THE UNITED REPUBLIC OF TANZANIA

NATIONAL BIOTECHNOLOGY POLICY

MINISTRY OF COMMUNICATION, SCIENCE AND TECHNOLOGY

2010

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ACRONYMS

AMU	Applied Microbiology Unit
BIO-EARN	East African Regional Programme and Research Network for Biotechnology, Bio-safety and Biotechnology Policy Development
BRELA	Business Registration and Licensing Authority
CIRAD	Centre de Coopèration Internationale en Recherche Agronomique Pour le Dèveloppement
DFST	Department of Food Science and Technology
DNA	Deoxyribonucleic acid
GDP	Gross Domestic Product
GMO(s)	Genetically modified organism (s)
HIV	Human Immunodeficiency Virus
IBS	International Biotechnology Service
ICGEB	International Centre for Genetic Engineering and Biotechnology
ICT	Information Communication Technology
IPR	Intellectual Property Rights
ISAA A	International Service for the Acquisition of Agri-Biotech Applications
MARI	Mikocheni Agricultural Research Institute
MTA (s)	Material Transfer Agreement(s)
MHEST	Ministry of Higher Education, Science and Technology
MSTHE	Ministry of Science, Technology and Higher Education
MUCHS	Muhimbili University College of Health Sciences
NBAC	National Biotechnology Advisory Committee
NFAST	National Fund for Advancement of Science and Technology
NGO	Non Governmental Organization
R&D	Research and Development
SETIs	Science, engineering and technology institutions
SUA	Sokoine University of Agriculture
TACRI	Tanzania Coffee Research Institute
TFNC	Tanzania Food and Nutrition Centre
TPPMCL	Tanzania Pyrethrum Processing and Marketing Co. Ltd.

FOREWORD

Biotechnology is defined as a body of techniques that uses biological systems, living organisms, or derivatives thereof to make or modify products or processes for specific use. It includes technologies such as tissue culture, DNA-based molecular markers, monoclonal antibody techniques, recombinant DNA (genetic engineering) techniques, and all other techniques employed for genetic modification of living organisms in order to provide new products and services.

To date, biotechnology has made profound impact in the fields of health, food, agriculture and environmental protection. It has been able to provide a wide range benefits to humanity: more effective drugs; more nutritional dairy and agricultural products; more resilient and productive crops and tree species; new sources of renewable energy; and safer, more effective treatment of waste. Furthermore, the application of biotechnology has led to new products and processes that have a competitive edge over the traditional ones in terms of effectiveness, productivity, cost and safety. In Tanzania use of biotechnology in various sectors of the economy is on the increase and is promising in terms of increasing productivity. This national biotechnology policy, therefore, provides guidelines towards safe application of biotechnology in research, in the development of and provision of biotechnology-based products and services in all sectors of the economy.

It outlines the frameworks for coordination in the application of biotechnology; funding of biotechnology programmes; management of Intellectual Property Rights regimes on

biotechnology ; conservation and utilization of genetic resources; improved public perception and creation of awareness on biotechnology products and services ; setting up priority areas for biotechnology applications in relevant sectors; fostering of public-private sector partnerships and in addressing three cross-cutting issues, namely the development of institutional and human resources, strengthening of national and international collaborations as well as ethical considerations. It is the expectations of the Ministry that if this policy is implemented fully it will make biotechnology contribute to economic growth and poverty reduction in the country.

The preparation of this policy has involved a number of stakeholders from various sectors of the society and the economy. On behalf of the Ministry of Communication, Science and Technology, I would like to express my heartfelt gratitude to all those, who in one way or another have contributed to the successful formulation of this policy document. Special thanks should go to the staff of the Ministry of Communication, Science and Technology, who has worked very closely with a team of experts from the beginning up to the publication of this policy document.

Prof. Peter M. Msolla (MP),
Minister of Communication, Science and Technology,

June 2010

1.0 INTRODUCTION

Biotechnology as science

Biotechnology is a body of techniques that uses biological systems, living organisms, or derivatives thereof to make or modify products or processes for specific use. As a research and development tool, biotechnology includes such technologies as tissue culture, DNA-based techniques, monoclonal antibody techniques, recombinant DNA (genetic engineering) techniques, and all other techniques employed for the genetic modification of living organisms, so as to produce new products and services.

