Food Security and Biotechnology in Africa

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MODULE 6. TAILORING BIOTECHNOLOGIES: TOWARDS SOCIETAL RESPONSIBILITY AND COUNTRY SPECIFIC APPROACHES

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INTRODUCTION

Biotechnology is the use of living systems and organisms to develop or make products, or "any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use" (UN Convention on Biological Diversity, Art. 2). Indeed, Biotechnology is a multidisciplinary subject that brings together some aspects of chemistry, biochemistry, physics, biology, , microbiology, engineering, computer science. Modern biotechnology embraces recombinant DNA technology, cellular biology, microbiology, biochemistry, as well as process design, engineering, modeling and control. Current applications are ranging from the development of new medicines and drugs to the farming of transgenic plants and animals as well as the clean-up of environmental pollutants. In Africa biotechnology is primarily considered and used as an exogenous instrument for the on-going modernization of agriculture and rural development because farmers do not have a hand in the development of the technology. Nevertheless, biotechnology has several potentials to raise agricultural systems in order to meet the needs for food for the growing African population. The role of biotechnology in ensuring food security and food sovereignty in Africa has become the subject of intense academic inquiry and public policy discourse. This debate still stayed at two extremes: one that perceives biotechnology as the source of solutions to many of the economic, social and environmental and food security problems that Africa is confronted with, and the other extreme that treats the technology with considerable cautious as a technology that will bring more tertiary dependence, profit-driven effort regardless of the risk to human health, social equity or environmental quality. This scenario has been replayed more and more in Africa than anywhere else in the globe. Controversies surrounding its development, increased focus on industrial crops, perceived dependency syndrome on few multinational seed companies among others have limited its widespread application. Agriculture in African continues to be plagued with poor planting materials, crops with poor yield, nutritionally deficient, long gestation periods, low biotic and abiotic stress resistance, high post harvest

losses, poor distributive channels, etc. However, the situation can be improved through a tailored application of science and technology. Tailoring biotechnology implies that it should fit to the viewpoint and needs of stakeholders, e.g. from small farmers to policymakers. Tailored biotechnology, that may include both classic and modern versions of biotechnology, accounts for the role of stakeholders in the process of technology development. Tailoring biotechnology involves that stakeholders can use the tool within their own context and on their own conditions, and have the opportunity to fulfil the required social, financial, ethical and other conditions for the implementation of the new technology. Specific cases studies of African countries could give information on the differences among African countries engaged in modern biotechnology: (a) those that are generating and commercializing GMO products and services, (b) those that are engaged in GMO technology R&D with confined field testing, c) those that are engaged in contained GMO research and d) those that are developing capacity for research and development in GMO, e) those are adopting national laws regulating biosafety. Furthermore, associated risks and public perception and the role of medias will be addressed.

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General objective of the module

The objective of this module is to allow students to understand how the innovation and policy making lead to tailor-made of both classic and modern versions of biotechnology to the needs and customs of specific countries.

Modes of lecture delivery

a. Lecture notes
b. Power point slides
c. Discussion groups
d. Mini surveys among stakeholders

Specific objectives

By the end of this module the students will have a deepen comprehension on:

1. How the multiple currently available technologies and innovation contribute to the rise of biotechnology.
2. The role of poly-making and medias on adopting biotechnology
3. How global and local value chain represent for local firms and suppliers in the countries to get access to larger markets and new technologies.
4. The role of the stakeholder perceptions, internalization and appropriation in the process of biotechnology for development.
5. Current experience throughout case studies of African countries that apply GMO crops.

Course structure

The course is subdivided into five units as follow:

- Unit 1. Technology and innovation to the rise of biotechnology: 5 Hours
- Unit 2. Policy-making and communication: 3 hours
- Unit 3. Value chain, agribusiness, local and global development: 3 hours
- Unit 4. Stakeholder participation: 3 hours
- Unit 5. Case studies of tailor-made biotechnology in specific countries: 6 hours

Unit 1. Technology and innovation to the rise of biotechnology: 5 Hours

Summary

Ancient biotechnology- early history is related to food fermentation and other domestication. Conventional crop breeding since the birth of agricultural communities, the Green Revolution of later years, and molecular marker-assisted selection can be considered as the second generation of biotechnology. Modern biotechnology was born with DNA engineering and the discovery of novel analytical techniques such as electrophoresis and DNA sequencing.

