in 1996 from the amalgamation of the various institutes under different departments, and the national universities. The institute falls under the Ministry of Scientific Research and Innovations rather than the Ministry of Agriculture. Due to this reporting structure, there are strained relationships between the institute and the Ministry of Agriculture.

IRAD is organized into three specialized centres, one on marine and fisheries, the other on forestry and environment and the third on oil palm; and five regional centres covering each of the five main agro-ecological zones of the country with cover crops and livestock research mandates. There is a biotechnology centre under the auspices of Yaoundé University, but it is not functional.

Policies and legislations

There is no standalone policy for biotechnology research in Cameroon, as it is argued that the policy direction for such research is well articulated in the science and technology policy. Despite having no policy the government promulgated the biosafety *Law N° 2003/006 in 21 April 2003* 'setting the pace for safety regulations governing modern biotechnology in Cameroon'. However it was not until May 2007 that a decree No. 2007/0737 was adopted to fix the application of the biosafety law. The law provides for the establishment of the regulatory institutions and committees. While some of these institutions such as the national biosafety committee and the institutional committees have been established they have no capacity to carry through the approval process for transgenic research and deployment.

Capacity in research

Generally, Cameroon has the requisite physical infrastructure for research within the main public research organizations for the agricultural research needs for the country. The centres have the physical structures for offices and laboratories for the research needs. There is however a general lack of modern equipment to carry out even simple soil and plant analysis in both IRAD and the universities to the extent that these services are provided by collaborating international institutions in the country. IRAD reports of the existence of a biotechnology laboratory at Ekona, where it is possible to carry out some tissue culture procedures.

Establishing the total scientific capacity for agricultural research in the country is not possible because no baseline study has been carried out. However IRAD reports that there are about 169 fte scientists across its centres of which 44 (26%) have PhD and 93 (55%) have masters. Currently, there is no molecular biologist or geneticist involved in either crop or livestock biotechnology or transgenic research in the country.

In 2010, the Cameroon cotton company expressed interest to experiment GM insect resistant and or herbicide tolerant cotton varieties. However some of the product developers declined the tender, arguing that the regulatory provisions were not well aligned with those of the International treaties such as the Cartagena Protocol on Biosafety. Nevertheless the cotton company managed to establish a partnership with Bayer Crop Science to start field trialing of GM cotton in 2010. This achievement prompted needs and demand for biosafety regulatory capacity building in the country. It is worth noting that Cameroon is also implementing a biosafety project titled *'Cameroon: Development and Institution of a National Monitoring and Control System (Framework) for Living Modified Organisms (LMOs) and Invasive Alien Species (IAS) under the Global BS Program'*.

SWOT analysis

Cameroon was one of the first countries in Africa to have a policy and legal framework on biotechnology. This has given it relative strength to undertake transgenic research and deployment. The country has also well-established biosafety institutions and well informed policymakers. However the lack of political will, and conflicts of decision-making in line ministries have made it impossible for the country to build the human and physical capital that is required to undertake not only transgenic but also other biotechnology research activities. The fact that agricultural research falls under another ministry other than agriculture has made difficult for the NARS to relate well with the ministry, causing poor relation and irrational decisions that have been detrimental to transgenic research and deployment. In such a situation, it is not possible to have proper coordination of research activities or partnerships with the stakeholders.

As a semi-humid to humid tropical country, Cameroon has huge opportunities to increase its agricultural productivities beyond is needs. There is however still high food and nutrition deficit, due to endemic crop pests, diseases and other production constraints that cannot be addressed with conventional breeding tools. Like other African countries there is however the threat of lack of capacity to manage emerging intellectual property and trade issues, and the activities of anti-GMO campaign groups.

Table 18. SWOT analysis for transgenic research in Cameroon

Strengths	Weakness
1. Policy and Legal framework	1. Lack of human and physical resources
2. Interim of biosafety institutions	2. Lack of donor support
3. Well informed policy and law makers	3. Poor institutional coordination
	4. Weak partnerships with the international system
Opportunities	Threats
1. Food and nutrition deficit	1. Intellectual property rights and trade issues
2. Production constraints for transgenic research	2. Activities of anti-GMO campaign groups
3. High potential for increasing productivity	

7.12 Burundi

The national agricultural research system in Burundi comprises of the Burundi Institute for Agronomic Sciences (ISABU) which accounts for about 66% of research capacity and investments; the national centre for food technologies; the National Veterinary Laboratories and the Institute for Agronomic and Animal Production Research which account for about 19%; and the universities accounting for the rest 15% of the research capacity. ISABU has the mandate for research in crops, livestock and natural resources management including forestry and agroforestry. Research activities are conducted in six agricultural research experimental stations, ten research centres and six research units spread throughout the agro-ecological zones in the country.

Like many institutions in the country, ISABU which was created in 1962, underwent a period of decline ant turmoil during the 1990s following the period of the civil war in 1993 but has picked up since the peace agreement in 2003. The physical infrastructure in the stations is poor and there are hardly any equipped laboratories for biotechnology or transgenic research.