Biotechnology applications

Biotechnology has made profound impact in the fields of health, food, agriculture and environmental protection. It has the potential to provide a wide array of benefits to humanity, including treatment of hitherto incurable diseases, safer, cheaper more effective drugs, more nutritional dairy and agricultural products, more resilient and productive crops and tree species, new sources of renewable energy and safer, more effective treatment of waste. With the help of biotechnology, new products and processes can be introduced to win a competitive edge over the traditional ones in terms of effectiveness, productivity, cost and safety.

2.0 JUSTIFICATION

Tanzania is today still among the poor countries of Sub-Saharan Africa and the world, with over 30% of its population

living below the international poverty line, earning less than 1 USD per day. The burden, breadth and incidence of poverty is more widespread in rural than in urban places. Over 60 percent of the people live in the former areas and agriculture forms the main stay. The positive aspect is that Tanzania is endowed with a lot of natural resources, which could be exploited for the nation's well being.

In promulgating the Vision 2025, the Government of Tanzania has postulated that by the year 2025, the economy of Tanzania would have been transformed from a low productivity, predominantly rural based subsistence agriculture, to a diversified semi industrial economy with a modern rural sector and high productivity agriculture, which ensures food security and food self sufficiency. To realize this vision, Tanzania considers science and technology to be central to creating wealth and improving the quality of life and bringing sustainable development in contemporary society, biotechnology being an important pathway to improvement of agriculture. This justifies the formulation of a national policy on biotechnology.

3.0 POLICY VISION, MISSION AND GENERAL OBJECTIVE

During implementation of the National Science and Technology Policy set out in 1996 to apply science and technology for national development, it was realized that in Tanzania, like in other developing countries, resources for development and promotion of science and technology were limited. It was, therefore not possible to pioneer many major scientific discoveries or inventions across the whole scientific and technological spectrum owing to those limitations.

However, it was possible to spell out directions, in which science and technology can be developed and utilized more effectively and efficiently in the key sectors of the economy. In this context, there is an implicit interrelationship between the development process on the one hand and the application of scientific knowledge, techniques and organizational methods in the production of goods and services on the other hand. Biotechnology is, among many other areas, anticipated to play a leading role in the 21st century in the application of scientific knowledge and techniques in production as stipulated in the National Science and Technology Policy as well as in the vision statement hereunder.

3.1 Vision

Achieve significant investment in biotechnological tools for generation of products, processes and technologies that shall enhance efficiency and productivity in food and agriculture, nutrition and health, being also cost effective and environmentally friendly in conservation of biodiversity.

3.2 Mission

Create infrastructure for research, development and commercialization in biotechnology so as to ensure a steady flow of bio-products, bioprocesses and new biotechnologies for social and economic development of Tanzania.

3.3 General objective

The general objective of this policy is to ensure that Tanzania has the capacity and capability to capture the proven benefits arising from health, agriculture, industry

and environmental applications of biotechnology while protecting and sustaining the safety of the community and the environment.

4.0 POLICY ISSUES, SPECIFIC OBJECTIVES AND POLICY STATEMENTS

4.1 Policy issue

Coordination in the application of Biotechnology

The coordination of biotechnology strategies in Tanzania will initially require a complete inventory of the existing human and institutional capacities in order to identify the available strength to build upon. It will also require identification of various stakeholders from research institutions and the industry. Tanzania will promote biotechnology development and utilization at the following levels:

- Research and technology development.
- Translation of research results into products.
- Commercialization and marketing of biotechnology products.

It is conceived that development of the biotechnology industry in Tanzania will require coordination between individual stakeholders and forging strong linkages between institutions within and abroad, national actors in the private sector as well as business promoters. The universities, R&D institutes laboratories existing in Tanzania will form the core actors.

4.1.1 Policy objectives

a) To coordinate biotechnology research and development activities between relevant stakeholders in the country.
b) To forge linkages between institutions within the country and those established in other countries as well as international institutions.

4.1.2 Policy statements

a) Provide adequate financial resources for coordination of activities of the National Biotechnology Advisory Committee.
b) Set biotechnology targets for institutions working in biotechnology research and development.
c) Foster close institutional collaboration between institutions conducting research under similar themes.
d) Define benefit items and the means of getting them from international institutions

4.2 Policy issue

Funding of Biotechnology Programmes

In order to ensure effective enhancement and sustenance of its social economic development towards realizing the National Development Vision 2025, the Government needs to allocate adequate financial resources for R&D activities related to biotechnology. Other biotechnology stakeholders should also complement the Government's effort.