Except specified elsewhere, Biotechnology in this unit is referred to modern biotechnology. Food biotechnology employs the tools of modern genetics to enhance beneficial traits of plants, animals and microorganisms for food production. It involves adding or extracting select genes to achieve desired traits. The general public has a vested interest in how modern agricultural practices affect the food we eat, the progress of efforts to develop new

drugs, the ethics and benefits of cloning, forensic science, bioterrorism, and improving the environment.

However, the adoption of biotechnology because of public concerns and societal issues have focused on both applications and ethical implications. This has created two polarities. One who believes that biotechnology firms and biotechnologists have framed the issue as one of science and technology applied to enhancing the quality of life. The other biotechnology opponents have framed the issue as a profit-driven effort regardless of the risk to human health, social equity or environmental quality.

Innovative biotechnology will be expected to make major contributions as we emerge from the current period of economic uncertainty. This, however, is against the backdrop of the vast majority of university students, farmers and employees in the bioscience industries having received little or no training in techniques that could greatly enhance their creative and innovative potential.

The urgent need to look for alternative biotechnologies and the actual accelerated rate of adopting plant molecular biotechnologies since the breakthrough report of the first transgenic plant in 1982–1983 is due to four major causes:

- increase in world population and the need for more food
- recognition that human health is affected by disease-causing pathogenic organisms and by the nutritional quality of foods, especially vitamins and minerals
- adverse global climatic changes accompanied by detrimental biotic and abiotic stresses to crops and ecosystems
- human societies searching for novel, non-food plant products such as biomaterials, therapeutics, biofuels, etc.

Nevertheless, general public needs to adopt the technology throughout equilibrated communication. For instance even in USA where GM crops have been introduced since 1990, only 75% of the population is aware on the existence of GMO crops, while only 33% of consumers know that GMO foods are now in supermarkets without any labeling.

The objective of this unit is to show how the different Biology related technologies, innovation, and the capacity to handle the processes have impacted the development of Biotechnology.

This unit is structured in the following sections:

Section 1. Multiple technologies

1. Process of adaption of new technology and societal issues
2. Green Revolution: Impacts and limits in Africa
3. Current Biotechnological processes: overview of technologies: genetic engineering; culture of recombinant microorganisms, cells of animals and plants; metabolic engineering; hybridoma technology; bioelectronics; nanobiotechnology; synthetic biology or xenobiology, protein engineering; transgenic animals and plants; tissue and organ engineering; immunological assays; genomics, transcriptomics, proteomics, metabolomics (“omics”); bioseparations, bioreactor technologies, CRISPR-cas9 technology, synthetic biology/genomis, etc.

Section 2. Innovations in Biotechnology

1. Innovation techniques
2. Integrated local innovations

Section 3. Capacity to handle approval processes

1. Evaluation of scientific data of GMO risks (Environmental issues, economical issues, technological risks, etc.).

Section 4. Discussion with students

Unit 2. Policy-making and communication: 3 hours

Summary

Policy-makers must evaluate the societal significance of scientific and technological issues such as biotechnology. Without a " policy-maker will" a country bears the brunt of non-functional legislative and regulatory frameworks, negligible investment in biotechnology R&D, low public awareness and inability to handle approval processes (Adenle, 2013).
A common citizen clearly cannot be expected to have an in-depth understanding of all the facts, relationships and issues of biotechnology.

In general, a broad understanding of biotechnology by citizens is imperative to ensure their personal integration into the technical and scientific aspects of culture; for the public to appreciate the importance of biotechnology and the need for adequate funding; to enhance national and regional effectiveness and competitiveness in a global knowledge-based economy; and to help solve some of the overwhelming problems. In practice, the non-specialist member of the public obtains his knowledge of all biotechnological things from the wider dissemination of information, mainly by the media but also through books, exhibitions, displays, TV and museums. Although biotechnology has made some people's lives in industrialized countries safer, freer of material constraints and more comfortable, it is also perceived as having its drawbacks. For some people such limitations become dominant, and they may show a deep seated fear of all that appears to be biotechnology. Many different ethical, religious, political and even commercial reasons all contribute to these attitudes. People often include not only a failure to understand the facts and reality but a denial that facts are important when compared to other considerations.