Policies and legislations

Burundi is one of the countries in Africa that after signing the Cartagena Protocol in 2005 has not made and attempts to do its own policy or legislative framework on biotechnology. A program to initiate the process of developing a biosafety framework was initiated in 2006, but was not followed up for implementation. Consequently Burundi has been left out by development partners and regional initiatives on biotechnology to the extent that the national system is not aware of the position of the government on the Cartagena Protocol.

The Ministry of Agriculture does not have any initiative on biotechnology research or biosafety framework. The Ministry of Environment is the national focal point on biosafety and it is supposed to be the secretariat for the National Biosafety Committee. The committee that comprises of various line ministries and relevant institutions was gazetted in 2006 but it is not functional.

The Ministry of Agriculture does not have any particular position on transgenic research in Burundi as it is waiting for the policy and the legislation from the national focal point. The Ministry views transgenic research as somewhat too advanced for its national research capacity.

The parliamentary committee on agriculture is quite conversant with the debate on GMO and would support the process of developing a policy and legislation. The committee is aware that the debate on GMO has a lot to do with business competition of multinational companies of America and Europe. The committee is however not well exposed to what is happening in the rest of the world because there is no government or donor support to this process in Burundi. The committee is also concerned that the NARS in the country does not have the capacity not only to participate in transgenic research but also to per take in the debate and advise the policymakers accordingly.

Research capacity

After destruction by the civil wall in the 1990, Burundi's physical and human capacity is far below the critical mass to undertake any meaningful upstream agricultural research. The current physical and human capacity as been rebuilt after the signing of the peace agreement in 2003 but is still relatively poor. Since then the number of scientists has been increasing gradually from a total of 69 fte in 2000 to about 98 fte in 2010[36] and now stand at about 112 fte. In ISABU the number of scientists has increased from 49 fte in 2003 to 63 fte in 2008 and now stands at 69 fte. Forty-five percent of these scientists are in crops research, 15% in post-harvest, 12% in Livestock, and 5% in forestry. The universities do not undertake much research due to teaching work load of scientists and luck of funds.

Most of these scientists in the NARS in Burundi are at either BSc or MSc level of qualification. Out of the 69 scientists in ISABU there are only 3 of them with PhD, 3 in training for PhD and, 40 with masters degrees. Due to the low salaries, the institute cannot retain highly qualified scientists and over the last 10 years most of those trained to PhD levels have been leaving either to universities or international organizations. The proportion of scientists with PhD has therefore remained at about 10% since 2008.

The institute has only seven fte scientists for livestock research but actually there is no meaningful research going on. There is there very little capacity to carry out not only transgenic research but also upstream crop and livestock research.

Funding for agricultural research also declined badly in the 1990s but started to build up after the peace agreement in 2003. In the last decade funding for agricultural research has increased from hardly USD 4 million (ppp 2005 price) to USD 9.2 in 2008, and currently to USD 10.3 million per year. Funding for agricultural research is from government (62%) and donors who are mainly the Belgian Government and the World Bank. ISABU is highly dependent on small grants from international agricultural research centres and regional organization for the operational costs of its research activities.

SWOT analysis

Burundi is one of the countries in Africa that does not have any biotechnology policy or legal framework, even under preparation. The government and research managers argue that after the devastation by the civil war the country does not have the capacity to partake in advanced research such as biotechnology. They believe that the research capacity is so poor that the country does not have qualified manpower to inform the policy or law making process. Currently, Burundi is in dire need for training and capacity building for the whole of its national agricultural research system.

There is however a strong will on the part of scientists and they have started lobbying the government to start the process of developing a policy and subsequently a legal framework for biotechnology.

Like other African countries, there are opportunities for transgenic research to contribute to food and nutrition security and in Burundi as there are many production constraints that can be resolved otherwise. Like in Uganda the

36. Gert-Jan Stads and Leonidas Ndimurirwo (2009), 'Burundi Recent Development in Public Agricultural Research, ASTI, IFRPI, Washington.

threat of banana Xanthomonas wilt is serious issue in the country that cannot be resolved in any other way. However the anti-GMO campaign groups have made inroads and are targeting the legislature and the policymakers to ensure that transgenic products do not find their way in the country.

Table 19. SWOT analysis for transgenic research in Burundi

Strengths	Weakness
1. Informed policy and law makers	1.Lack of biotechnology policy and legislation
2. Strong will of scientists	2. Lack of human and physical capacity
	3. Lack of donor support
Opportunities	Threats
1. Food and nutrition deficit	1. Anti-GMO lobby groups
2. Production constraints for transgenic research	2. Intellectual property and trade issues
3. High potential for increasing productivity	

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Annex I Transgenic research activities in participating CGIAR centres