4.2.1 Policy objectives

a) To ensure adequate availability of funds from sustainable sources for biotechnology research and development programmes.

b) To institute other innovative sources of financing biotechnology programmes.
c) To ensure that quality biotechnology products and technologies are developed and marketed.

4.2.2 Policy statements

In order to ensure sustainable funding for biotechnology research and development, the following are the policy statements:

a) Provide sustainable funding for enforcement of biotechnology programmes.
b) Promote and attract the participation of the private sector investors in biotechnology.
c) Facilitate capacity building of research scientists in biotechnology.
d) Promote multidisciplinary research in all sectors.

4.3 Policy issue

Intellectual Property Rights regimes on biotechnology

In order to encourage and promote biotechnology, IPR policy has to be in place. The need for IPR policy is to provide the nation with clear visionary directions towards IPR future development in the context of globalization. However, Tanzania has yet to have policy guidelines on access to and on exchange of genetic resources. Furthermore, Material Transfer Agreements (MTAs) are in existence but these are largely not standardized. There is also no clear institution or authority in Tanzania, which handles or processes MTAs.

4.3.1 Policy objectives

a) To establish Intellectual Property Rights on biotechnology inventions, innovations and services.
b) To develop policy guidelines on access to and on exchange of genetic resources.

4.3.2 Policy statements

In recognizing the importance of IPR policy guidelines and on the need to exchange genetic resources, the following are the policy statements:

a) Strengthen the institutions responsible for Intellectual Property Rights issues.
b) Encourage R&D institutions to develop their Institutional Intellectual Property Rights frameworks.
c) Facilitate the development of policy guidelines on exchange of genetic resources.
d) Identify, designate and facilitate sectoral authorities to handle the processing and issuing of standardized MTAs.

4.4 Policy issue

Conservation and utilization of genetic resources

The conservation and utilization of plant, animal and microorganism genetic resources is of great economic importance for a number of reasons. Firstly, these resources comprise a significant sector in economic terms in a country. Secondly, relatively few varieties or species have been utilized over the centuries for production.

Thirdly, modern utilization practices have tended to concentrate on the development of a very small portion of the available genetic resources. Accordingly, the narrow pool of the biodiversity is under constant threat of extinction due to various human activities leading to environmental pollution and climate change. Therefore, the need to sustainably conserve and utilize the national genetic resources is important and urgent.

4.4.1 Policy objectives

a) To effectively integrate relevant international agreements on conservation and utilization of genetic resources in respective national sectoral policies.
b) To develop national programmes for sustainable conservation and utilization of genetic resources.

4.4.2 Policy statements

In order to sustainably conserve and utilize genetic resources, the following are the policy statements:

a) Enact a law on conservation of genetic resources both in-situ and ex-situ.
b) Survey and make inventory of genetic resources in all sectors.
c) Create sectoral designated centers for conservation and utilization of genetic resources.
d) Promote sustainable utilization of genetic resources.
e) Create public awareness on the value of genetic resources for food and agriculture.

f) Enter into bilateral and regional agreements on conservation and utilization of bio-diversity.
g) Establish a data bank of both indigenous and exotic genetic resources available in the country.

4.5 Policy issue

Improved public perception and creation of awareness on biotechnology

There is apparently poor public perception about the safety and efficacy of new and emerging technologies, including biotechnology. Furthermore, there is inadequate awareness and understanding among the public, policy markers, decision makers and research managers on practical applications, research and development opportunities of biotechnology.

Lack of public understanding of biotechnology and the issues surrounding it has resulted in a backlash in many regions of the world. This has also resulted in selective trade barriers. This situation can be solved only through improved communication and better understanding of the scientific principles that underlie biotechnology. In this way people of diverse backgrounds can appreciate benefits from biotechnology applications.

4.5.1 Policy objectives

a) To create awareness and improve perception of the public on biotechnology.
b) To enable policy and decision makers as well as the general public make informed decisions on the

potential application of biotechnology for the socio-economic development of the country.

4.5.2 Policy statements

In view of the importance of accurate information as a tool for informed decision-making, the following are the policy statements:

a) Promote and support public education initiatives for accurate and balanced information on biotechnology.
b) Foster debates and discussions about benefits and risks, environmental and ethical implications on biotechnology applications.
c) Designate a National Biotechnology Day.

4.6 Policy issue

Setting up priority areas for biotechnology in relevant sectors

The need to attain improved agriculture, health, industrial production, trade as well as environmental protection must be governed by a priority setting process. In recognition of the meager human and financial resources available, priority must be given to those activities that hasten national development.

