BIOTECHNOLOGY

IN

UGANDA

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1 INTRODUCTION

Uganda, also known as the “Pearl of Africa,’’ is a landlocked country located in Eastern Africa, crossed by the equator, is bordered by Rwanda, Lake Victoria and Tanzania to the south, Kenya to the east, Sudan to the north and Democratic Republic of the Congo (Zaire) to the west. Most of the country is a vast plateau with the main mountain ranges of Mufumbiro and Ruwenzori located in the west as well as Mt. Elgon to the east.

Uganda is about the size of Oregon, the area is about 241,136 km^2, of which 25% of this is arable land. About 20% of Uganda’s surface is covered in water including Lake Edward, Lake Albert, Lake Kyoga, Lake Mburo, and Lake Victoria (Uganda takes up 48% of Lake Victoria). River Nile has its source in Uganda; it is one of the longest rivers in the world.

Uganda has a population of about 30.9 million people; it’s expected to rise to 130 million by 2050! (Uganda, 2008). This is due to annual growth rate of 4.0%, an infant mortality rate of 86/1,000 and a life expectancy of 45.3 yrs. This is a massive population explosion that has to be fed! It is a challenge because since 82% of the population is currently employed in agriculture, it is predicted that there will be no more land available for cultivation in the next 40 years, hence more modern technology is needed. (Uganda, 2008).

Uganda is mainly an agricultural country, which contributes to 30% of the GDP (GDP -$26.7 billion). About 70% of the farming communities in Uganda grow and depend on bananas, coffee, cotton, tea, maize, tobacco, sugar cane, cocoa, horticulture, cassava, sweet potatoes, millet, sorghum, beans, groundnuts, rice; livestock rearing (cattle, goats, sheep, and poultry). However, agriculture in Uganda is mostly being done at a subsistence level, for home consumption. Disease and pests have fraught the full productivity in agriculture.
Freshwater fishing is also very important in Uganda; it also provides a source of income to the farmers.
Like all developing countries in Africa, Uganda has also been confronted with the complex issues related the development, application, importation and commercialization of genetically modified crops. Many of these issues have scientific and technical underpinnings, and so the need for decision-makers to seek and acquire scientific advice has grown.

2 BIOTECHNOLOGY

Biotechnology is as old as human civilization that started ten thousand years ago with growing plants and raising animals presumably in the Upper Nile Valley Regions. However, biotechnology has received enormous global attention because of the new scientific technological progresses made in the life sciences area during the 1960s and 1970s.

According to the International Service for National Agricultural Research (ISNAR) Research Report No. 5 (1993), biotechnology has been described as "any technique that uses living organisms or substances from those living organisms to make or modify a product, to improve plants or animals or to develop micro-organisms for specific uses". It comprises a continuum of technologies ranging from the well known and ancient

techniques of traditional technologies such as food fermentation to the current and more strategic research on genetic engineering in plants and animals based on the use of recombinant DNA technologies (rDNA), monoclonal antibodies and tissue culture techniques.

2.1 BIOTECHNOLOGY IN UGANDA

Uganda has unique health, environmental, social and economic problems that attract both local and international research interests. Since 1990 the number of research projects involving plants as well as humans as research participants in Uganda has more than tripled. This increasing quest for knowledge and the search for novel remedies to health, environmental, social and economic challenges is beneficial but could involve exposure to a spectrum of risks.

There are guidelines to provide a national framework for harnessing the benefits of research while ensuring that the rights, interests, values and welfare of research participants are protected.

Modern biotechnology could contribute to the improvement of health care through drug and vaccine development to treat and prevent diseases particularly infectious diseases such as malaria and HIV/AIDS, increasing productivity in agriculture through development of disease resistant and high yielding crop varieties for improved productivity in agriculture, thus increasing food security. Lastly, to harness productivity in food and beverage industry, chemical and detergent, waste management and other industries where molecular manipulation of micro-organisms yields better tools and products.

Different government sectors have embraced biotechnology in Uganda. These include;

2.1.1 AGRICULTURE

Biotechnology is being used to address problems in all areas of agricultural production and processing. This includes plant breeding, to raise and stabilize yield, to improve resistance, against pests, disease and abiotic stresses such as drought and cold and to enhance the nutritional content of food.
Biotechnology is also being used in agriculture to develop low cost disease free planting materials for crops such as banana, cassava and cotton.