Centre/program	Project title	Partners	Trait	Stage
ILRI	1. Developing disease resistant cattle in Africa	Roslin Institute, University of Missouri	Trypanosomiasis resistance	Proof of concept
CIMMYT	1. Water Efficient Maize For Africa phase II (WEMA II)	Monsanto, AATF, Kenya, Mozambique, South Africa, Tanzania, Uganda.	Drought tolerance and Insect Resistance	CFT
	2. Improved Maize for African Soils (IMAS)	Pioneer, Kenya and South Africa	NUE	Laboratory
CIP	1. Insect resistant sweetpotato	NARO Uganda, Jomo Kenyatta University	Insect resistance	CFT
	2. Developing leaf roll resistant potato			Proof of Concept
	3. Developing late blight resistant potato	Cornell, Wageningen Univ. NARO Uganda	Disease Resistance	Proof of Concept
	4. Developing sweetpotato virus disease resistant sweetpotato for Africa	DDPSC, NARO,	Disease Resistance	Proof of Concept
ICRISAT				
PL5-Chickpea and pigeonpea (Global)	1. Developing Chickpea, cowpea and pigeonpea cultivars with high resistant to targeted insects through integrated breeding methods	Gov. of India, ICAR	Insect resistance	CFT
PL8-Pigeonpea (Global)	2. Development and characterization of hybrid pigeonpea parents with resistance to key biotic and abiotic stresses	Gov. of India, ICAR	Multiple resistance	
PL3-Groundnut (WCA/ESA/SSA)	3. Development of short duration, drought tolerant, nutrient dense and low afflation breeding lines/varieties	Gov. of India, ICAR; JIRCAS	Drought Tolerance	CFT
PL7 -Herbicide Tolerance	4. To develop transgenic chickpea tolerant to herbicides	Gov. of India, ICAR	Herbicide tolerant	Proof of Concept
PL7 Sorghum SA	5. Development of varieties and hybrid parents with improved resistance to shoot fly, stem borer, aphids and charcoal rot	Gov. of India	Insect resistant	Proof of concept
	6. Development of varieties and hybrid parents with enhanced biomass yield, foliar disease and stem borer resistance	Gov. of India, ICAR	Multiple	Proof of concept
Cowpea Nutrition	7. Bio fortified Cowpea	Gov. of India, ICAR	Vitamin A	Proof of Concept

Centre/program	Project title	Partners	Trait	Stage
Ground Nut Nutrition	8. Developing Bio fortified Groundnut	Gov. of India, ICAR	Vitamin A	CFT
Groundnut productivity	9. Developing disease Resistant Groundnut	Gov. of India	Virus resistance	Proof of Concept
IITA	1. Developing transgenic banana with resistance against Xanthomonas wilt	NARO, KALRO, AATF,	Disease resistance	MLT
	2. Developing control of cassava brown streak disease	Dantford Center, KALRO, NACRI	Virus resistance	CFT
	3. To evaluate transgenic plantain for nematodes resistance under field conditions	University of Leeds, UK, NARO	nematode resistance	CFT
	4. Developing control of bacterial wilt disease in enset	EIAR	disease resistance	Proof of Concept
	5. Genetic transformation and regeneration of yam (Dioscorea spp.)		protocol	Protocol development
	6. Fast breeding for slow crops: doubled haploids in cassava and banana	UC Davis, CIAT	New breed tools	Proof of Concept
IRRI	1. Developing nutritious rice	NARS	Pro-Vitamin A,	MLFT
	2. Developing Iron rich rice	NARS	High Fe	CFT
	3. Developing drought tolerant rice	JIRCAS	drought tolerant	proof of concept
	4. Developing photosynthetic efficient rice	None	Growth	Proof of Concept

Annex II SWOT analysis for the participating CGIAR centres

Centre	Project title	Budget	Funding	
ILRI	1. Developing disease resistant cattle in Africa	2,000,000	200,000	
CIMMYT	1. Water Efficient Maize For Africa phase II (WEMA II)	5,000,000	5,000,000	for all partners
	2. Improved Maize for African Soils (IMAS)	17,000,000,000	4,285,714	for all partners
CIP	1. Developing weevil resistant sweetpotato	1,000,000*	400,000 in 2013	*total needed for 3 to 6 years
	2. Developing late blight resistant potato	1,000,000*	400,000 in 2013	total needed for 3 to 6 years
	3. Developing virus disease resistant sweetpotato	1,300,000*	–	*total needed for 3 to 6 years
ICRISAT	1. Developing chickpea, cowpea and pigeonpea cultivars with high resistance to targeted insects through integrated breading methods	9,000,000		
	2. Development and characterization of hybrid pigeonpea parents with resistance to key biotic and abiotic stresses			
	3. Development of short duration, drought tolerant, nutrient dense and low afflatoxin groundnut breeding lines/varieties	2,300,000		
	4. To develop transgenic chickpea tolerant to herbicides			
	5. Development of varieties and hybrid parents with improved resistance to shoot fly, stem borer, aphids and charcoal rot			
	6. Development of varieties and hybrid parents with enhanced green forage, sweet stalk, Stover yield, foliar disease and stem borer resistance and quality for fodder and other uses			
	7. Developing bio fortified cowpea			
	8. Developing disease resistant groundnut			
	9. Developing bio fortified groundnut			
IITA	1. To evaluate transgenic plantain for nematodes resistance under field conditions	500,000	45,000	for centre only
	2. Developing control of cassava brown streak disease	900,000	336,000	One yr, for centre only
	3. Developing transgenic banana with resistance against Xanthomonas wilt	1,160,000	386,000	One for centre only
	4. Developing control of bacterial wilt disease in enset	2,590,000	647,500	for all partners
	5. Genetic transformation and regeneration of yam (Dioscorea spp.)	703,941	351,971	for centre only
	6. Fast breeding for slow crops: doubled haploids in cassava and banana	330,000	110,000	for centre