4.6.1 Policy objectives

a) To set up priority areas for biotechnology applications in relevant sectors of the economy.
b) To provide improved goods and services from

biotechnology products for social and economic development.

4.6.2 Policy statements

The following are policy statements prioritizing biotechnology for the relevant sectors:

a) Carry out regular biotechnology application review.
b) Develop new varieties of high quality and high yielding disease/pest resistant plants and animals.
c) Promote the production of vaccines, diagnostic kits as well as new medicines.
d) Promote the design and application of techniques for environmental bioremediation and biodiversity conservation.
e) Promote research activities, which are demand driven and adhere to national priorities.

4.7 Policy issue

Fostering public-private sector partnership and linkages

The past decade has seen the establishment of a multitude of private investors and Non-Governmental Organizations (NGO) enterprises in Tanzania. However, most of these have indulged in importation of goods or industries that neither use locally available raw materials nor require research investments in Tanzania. This has denied collaboration with public research institutions in the country with regard to technology development

and commercialization of research results in the relevant sectors of economy. Accordingly, a weak linkage exists between the public and private sectors. Any research innovation by the public sector with commercial value has thus been channeled to the government for commercialization.

4.7.1 Policy objectives

a) To foster public - private sector partnerships and linkages in technology development and transfer.
b) To increase participation of stakeholders from the private sector in commercialization of research results from the public sector.

4.7.2 Policy statements

In realizing the importance of public-private sector partnership in technology development and industrial opportunities, the following are policy statements:

a) Encourage the private sector to invest and adopt scientific innovations from the public R&D institutions.
b) Facilitate researchers to undertake biotechnology applications in all sectors and to commercialize research results.
c) Encourage exploitation of the third generation biotechnologies.

4.8 Policy issue

Cross cutting issues

4.8.1 Development of institutional and human resources

Tanzania has a shortage of scientists specialized in diverse areas of biotechnology. Likewise, specialized laboratories for advanced biotechnological research, such as DNA sequencing and molecular cloning do not exist in the country. Considering the potentials of biotechnology in development, it is imperative that Tanzania now sets forth to develop institutional and human resources in this area.

4.8.1.1 Policy objectives

a) To develop and sustain optimum institutional and human resources capacities in biotechnology.
b) To improve the current curriculum in basic sciences at all levels of education in order to generate a pool of human resources, who can work in the field of biotechnology.

4.8.1.2 Policy statements

In order for Tanzania to catch up with biotechnological developments the following are the policy statements:

a) Create conducive working environment to educators and researchers in biotechnology.
b) Establish a succession programme for biotechnology experts.

4.8.2 Strengthening national and international collaboration

For a successful technology transfer process, it is crucial for institutions in Tanzania to develop strong collaborative links with other relevant research institutions nationally and internationally. Regional networks, working on specific problems of key importance for development of the country in the region are often very competitive in the application for funding from major donor organizations. A regional network can have a catalytic effect on other national research institutes and provide a basis for future contacts and collaboration between scientists in the region. International contacts for Tanzanian research centers are equally important and can greatly facilitate the technology transfer process. Such collaboration provides access to cutting edge science and highly advanced R&D structures, which facilitate project efficiency and ensures backstopping. Tanzania is a member to the International Centre for Genetic Engineering and Biotechnology (ICGEB) and also participates in regional and international networks, which include the Eastern Africa Regional Programme and Research Network for Biotechnology, Bio-safety and Biotechnology Policy Development (BIO-EARN), Program for Bio-safety Systems (PBS) and Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA).

Currently, there are a number of global initiatives

aiming at availing biotechnology services to developing countries. For example, ICGEB, the International Biotechnology Service (IBS) and the International Service for the Acquisition of AgriBiotech Applications (ISAAA) have much knowledge and technologies to offer. Within Africa a number of professional institutions support biotechnology programmes such as: The Biotechnology Trust Africa (BTA), African Biotechnology Stakeholders Forum (ABSF), BIO-EARN and ASARECA do a commendable job in ensuring that biotechnology is taken on board as a tool for development. Tanzania requires strengthening collaboration with such institutions in order to promote the development and application of biotechnology.

4.8.2.1 Policy objectives

a) To develop new and strengthen existing national and international collaborations, with relevant research centers.
b) To establish networks between relevant research and development institutions for regional collaboration.