82% of the Uganda's population are engaged in farming, contributing to 30% of the GDP. This has led to policy changes which have included the Plan for Modernization of Agriculture (PMA), which was finalized in 2000 with a vision to transform agriculture in Uganda for "*poverty eradication through a profitable, competitive, sustainable and dynamic agricultural and agro-industrial sector"*. PMA aims at achieving the broader objective of poverty eradication, and to transform agriculture from the subsistence to

commercial market oriented production agriculture. Among the strategies undertaken by the PMA was research and technology for development. (http://www.pma.go.ug/about.php)

Agricultural research institutes are all under one umbrella, National Agricultural Research Organisation (NARO) which was established in 1992 as the peak body with the mandate to undertake, promote and coordinate research in all aspects of crops, fisheries, forestry and livestock, and ensuring dissemination and application of research results. A total of nine research institutions are under NARO.

1) **Kawanda agricultural research institute (KARI)**

   Most biotechnology research in crop production has been done here. KARI is involved in tissue culture, micro propagation and application DNA recombinant techniques for banana and coffee improvement (UNCST 2003); Wafula et al., 2005) KARI is currently hosting trials of the sigatoka resistant GM banana developed at Katholieke Universiteit Leuven (KUL), Belgium(www.allafrica.com). These have been engineered to have resistance to bacterial wilt and Black Sigatoka fungal *(Mycosphaerella fijiensis)* disease. Genes from rice have been used (Nature, 2007). This banana field trial will take 5 to 10 years and if successful, there will be knowledge transfer to the indigenous ‘‘popular East African Highland banana cultivars’’
   One of the research arms of NARO, mandated to carry out research on banana; the National Banana Research Programme has been set up to enhance banana productivity and management of the weevil, black Sigatoka and nematodes.

2) **Namulonge agriculture and animal research Institute (NAARI)**

   Research at Namulonge has focused on development of a cassava germplasm bank from best varieties particularly disease resistant ones for propagation and multiplication and distribution to farmers. They are also involved in the development of cassava mosaic resistant variety by introgression of African cassava mosaic (ACMV) resistant genes into local elite cassava under Association for Strengthening Agricultural Research in Eastern and Central Africa (Asareca) in Serere (Eastern) and in Namulonge (www.naro.go.ug/cassava/). Laboratory testing has been done; they are waiting for approval by the UNCST and parliament to start field trials.

3) **The National Semi-Arid Resources Research Institute (NaSARRI)**

   Under the National Agricultural Research Organisation, in Mubuku, Kasese district. This will handle the upcoming GM cotton field trial, the Bt cotton variety (resistant to the bollworm pest and herbicide-tolerant). It contains a gene from bacteria, *Bacillus thuringiensis*

4) **Faculty of agriculture, Makerere University**

In collaboration with NARO, the faculty carries out training of most of scientists in the research institutes. Currently the faculty offers a Master of Science in crop science, biotechnology option focusing on genetic engineering in crop production. The faculty also conducts research in areas such as diagnostics, DNA mapping and marker assisted breeding. Bovine hormone for growth and milk production is one of the research projects.

5) **Faculty of Veterinary medicine, Makerere University**

It applies molecular techniques on research in diagnostics, veterinary microbiology and pathology. In conjunction with the department of Biochemistry, it offers a Master of Science in Molecular Biology and Biotechnology though the course is still young and needs more capacity building to reach standard.

6) **Livestock health research institute (LIRI)**

The mandate of this institute to develop tools and methods for prevention and control of animal diseases as well as genetic improvement of the existing livestock breeds. One of the biotechnologically related research activities at this institute has been the development and standardisation of PCR and PCR-ELISA for diagnosis in the control and eradication programmes of trypanosomiasis.

7) **Agro-genetic technologies (AGT)**

This is one of the agricultural research establishments under the private sector. The laboratory is recognised for her work on developing protocols for mass propagation of bananas and trees such as Mvule.

2.1.2 HEALTH

Socially responsible health care service is delivered through educating the public how to protect from different infectious and non infectious diseases. However, if diseases have already occurred, therapeutic services should be available. Therefore, health care biotechnology can be applied in different areas of health care delivery system and it is indeed a very powerful tool.