Centre	Project title	Budget	Funding
IRRI	1. Pro vitamin A rice development for Philippines, Indonesia and Indonesia	3,900,000	3,900,000
	2. Reduction of iron deficiency under the Harvest Plus program	600,000	1,500,000
	3. Investigations for candidates genes for drought tolerant	750000	750000
	4 Investigations for candidates genes for disease resistance	375,000	375,000
	5 Investigations for candidates genes for phosphorous uptake	375,000	375,000
	Total	83,783,941	19,026,851

Annex III SWOT analysis for the centres

Centre	Strengths	Weakness
ILRI	1. Headquarters in Africa	1. Weak communication, and public relations
	2. State of the art bioscience facility	2. Inadequate partnership with NARs and SROs
	3. Critical mass of scientists and physical infrastructure	3. Not well known by policy and law makers
	4. Reasonable support and good will from donors	4. Weak partnership with private sector
	Opportunities	Threats
	1. Increasing importance of livestock for food and nutrition security	1. immerging intellectual property rights, and trade issues
	2. Critical Livestock production constraints for transgenic research	2. Restrictions from some donors
	3. Potential for increasing livestock productivity	3. Competition with SROs
	4. Partnerships with the private sector and advanced research centres	4. Lack of capacity in NARs for partnerships
		5. Strong Anti-GMO lobby groups and organizations
CIMMYT	1. Strong presence in Africa (East and southern)	1. Inadequate communication channels
	3. Good partnership with NARS	2. Inadequate partnership with SROs
	3. Critical mass of Scientists	3. Lack of own transgenic products
	4. Strong support from development partners and private sector	4. Inadequate
	Opportunities	Threats
	1. Maize and Wheat staple food in Africa	1. Emerging intellectual property rights, and trade issues
	2. Critical constraints for transgenic research in mandate crops	2. Restrictions from donor
	3. High potential for increasing maize and wheat productivity	3. Competition with SROs
	4. Partnership with the private sector and advanced research centres	4. Conflict of interest with some stakeholders
	5. Emerging threats of pests and diseases with climate change	5. Strong Anti-GMO lobby groups and organizations

Centre	Strengths	Weakness
IITA	1. Headquarters in Africa	1. Inadequate communication, and public relations
	2. Mandate crops critical for critical food security crops in Africa	2. Inadequate partnership SROs
	3. Critical mass of scientists	3. Low critical mass of human capacity
	4. Support and good will from donors	4. Poor interaction with policymakers except in Nigeria
	5. Good Partnerships with NARS in some countries	5. Weak partnership with private sector
	Opportunities	Threats
	1. Expanding utilization of mandate commodities	1. Emerging intellectual property rights, and trade issues
	2. Critical production constraints for mandate crops	2. Restrictions from donors
	3. High potential for increasing mandate crop productivity	3. Lack of capacity in NARS for partnerships in some countries
	4. Emerging pests and diseases with climate change	4. Strong Anti-GMO lobby groups and organizations
CIP	1. Strong leadership in transgenic research	1. Lack of communication and public relations
	2. Mandate crop emerging as staple food	2. Inadequate partnership with NARs in some countries and SROs
	3. Good partnership with NARS in some of the primary target countries	3. Weak Regional Office in Africa
	4. Highly focused on 2 (possibly 3) GM products with highest potential for adoption	4. Poor interaction with policy and law makers
	Opportunities	Threats
	1. Increasing utilization of mandate commodity	1. Weak leadership in NARS for product deployment
	2. Critical production constraints that can be addressed by Transgenic Research	
	3. High potential for increasing productivity of mandate crops	
	4. Partnerships with the private sector and advanced Research centres	
ICRISAT	1. Well established strong regional offices	1. Inadequate partnerships in Africa
	2. Holistic approach to transgenic research	2. Weak partnership with NARS and SROs in Africa
	3. Critical mass of Scientists	3. Poor interaction with policymakers in Africa
	4. State of the art genomics and transgenic research facilities	
	5. Strong support from government of India and other donors	
	Opportunities	Threats
	1. increasing importance of mandate crops	1. Inadequate financial resources for optimum utilization of the physical capacity
	2. Critical production constraints for transgenic research	2 Lack of capacity with NARS for partnerships
	3. High potential for increasing mandate crop productivity	3. Low interest of private sector on mandate crops
	4. Partnerships with private sector	4. Strong Anti-GMO lobby groups and organizations
	Strengths	Weakness