4.8.2.2 Policy statements

In order to develop and strengthen collaboration, the following are policy statements:

a) Develop and maintain a reliable Information and Communication Technology (ICT) system for biotechnology institutions in Tanzania.

b) Establish an environment conducive to support national and international initiatives in biotechnology.
c) Promote collaboration through national, international and bilateral agreements.

4.8.3 Ethical consideration relating to biotechnology

Ethical issues are important when research touches the lives, welfare, interests, privacy of people and their properties that can stimulate different public opinions. The Government, through the National Biotechnology Advisory Committee (NBAC) or other regulatory body, is obliged to address ethical issues in biotechnology and oversee appropriate implementation of codes of conduct in various institutions and Government departments. Gaps in ethical procedures should be identified and recommendations made to address them. The areas include but are not restricted to the disclosure and use of genetic information, gene therapy and human cloning for medical purposes; the potential impact of GMOs on the environment, horizontal gene transfer from GMOs to other organisms, trans-species gene transfer and participation in research and clinical trials.

4.8.3.1 Policy objective

To ensure that ethical aspects relating to biotechnology applications are taken into considerations.

4.8.3.2 Policy statements

In order to ensure effective ethical considerations relating to biotechnology applications, the following are policy statements:

a) Set-up a national strategy to address ethical issues on biotechnology.
b) Encourage institutions to form ethical clearance committees.

5.0 INSTITUTIONAL FRAMEWORK

Currently, the biotechnology industry in Tanzania is at initial stages of development; with little strategic research being carried out. The success of the biotechnology industry will inevitably depend upon the degree to which the country shall invest in developing, consolidating and strengthening basic scientific research, technology and R&D activities.

Establishment of a National Centre of Excellence for Biotechnology and Genetic Engineering shall created biotechnology platforms to support the biotechnology industry. The Centre shall be autonomous, operate on commercial basis and mandated to conduct basic scientific research, technology development and serve as a link with industries for commercialization of products. Prioritization of activities of the Centre will be aligned with national priority areas, market demands and will have a major focus on agriculture, human management, health, livestock, food processing, wildlife, forestry and environmental management.

At present, there are national scientists, who are working in research or academic in the field of biotechnology in and outside

the country. These will form a critical mass of human resource base to initiate the development of biotechnology in the country. Tanzanian scientists working in developed countries will be invited to participate. The policies on institutional framework are set out below.

5.1 Policy objective

a) To create a Centre of Excellence for the development of adequate capacities in industrial biotechnology within the country.

5.2 Policy statements

In order to achieve the objective, the following are policy statements:

a) Establish physical infrastructure for the creation of a Centre of Excellence in Biotechnology.
b) Maintain inventory of biotechnology laboratories in the country together with their activities and products.
c) Establish new and promote existing industries for biotechnology products.
d) Develop and retain human resources in biotechnology fields and provide them with adequate finance, infrastructure, facilities and attractive schemes.
e) Determine human resource needs for the biotechnology R&D and train accordingly.
f) Facilitate researchers to develop biotechnology products for commercialization.
g) Designate national reference laboratories for the detection of genetically modified organisms (GMO) products and materials based on specializations.

6.0 LEGAL FRAMEWORK ON BIO-SAFETY

Implementation of the biotechnology policy will require having in place National bio-safety guidelines that stipulate the regulation of risk assessment and management procedures and monitoring in accordance with international standards. These guidelines are intended to protect individuals, communities, environment and biodiversity by minimizing potential hazards associated with biotechnology applications while facilitating beneficial utilization.

An appropriate institutional framework is necessary not only for the acquisition, testing and adaptation of technology, but also in order to reassure consumers and public opinion regarding the safe application of biotechnology. This involves establishment of necessary guidelines and laws as well as the development of capacity to enforce regulations.

6.1 Policy objective

a) To establish and implement bio -safety regulations and guidelines

6.2 Policy statements

The following are the policy statement:

a) Facilitate the development of bio-safety guidelines.
b) Maintain transparency in the implementation of bio-safety regulations.
c) Enforce international regulatory frameworks.

7.0 ROLES OF STAKEHOLDERS IN IMPLEMENTING THE POLICY

In order to implement effectively the National Biotechnology Policy in Tanzania all sectors of the economy need to be involved. Responsibilities of some priority sectors include:

- Health: To search for alternative treatment and vaccination for various human and animal diseases.
- Agriculture and Food Security: To increase crop production by using high quality seed varieties that can resist pests and diseases and tolerate drought.