Biotechnology tools and techniques help discovering how healthy bodies work and what goes wrong when problems arise. Knowing the molecular basis of health and diseases will lead to improved and novel methods of treating and preventing. Biotechnology products include quicker and more accurate diagnostic tests, therapies with fewer side effects, and new and safer vaccines.

Application of biotechnology in health care system is enormous and Uganda would be able to improve its health care service status very significantly and in a cost effective manner if she could be able to develop capacity and capability in this area very rapidly.

The health biotechnology research and development capacity building and application should take the traditional healing practices and indigenous knowledge on botanicals and active compounds of the animal source into account.
Uganda has been hit by the HIV/AIDS scourge and many other infectious diseases. The following research institutes and laboratories have been set up to improve the livelihood of Ugandans.

1) **Joint Clinical Research Center, Kampala (JCRC)**

   This was set up to serve as a national AIDS research centre, and was born as collaboration between Makerere University's School of Medicine and Uganda's Ministries of Health and Defence. The Centre pioneered the use of antiretroviral drugs (ARVs) in Uganda in 1996, and has cumulatively provided ARVs to more than 30,000 clients, making JCRC the largest provider of ARVs in sub-Saharan Africa.
   The first vaccine trial in Africa "ALVAC-HIV," (1996) was conducted at this center. A live recombinant canary pox vector to express envelope and core genes of HIV-1 was used to construct the vaccine. This was conducted using adults as participants. The HPTN 027 paediatric vaccine trial followed in 2006. This was to evaluate the safety and immunogenicity of ALVAC-HIV vCP1521 in infants born to HIV-1 infected women in Uganda**.**

2) **Uganda virus research institute (UVRI), Entebbe and Medical Research council (MRC) and International AIDS vaccine initiative (IAVI)**

   They use modern molecular techniques to carry out research on HIV/AIDS and associated diseases. UVRI, JCRC through International AIDS Vaccine Initiative (IAVI) carried out trials on bio-engineered ALVAC-HIV vaccine (phase 1) in year 1996 and has now been carrying out DNA vaccine phase 1 trials (UNCST 2003). The Adeno 35 phase I trial, a phase I placebo-controlled, double blinded trial to evaluate safety and immunogecinity of Ad35 vaccine starts 2009.

3) **The Aids Support Organisation (TASO)**

   This was set up as a government institution to support HIV/AIDS patients. Research and health care is going on here. There is a Pre-Exposure Prophylaxis Trial (PREP) going on and it is targeting discordant couples (TASO, 2008)

4) **Makerere University medical school and Mulago Referral hospital**

   The medical school in collaboration with the Mulago hospital has a number of research laboratories and projects related to health in Uganda. These include **Makerere University Walter Reed Project** (**MUWRP), Infectious Diseases Institute (IDI)** among others. Modern molecular techniques and tools are being used in different research groups to study HIV/AIDS, malaria and drug resistance, Tb drug resistance and genetic susceptibility of individuals to tuberculosis.

5) **Med-Biotech Laboratories (MBL)**

A private research laboratory using molecular techniques for research on malaria vaccine development under Dr Thomas Egwang.

2.1.3 INDUSTRY

Industries such as foods and beverages, pharmaceutical industry do still use traditional techniques though there are indicators of moving into biotechnologically based production.

3 THE COMPETENT AUTHORITY IN UGANDA

The oversight of research in Uganda is carried out at two levels:

i. The institutional level by the Institutional Review Committees and
ii. The national level by the Uganda National Council for Science and Technology (UNCST).

The UNCST also works with the Research Secretariat in the Office of the President, for national security reasons. For clinical trials, an additional requirement is to obtain the National Drug Authority's authorization to import and/or use the trial drug/device in Uganda.

3.1 OVERSIGHT BY THE UNCST

The UNCST is a semi-autonomous government agency established in 1990 (CAP 209 of the Laws of Uganda) to develop and implement strategies for integrating science and technology (S&T) into the national development process, provide advice to the government of Uganda on policy matters necessary for advancing S&T and, oversee and coordinate research and development (R&D) in Uganda.

The UNCST specific functions for R&D coordination and oversight include:

- To advise and coordinate the formulation of an explicit national policy on all fields of science and technology;

- To act as a clearing house for information on research and experimental development taking place in scientific institutions, centres and other enterprises and on the potential applications of their results;

- To work in close co-operation with and co-ordinate all scientific and technological activities of persons, institutions, sectors and organizations

- To establish specialized committees, research councils, organizations and experimental and developmental activities or other scientific and technological services.