Centre	Strengths	Weakness
IRRI	1. Well established physical infrastructure for biotechnology research	1. Weak presence in Africa
	2. Strong partnership and communication in Asia	2. Weak partnerships and public relationships in Africa
	3. Critical mass of scientists	3. Unkown by policymakers and in Africa
	4. Critical production/nutrition constraints for rice transgenic research	4. Lack of comprehensive program for Africa
	Opportunities	Threats
	1. Rice increasingly becoming a staple food in Africa	1. Restrictions from some donors
	2. Critical production constraints for transgenic research	2. Poor interaction with stakeholders in Africa
		3. Lack of an African program
		4. Strong Anti-GMO lobby groups and organizations

Annex IV Transgenic research projects in countries

Country Project title	Partners	Crop	Trait	Event	Stage
Kenya					
1. Drought Tolerant Maize for Africa	AATF, CIMMYT, +	Maize	Drought tolerance	CspB-Zm event 1	CFT
2. Bio fortified Sorghum for Africa	AATF, AHBFI, Danforth Centre +	Sorghum, *Sorghum bicolor*	Nutritional enhancement		CGHT
3. Insect Resistant Maize for Africa	CIMMYT, Monsanto+	Maize	Insect Resistance	Cry1Ab216, Cry1Ba	CGT
4. Insect Resistant Cotton	Monsanto	Cotton, *Gossypium hirsutum*	Insect Resistance	Borguard II	CFT
5. Virus Resistant Cassava for Kenya	Danforth, KALRO, IITA PSC+	Cassava, *Manihot esculenta*	CBSD resistance	RNAi	CFT
6. Protein, Iron and vitamin A fortified Cassava.	Danforth Centre +	Cassava, *Manihot esculenta*	Nutrition		CFT
7. Virus disease resistant sweetpotato for Kenya	Monsanto +KALRO	Sweetpotato, *Ipomoea batatas*	Virus disease	CPT 560	CFT
Uganda					
1. Insect Resistant Cotton	Monsanto, ABSPII, Cal. Univ. +	Cotton, *Gossypium hirsutum*	Insect Resistance	Borguard II	CFT
2. Virus Resistant Cassava for Uganda	IITA, Danforth, KALRO C +	Cassava, *Manihot esculenta*	Virus resistance	RNAi	CFT
3. Insect Resistant Maize for Africa	CIMMYT, Monsanto+	Maize	Insect Resistance	Cry1Ab216, Cry1Ba	CGT
3. Drought Tolerant Maize for Africa	AATF, CIMMYT +	Maize	Drought tolerance	CspB-Zm event 1	CFT
4. Disease (Xanthomonas wilt) Resistance Banana	IITA, NARO, KALRO, AATF	Banana, Musa spp.	Disease resistance	Pflp and Hrap	CFT
5. Parasitic nematode and weevil resistant banana	A, UoL, NARO	Banana, Musa spp.	nematode resistance	Maize cystatin and synthetic peptide	CFT
6. Iron and vitamin A fortified Banana	Queensland Univ. of tech, NARO	Banana, Musa spp.	Nutrition		CFT
7. Weevil and virus disease resistant sweet potatoes that are in the stage of confined greenhouse and field trials respectively	CIP, NARO, Donald Danforth Centre +	Sweetpotato, *Ipomoea batatas*	Insect and virus disease resistance		CGT and CFT