- Industry and Trade: To increase competition by selling products of good quality produced by biotechnology techniques.

- Research and Development Institutions in all relevant sectors (Public and Private): To carry out different research and development activities in biotechnology geared towards solving socio-economic problems of the country.

- Education and Mass Media: To educate the public at all levels on biotechnology issues and its importance on the application of biotechnology to socio-economic development.

- Religious Institutions: To provide education on the importance of the application of biotechnology to socio-economic development.

- Legal Affairs and Public Safety: To assist in developing and implementing the legal mechanisms for monitoring and evaluation of biotechnology programmes in the country.

- Livestock Development: To increase production by using modern breeding techniques and high quality fodder plant varieties that can increase productivity.
- Financial Institutions: To finance biotechnology programmes.

- Environment: to develop legal mechanisms for protection of the environment

- Natural Resources: To produce more seeds of rare species which are widely used for different purposes e.g. for medicinal and food purposes.

- Academic associations: Like the Biotechnology Association of Tanzania and others that will provide additional scientific facts and guidance on the application of appropriate biotechnologies and on biosafety aspects.

8.0 MONITORING AND EVALUATION

A prerequisite for sound policy implementation is the existence of adequate monitoring and evaluation (M & E) mechanisms. The relevance of M & E processes is that they are an integral part of policy-making, planning and management

of development initiatives; which in this case are the outlined policy issues. M & E processes are purposely initiated and carried out by the Government or Implementing Authority on its behalf, and involving relevant stakeholders in order to obtain measurable products of implementation. Elements to be monitored include the strategic policy options, the areas of priority and the principles of implementation. The aim should be to monitor and assess the relevance of objectives, efficiency, effectiveness, impact and sustainability.

Monitoring and evaluation will enable the interpretation and evaluation of information about biotechnology applications in order to determine which options will lead to the most desirable patterns of use. Tools include system analysis, biological and physical decision support models, computer simulation models and environmental impact analysis. All these tools will facilitate communication among stakeholders and provide input into socio-political process of prioritizing alternative biotechnology applications.

Monitoring indicators of key processes in biotechnology and economic development are essential for evaluating policy measures. A variety of methods and systems are available to monitor the quantity and quality of biotechnology materials. However, government commitment and investments are needed to guarantee consistent and unbiased sources of both environmental and economical information.

In order to establish effective mechanisms for monitoring and evaluation, the following will have to be undertaken:

a) Facilitate the identification of areas and key actors to be responsible for carrying out monitoring and evaluation.
b) Facilitate the development of various indicators for monitoring and evaluation of the progress in bio-policy implementation.
c) Establish a comprehensive reporting and feedback mechanisms.

9.0 IMPLEMENTATION

a) Prepare a strategic action plan for implementation of the National Biotechnology Policy directives.
b) Review of the regulatory frameworks by the National Biotechnology Advisory Committee as need arises with the view of addressing gaps and weaknesses.

GLOSSARY

Biotechnology: Is defined as a body of techniques that use biological systems, living organisms, or derivatives thereof to make or modify products or processes for specific use.

Bio-safety: The policies and procedures adopted to ensure the environmentally safe applications of modern biotechnology.

DNA: *Deoxynucleic acid*; a genetic material that acts as a carrier of genetic information.

Gene: The fundamental and functional units of heredity; the portion of a DNA molecule that is made up of an ordered sequence of nucleotide base pairs that produce a specific product or has an assigned function.

GMO: A genetically engineered organism whose genetic material has been changed through gene technology in a way that does not multiply naturally by mating and/or natural combination.

Ex-situ: It is the process of protecting an *endangered species* of plant or animal outside of its natural habitat.

In- situ: At the natural or normal place, contained to the site of origin without invasion of neighboring tissues.

Monoclonal antibody techniques: Techniques of producing antibodies that recognize a single specific antigen and are produced by a clone of specialized cells.

Recombinant DNA: DNA formed by combining segments of DNA from different organisms.

Tissue culture: Propagation of tissue removed from organisms in a laboratory environment that has strict sterility, temperature and nutrient requirements.

For further Information, contact: Permanent Secretary
Ministry of Communication, Science and Technology,
Plot 1168/19 Jamhuri Street P. O. Box 2645,
Dar es Salaam - Tanzania
Tel: +255 - 22 - 21112454/7, Fax: +255 - 22 - 2112533,
Email: mst@mst.go.tz | Web: www.mst.go.tz