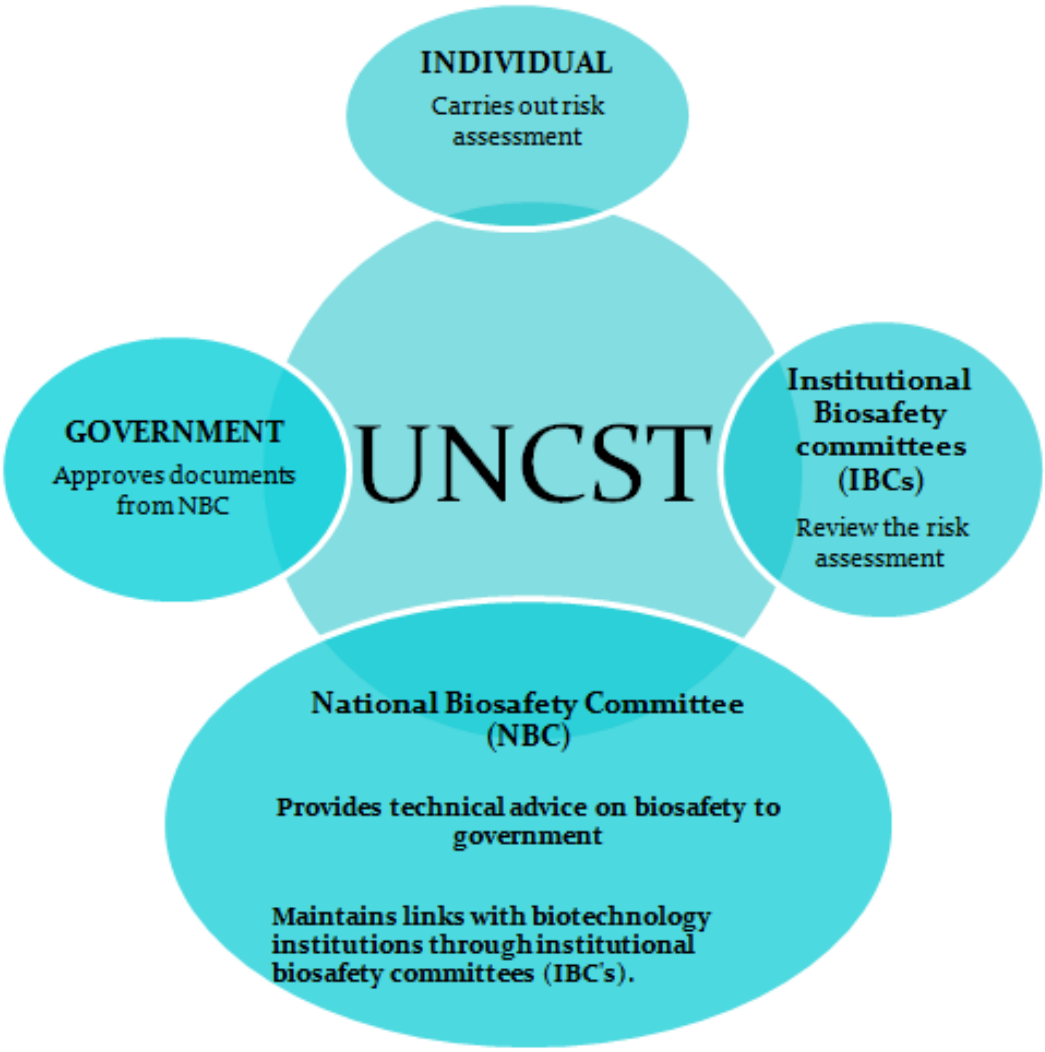

Figure 1 showing how UNCST executes its activities with other bodies

In executing the above functions, the UNCST registers and, in liaison with the Research Secretariat in the Office of the President, clears all research intended to be carried out in Uganda. In so doing, the UNCST receives and reviews research protocol for their scientific merit, safety and ethical appropriateness, and thereby issues permits to conduct the research in Uganda. The research permit is granted at a national level to facilitate the carrying out of research within the country.

Thus, all persons intending to carry out research in Uganda are required to register their research activities with the UNCST, and obtain UNCST approval of the intended research activities. Research project proposals submitted to UNCST for registration and approval should be well written and fully developed.