Country	Project title	Partners	Crop	Trait	Event	Stage
Ethiopia			None			
Malawi						
1. Insect resistant cotton		Monsanto, ABSPII, +	Cotton, *Gossypium hirsutum*	Insect Resistance	Borguard II	CFT
South Africa						
1. Bio fortified cassava		ARC-IIC +	Cassava, *Manihot esculenta*	Starch enhancement	TMS60444	
2. Insect and herbicide tolerant Cotton		ARC-IIC +	Cotton, *Gossypium hirsutum*	Insect/herbicide tolerance	9 events	Rel.
3. Insect Resistant Potato for South Africa		Michigan State University, ABSP, ARC	Potato *(Solanum tuberosum)*	Insect resistance	ARC-OVI	CFT
4. Alternative Sugarcane for South Africa		SASRI +	Sugarcane, *Saccharum officinarum*	Alternative sugar	NCo310	CFT
3. Drought tolerant and Insect Resistant Maize for South Africa		CIMMYT, Monsanto+	Maize	Insect Resistance	Cry1Ab216, Cry1Ba	CFT
5. Drought Tolerant Wheat for South Africa		AGERI, +	Wheat (*Triticum durum*)	Drought tolerance	HVA1	CFT
6. Bio-fortified Sorghum for Africa		AHBFI +	Sorghum, *Sorghum bicolor*	Nutritional enhancement		CGHT
7. Insect and disease tolerant Maize for South Africa		Syngenta +	Maize, *Zea mays*	Insect/herbicide resistance	GA21 MIR162 BT11xGA21	FTR
Zimbabwe			None			
Ghana						
1. Insect Resistant Cowpea for Africa		AATF, NGICA, IITA, +	Cowpea, *Vigna unguiculata*	insect resistance	Cry1Ab and nptII	CFT
2. High protein Sweetpotato;						
3. N-use efficiency, Water –use efficiency, and Salt Tolerant (NEWEST) Rice;		AATF, CIAT, Acardia Bios+	Rice	Abiotic stresses		Lab
4. Insect resistant Bt Cotton.						
Nigeria						
1. Insect Resistant cowpea for Nigeria		AATF, IITA, +	Cowpea, *Vigna unguiculata*	Insect resistance	Cry1Ab and nptII	CFT
2. Protein, Iron and vitamin A fortified Cassava.		Danforth Centre +	Cassava, *Manihot esculenta*	Nutrition		CFT
3. N-use efficiency, Water –use efficiency, and Salt Tolerant (NEWEST) Rice;		AATF, CIAT, Acardia Bios+	Rice	Abiotic stresses		Lab
Cameroon						
1. Insect Resistant Cotton		Monsanto, ABSPII, CU	Cotton, *Gossypium hirsutum*	Insect Resistance	Borguard II	CFT
Burkina Faso						
1. Insect Resistant Cowpea for Africa		AATF, NGICA, IITA, +	Cowpea, *Vigna unguiculata*	insect resistance	Cry1Ab and nptII	CFT
2. Bio-fortified Sorghum for Africa		AHBFI +	Sorghum, *Sorghum bicolor*	Nutritional enhancement		CGHT
3. Insect Resistant Cotton for Africa		Monsanto, ABSPII, +	Cotton, *Gossypium hirsutum*	Insect Resistance	Borguard II	CFT
4. N-use efficiency, Water –use efficiency, and Salt Tolerant (NEWEST) Rice;		AATF, CIAT, Acardia Bios+	Rice	Abiotic stresses		Lab
Burundi		NIL				

Annex V Donor supported transgenic research in Africa and Asia

Donor	Activity	Countries	Partners
USAID	Insect Resistant in Cowpea	Nigeria, Ghana, Burkina Faso	AATF
	Climate resilience rice	Nigeria, India, Uganda, Bangladesh,	AATF, ICARDA
	Virus resistant Cassava	Uganda, Kenya	Danforth, IITA
	Drought Tolerant Maize	Uganda, South Africa, Tanzania, Kenya, Mozambique	CIMMYT, AATF
	Disease resistant Banana	Uganda, Kenya	IITA, ABSPII
	Nitrogen Use Efficient Maize	South Africa, Kenya	
	Insect resistant eggplant	Bangladesh, India, Philippines	ABSPII
	Disease resistant potato	India, Indonesia, Bangladesh	ABSPII, CIP
	Climate resilient wheat	India	ICARDS
	Climate resilient millet	India	UC Davis
	Virus Resistant papaya	Philippines	ABSPSII
	Bio fortified rice	Philippines, Indonesia	IRRI
BMGF			
	Golden Rice	Philippines, India, Bangladesh	IRRI
	Bio cassava Plus	Kenya Nigeria	Danforth Centre
	High iron rice	India, Philippines, Indonesia	IRRI
	Virus resistant cassava	Uganda, Nigeria	Danforth Centre
	Bacteria will resistance in enset	Kenya, Ethiopia	IITA, EIAR
	Weevil resistance sweetpotato	Uganda, Kenya	CIP
	Water efficient maize for African	Kenya, Mozambique, south Africa, Tanzania, Uganda	CIMMYT, AATF, Monsanto
	Improved Maize for Africa Soils	Kenya, south Africa	CIMMYT, Pioneer
	C4 Rice	Global	IRRI
	Wheat rust resistance	Global	ICARDA
	Fast Breeding Banana and cassava (BREAD project–NSF/BMGF)	Global	UC Davis, IITA, CIAT
	Yam transformation	Kenya	IITA

Donor	Activity	Countries	Partners
DFID			
	Improved yield and stress tolerance in tropical grain legumes (cow pea, groundnuts, common bean and chickpea	Nigeria, India, Ghana	IITA, ICRISAT
	Water efficient maize for African	Kenya, Mozambique, South Africa, Tanzania, Uganda	CIMMYT, AATF, Monsanto
	C4 Rice	Global	IRRI
	Wheat rust resistance	Global	ICARDA
	Nematode resistance plantain (DFID/ BBSRC was funding this project from 2008–2011)	Uganda	Leeds University, IITA

Annex VI Terms of reference for the study

This study presupposes that with the current levels of physical and human capacity, financial investments, and institutions dealing with agricultural biotechnology research in Africa, there is need for a strategic framework for CGIAR centres on this agenda. Such a framework should be based on comprehensive understanding and information on (i) human capacity and the investments in agricultural biotechnology of CGIAR and NARS; (ii) research activities, in particular by the CGIAR centres and NARs, and the anticipated research outcomes and potential products; (iii) national polices, legislations, regulations and perceptions on agricultural biotechnology; and (iv) donor policies and strategies. This study will document these parameters and provide a prognosis of the political economy of agricultural biotechnology in Africa. Based on the analysis of this information, the study will seek to consult with CGIAR centres working in Africa, Regional and subregional research organizations, and NARS in selected countries to draft a strategic framework for biotechnology research by the CGIAR in Africa.