Communication proceeds primarily through both the electronic and the print media, but many special interest groups may disseminate their own information and interpretations, often in printed form but also verbally in meetings and elsewhere. In various countries, to varying extents and with varying quality, newspapers, magazines, radio and television report and discuss topics of public concern; biotechnology is fairly prominent among them, especially when dealing with genetically modified crops and foods or with new and potentially important advances in medicine.

The public perception of biotechnology is dominated by modern biotechnology, notably the application of GMOs in food and agriculture. With GM foods and crops, some countries have mounted 'national debates' which have themselves acquired some prominence, although the overwhelming proportion of the population played no part and appeared indifferent and rely on specialist and politician decisions.

The aim of a public understanding of biotechnology as well as other scientific and technology issues might be defined as a knowledge of the facts, findings and methods of science, without necessarily an ability to think creatively in specific areas. Existing national policy should be known to allow citizens to be familiar to biotechnology, and gain access to reliable and balanced information. Risk assessment based on specific guidelines and sound scientific evidence should be available to ensure efficiency, transparency and safety so as to build confidence with the public and policy-makers; and by demonstration through trials to show farmers the benefits. The current risk assessment of GMOs is primarily focused on potential risks, while potential benefits are usually not considered by medias.

The objective of this unit is to illustrate the role of scientists, medias as well as poly-makers in national and international systems on adopting biotechnology.

Brief content

Section 1. Policy-making theories

1. Role of scientists in determining policies related to biotechnology
2. International approaches
3. Government approaches
4. Civil society perception and Citizen perception

Section 2. Instruments of policy making

1. Current international and national policies

Section 3. Role of medias

Section 4. Discussion with students

Unit 3. Value chain, agribusiness, local and global development: 3 hours

Summary

Value chain research provides a capacity to increase efficiencies, business integration, responsiveness and ultimately market competitiveness.

Biotechnology has the potential to improve living standards in low-income countries. The biotechnology sector is comprised of biotechnology firms, research institutions, and related industrial companies, and farmers that discover, develop, and commercialize biotechnological products and processes. Biotechnology business can be divided into four major market segments: biomedical, environmental, industrial, and agricultural.

Although it remains an area of controversy, biotechnology in Africa has already achieved significant productivity gains and improvement in health status of farm workers. However, due to the privatization and increased intellectual property rights (IPRs) protection, many people in Africa find it very difficult to access modern biotechnology research tools (e.g. genetic engineering, micro-propagation, mutation breeding etc.) to ensure food security. To have a good value chain, it important to understand and tailor the strategic alliances and gain to gain policy between firms, agribusiness sector, government agencies, educational institutions, and local communities.

The objective of this unit is to determine how global and local value chain represent for local firms and suppliers in the countries to get access to larger markets and new technologies.

Section 1. **Agricultural value chain**

1. Definition of value chain
2. Current impact of the business of biotechnology
3. Business and scientific partnerships benefits to society
4. Strategies for value chain management

Section 2. Local and global requirements and developments

Section 3. Discussion with students

Unit 4. Stakeholder participation: 3 hours

Summary

The attitudes and interests of stakeholders involved in national public debates on the risks and benefits of genetically modified crops are having a significant influence on public opinion as well as public policy outcomes related to the use of genetically modified organisms (GMOs) in agriculture in developed and developing countries. The role of the stakeholder participation, internalization and appropriation in the process of biotechnology development is very important for the adoption of the technology.

Biotechnology is expected to play an important role in transforming the economy from a predominantly agricultural one with low productivity to a diversified and semi-industrialized economy with a modern rural sector and high productivity in agricultural production that generates reasonably high incomes and ensures food security and food sovereignty.

Biotechnology can contribute significantly to sustainable agricultural development and enhanced food security by improving local crop productivity, reducing chemical inputs, protecting crops against pest and post-harvest losses, improving nutrition, increasing crop tolerance to stress, and by producing value-added products.