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3.2 UGANDA AND GMO'S

The capacity to handle GMOs in terms of laboratory infrastructure and human resources in various fields of biotechnology is being developed and accumulated. This includes gene mapping, transformation and regeneration. The key institutions involved in biotechnology work in Uganda include both public sector bodies and the private industry. In the public sector domain, a number of departments at Makerere University are involved in biotechnology R and D. They include departments of Crop Science, Biochemistry, Animal Science, Veterinary Parasitology and Microbiology, the Institute of Environment and Natural Resources, Food Science and Technology Research Institute and the Medical School at Makerere University. Under National Agricultural Research Organisation (NARO), biotechnology is predominantly taking place at the Kawanda Agricultural Research Institute (KARI). The private sector is represented by two key institutions. These are the Med-Biotech Laboratories (MBL) and the Agro-Genetic Laboratories (AGL).

For example, the Makerere University Crop Science Department has laboratory infrastructure for basic molecular biology and tissue culture work. Molecular biology work includes diagnostics and marker assisted breeding while tissue culture applications revolve around banana improvement. Genetic engineering work is being explored through partnerships with the International Network for Improvement of Banana and Plantain (INIBAP) and NARO. The Catholic University in Leuven, Belgium (KUL) is another partner that the department collaborates with in banana improvement initiatives.

Support for research at the department comes from the Rockefeller Foundation, the East African Regional Programme and Research Network for Biotechnology, Biosafety and Biotechnology Policy Development (BIO-EARN), European Union, United States Agency for International Development (USAID) and the Belgian Government. The diverse sources of assistance are taking care of both equipment and money for running projects. Fellowships from the Rockefeller Foundation have enhanced the human resources capacity in the department, while BIO-EARN is highly acknowledged for provision of equipment that has enabled modernization of the laboratory to a molecular biology category. Although the department's capacity to undertake transformation and advanced biotechnology work is growing, the actual transformation has been put on hold by lack of a national biotechnology and biosafety policy which is pending debate and approval by parliament.

4.1 BENEFITS FROM BIOTECHNOLOGY

Biotechnology may be the answer to Uganda's growing population and economically help in its development. Many scientists support it: "*Biotechnology will be an engine for Uganda's social economic development that would enable it catch up with the countries so far ahead of it''*, *Dr. Thomas Egwang, Director General Medical Biotech Laboratories Kampala.* Some advantages are listed below.

- Resistance to pests and herbicide tolerant plants
- Better natural waste management
- Higher yields to ensure food security and income
- Reduced maturation time
- Vaccine research and improvement of health
- Spread of technology to the region, job security

4.2 CHALLENGES FACING BIOTECHNOLOGY IN UGANDA

Although biotechnology has been embraced in Uganda by especially the scientific community, there are some challenges and fears envisaged.

- Risks on humanity/environment especially with toxicity and allergy
- Taste, texture and colour changes
- Loss of natural varieties (''Ensigo enjingirire'').
- Loss of market to EU market (Izama et al., 2003) and speculations that there will be gain in US, with this economic crisis, there are a lot of uncertainities.
- Pressure/funding from US, fears of less or no funding of research in many aspects of biotechnology, if GMs are not introduced.
- Like other countries, there is less public awareness of biotechnology and its applications.
- Lack of adequate well trained and specialised human resource to handle biotechnological research, evaluation and risk assessment
- Delay in approving the national biotechnology and biosafety policy has caused a slow pace at which biotechnology is growing in the country.
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- "Modern colonization - patents"

  The farmers believe that they will start depending on the western world for seeds.

  There has been creation of **African Agricultural Technology Fund (AATF).** It is established in Nairobi and funded by USAID, the Rockefeller Foundation. It will act as a broker to help Africa acquire biotechnology products. AATF will bear liability for any possible negative impacts of GMOs in future.

5 CONCLUSION

Biotechnology will be one of the tools used to solve some of Uganda's problems including food insecurity and infectious diseases, as stated by Jimmy Carter, a former US president said, *"Responsible biotechnology is not the enemy; starvation is. Without adequate food supplies at affordable prices, we cannot expect world health or peace."* However, since there is no law on biotechnology and bio safety in Uganda, coupled with insufficient knowledge, there is a lot of resistance from the public and this has hindered its progress.

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