The overall objective of the study is 'to provide comprehensive analysis of the current capacity and regulatory situation, and implications for CGIAR agricultural biotechnology research for development in Africa with the main focus on transgenic biotechnology.' The study will set the stage for a strategic framework for transgenic biotechnology research in Africa for the participating CGIAR centres.

The study will involve the following tasks:

1. Carry out a comprehensive literature review on the current human resource and infrastructure capacity at national and international level as well as the source of funding for agricultural transgenic biotechnology research by CGIAR centres in Africa.
2. Collate information on the current human and physical capacity, and also level and source of funding for agricultural transgenic biotechnology research and development in a sample of countries in Africa.
3. Assess the status of agricultural transgenic biotechnology policies, legislations, regulatory frameworks, and institutional capacity for implementation of the same in the sample countries.
4. Review the knowledge base and perceptions of policymakers on agricultural transgenic biotechnology research and development, policies, legislations, regulatory frameworks, and institutional capacity in a sample of countries in Africa.
5. Benchmark with other developing countries, especially from Asia on the status of transgenic biotechnology research and development.
6. Provide details of potential donors and agencies supporting agricultural transgenic biotechnology research in Africa.
7. Review the policies and strategies of key donors of agricultural transgenic biotechnology research in Africa.
8. Compile a report on opportunities and challenges for CGIAR's agricultural transgenic biotechnology research in Africa.

9 Propose a strategic framework for transgenic biotechnology research for CGIAR in Africa, in partnership with NARS and the process of fast tracking approvals of transgenic products in the pipeline, through the value chain.

Compile a comprehensive report of the study.

Methodology

The methodology for the study will involve literature review and data collection from the relevant institutions and a field survey with structured questionnaire. Scheduled meetings will be held with CGIAR centres, donors, subregional agricultural research organizations (SROs), National Research Institutions and universities, and selected donors.

In particular the study will seek to consult top level policymakers, the executive and law makers of the sampled countries with a view of seeking their position and priorities for transgenic research. The study will seek the support and approval of the political apex organization—the African Union so as to enhance regulatory process and uptake of the products of research.

In this regard the study will consult with the African political and economic apex organizations (African Union, COMESA); national governments policymakers, (permanent secretaries and ministers), and law makers (relevant parliamentary committees).

A desk study will be carried out after which the consultant will produce a detailed work plan for the field visit. It is proposed that the study will cover some 11 countries that have greater potential for application and adoption of biotechnology products. Three to four donors of agricultural biotechnology in Africa will also be part of the sample of the study.

A strategic framework for the future of biotechnology research for CGIAR will then be developed and discussed with the Directors General and coordinators of agricultural biotechnology research programs. Subsequently, the outcomes will be discussed with apex African political and policy organization and a sample representation of the policy and law makers that had been consulted.

Transgenic agricultural research and product development in Africa—A strategic framework for international and national research Strategic framework matrix

Vision: Increase crop and livestock productivity and quality for wealth creation, food and nutrition security, and ecosystem quality in Africa through transgenic research

Objectives	Strategies	Actions	Outputs and outcomes
1. Improve planning, implementation efficiency, policy and communication of transgenic research in Africa	S1.1 Establish a CGIAR biotechnology strategy support and planning group	A1.1 Centre DGs support establishment of the group and propose a TOR	O1.1 CGIAR biotechnology strategy support group established with scientists based in Africa by 2015
	S1.2 Reviewing and harmonizing institutional biotechnology policies	A1.2 Centre DGs to form an inter-centre biotechnology policy harmonisation and review team to review policies in consultation with legal firms and stakeholders	O1.2 Centre biotechnology policies reviewed, harmonised and shared with partners by 2015
	S1.3 Centres jointly communicate and interact with public and policymakers on transgenic products.	A1.3 Operationalize the biotechnology strategy and support group	O1.3 Inter-centre policy briefs and communication briefs released to stakeholders
	S1.4 Periodic inter-centre transgenic research review and planning	A1.4 Operationalize biotechnology strategy and support group	01.4 Inter-centre shared services and field trials
	S1.5 Mainstream advocacy, capacity building for biosafety, policy and baseline studies in Africa to regional and sub-regional organizations	A1.5 Centre DGs support and ask FARA and SROs to take initiative	O1.5 Policy makers in Africa better informed on GMOs and biosafety institutions operate more efficiently
2. Develop crop varieties with novel traits for increased productivity, economic benefits and nutritional value	S2.1 Enhance support to release and commercialization of ongoing transgenic research	A2.1 Centre management support and facilitate ongoing transgenic research activities	O2.1 At least three transgenic varieties released in Africa by 2017
	S2.2 Diversify donor funding for transgenic research in Africa	A2.2 Centres explore financial support from multilateral donors	O2.2 At least three new donors support transgenic research in Africa by 2017
	S2.3 Deploy transgenic products on orphan food crops being developed by centres	A2.3 International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) to initiate process to deploy novel transgenic products on orphan crops in Africa with national agricultural research systems.	O2.3 At least three transgenic research activities on orphan crops started by 2016 and varieties released by 2022
	S2.4 Develop a program for bio-fortified rice for Africa	A2.4 IRRI to initiate a program on bio-fortified rice for Africa with national agricultural research systems	O2.4 Research program on bio-fortified rice initiated by 2016 and varieties released by 2025
	S2.5 Develop binding partnerships with regional and sub-regional organizations to be agents of basic research	A2.5 DGS initiate discussions with AU, FARA and sub-regional organizations	O2.5 Binding and monitorable partnerships with regional and sub-regional organizations