For agricultural biotechnology to be effective, it must be based on clear and realistic research priorities based not only in formal science but also taking into account indigenous knowledge, which are closely linked to farmers' needs. Lack of pragmatic approach may result in limited biotechnology adoption and inability to meet the demand of African farmers and other stakeholders. The potential of biotechnology can only be realized if due attention is paid to the whole array of policies and programs needed for sustainable development.

Some African countries are making some effort to build a national capacity in biotechnology in terms of the physical human organizational or institutional resources. Biotechnology stakeholders can be enumerated as follow: scientists (universities, research institutes, etc.), policy makers (ministries, UN organizations, etc.), regulatory agencies, legislators (parliaments), civil society, community based society, donors (NGO's, bilateral and multilateral agencies), farmers, industrialist and end-users (consumers).

The importance of the functions of each category of stakeholder generally connects to the other. It is vital that all functions are addressed properly for the realization of the systematic synergy required for making the desired impact of biotechnology.

End-users of biotechnology products are paramount to biotechnology activities, since are key persons for the adoption and appropriation of the technology. The stakeholder perspectives on the adoption of GM technology in African countries is very important to consider but difficult to assess (Adenle, et al., 2013) in order to lead for development. Current study on views and positions of stakeholder groups in Africa with respect to GM crops revealed that small farmers are willing to adopt new technology to improve their crop productivity so as to secure enough food to eat (Adenle, et al., 2013).

Food self-sufficiency and improved quality of life of resource-poor farmers should be targeted as ultimate socio-economic impacts for products resulting from the application of biotechnology including GMOs in Africa. Thus GM technology has to make his impact more visible on food security after one decade of implementation in some African countries. Stakeholders should be sensitized to understand the technology and its potential impact to enable them contribute to its development. Moreover, a consensus is needed to regulate GMO products and controversy surrounding the adoption of GMOs.

The objective of this unit is to analyse the role of the stakeholder perceptions, internalization and appropriation in the process of biotechnology for development.

Brief content

Section 1. Stakeholder involvement and public engagement

1. Potential benefit of the technology for stakeholders
2. Stakeholders involvement on internalization and appropriation in the process of biotechnology
3. Perception of the technology by different stakeholder groups:
4. Safety issues and precautionary principles
5. Precautions of gene flow

Section 2. Indigenous knowledge and adoption of new technology

1. Indigenous knowledge
2. Strategies of adoption of the new technology with endogenous knowledge

Section 3. Discussion with students

Unit 5. Case studies of tailor-made biotechnology in specific countries: 6 hours

Summary

However, with the increasing food insecurity, rapid scientific and technological advances and growing commercialization of GM crops in USA, Indi and Argentina have led to a paradigm shift, moving the debate on GMOs from the confines of scientific and environmental groups to the center of general public and policy-makers in Africa. The benefits that can be derived from GM crops are now becoming evident in Africa, notably in countries which have adopted commercial GM crops such as Burkina Faso, Egypt, Sudan and South Africa.

The adoption of GM crops in Africa has increased steadily over the past 17 years due to the socio-economic and environmental benefits.

Worldwide there are currently 75 countries that have signed the Cartagena protocol of biosafety, among which there is up to 45 African countries. Although the great number, only 20 countries have ratified the protocol and adopted internal law on GMOs. However, some countries perform confined field trial without adoption of specific law (Uganda). Some African countries have better experience of scientific research in the field of Agriculture than others.

Their knowledge base and accumulated expertise have made it possible for them to leap into GM crops. Five categories of African countries engaged in biotechnology could be distinguished: (a) those that are generating and commercializing biotechnology products and services, (b) those that are engaged in third generation biotechnology R&D with confined field testing, c) those that are engaged in contained research and d) those that are developing capacity for research and development and e) those that are developing internal laws.

The objective of this unit is to understand current experiences in African continent throughout case studies of five countries that are involved in GMO crop experiments or commercialisation.

Brief Content

Section 1. Overview of status of Biotechnology and Biopolicy in Africa

Section 2. Case study of five countries that have adopted GM crops: Burkina Faso, Egypt, Kenya, Nigeria, and South Africa.

Section 3. Overall advantages and drawbacks of modern biotechnology

1. Overall known positive aspects of biotechnology
2. Concerns if any of GMOs

Section 4. Discussion with students