Objectives	Strategies	Actions	Outputs and outcomes
3. Develop livestock breeds with novel traits for increased productivity and economic benefits	S3.1 Revamp ongoing research on trypanosomiasis resistance in cattle	A3.1 Centre scientists and management solicit sustainable funding for ongoing research on disease resistance in cattle	O3.1 Ongoing transgenic research for disease resistant cattle continues to conclusion and transgenic cattle released by 2025
	S3.2 Enhance basic (genomics and sequencing) livestock research	A3.2 Centre management allocates staff and resources for livestock genomics research	O3.2 Genes discovered for endemic economic cattle diseases
	S3.3 Expand transgenic research into small ruminants and poultry	A3.3 DDG research to decide on feasibility	03.3 Genes discovered for endemic and economic small ruminants and poultry
4. Develop capacity in national agricultural research systems in transgenic biotechnology research and services in Africa	S4.1 Capacity building components for national agricultural research systems in research activities	A.4.1 Program leaders review projects to include capacity building for national agricultural research systems	O4.1 Critical mass of scientists in national agricultural research systems undertaking transgenic research in all test countries
	S4.2 Capacity building and training needs assessment for biotechnology research in national agricultural research systems	A4.2 Centres initiate a process to establish training and capacity needs for national agricultural research systems in Africa in conjunction with FARA	O4.2 Comprehensive training and needs for national agricultural research systems in Africa established by 2016
	S4.3 Develop training and capacity building programs in national agricultural research systems and universities	A4.3 Centres jointly with national agricultural research systems, SROs and ROs initiate the process to develop training and capacity building programs for national agricultural research systems in Africa	O4.3 Critical mass of scientists undertake transgenic research in at least 15 countries in Africa by 2020
	S4.4 Support regional bioscience research service and capacity building entities	A4.4 ILRI-BecA Hub develops marketing strategy and mechanisms for joint activities with the PPTC of ICRISAT	O4.4 ILRI-BecA Hub/ joint training programs in place by 2017 and ILRI has services used by over 300 African scientists a year by 2016
	S4.5 Support national agricultural research systems and SROs to develop South-South cooperation programs, especially with India	A4.5 Centre DGs (in particular ILRI and ICRISAT) propose a South-South cooperation program to selected SROs and national agricultural research systems in Africa	O4.5 South-South research partnership program developed by 2016
5. Enhance deployment, stewardship, commercialization and adoption of transgenic products in Africa	S5.1 Mainstream confined field trials, release of products into national research programs and owned by national agricultural research systems or private sector in best bet countries with conducive policies, legislations and regulatory framework	A5.1.1 Centre management begins negotiations with national agricultural research systems and private sector to take over responsibilities for CFTs, release and stewardship of transgenic products	O5.1.1 CFTs, release and stewardship responsibility taken over by national agricultural research systems and private sector by 2017
		A5.1.2 Biotechnology strategy and support group develops criteria and advises centres on focal countries	O5.1.2 Transgenic research products released within stipulated time frame
	S5.2 Strengthen centre-national agricultural research systems and private sector partnerships for release and stewardship of transgenic products	A5.2 Centres review and get into binding partnerships with national agricultural research systems and private sector	O5.2 Transgenic research products released by national agricultural research systems and private sector within stipulated time frame
	S5.3 Centres participate in regional, sub-regional and Nationals stakeholders fora	A5.3 Centres include participation in stakeholder fora in their research projects	O5.3 Incremental support of transgenic research by the public and by policymakers
	S5.4 mainstream release, commercialization, intellectual property rights and trade related issues into transgenic research programs.	A5.4.1. Centres to include ex-ante assessments for release and commercialization in transgenic research project proposals.	05.4.1 Transgenic research projects include release and commercialization assessments by 2017.
		A5.4.2 Centres include IPR status and trade implication issues of transgenic products in their regular communications statements	O5.4.2 Increased acceptability of transgenic products from centres by policymakers in Africa

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