Biotechnology related policy, management and negotiation competence: Case study from Ethiopia

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SUMMARY

The report gives an overview of relevant public management and research institutions, and institutions of higher learning including mandates and capacity. It also covers policies and legal/regulatory framework. Based on interviews with responsible staff in relevant institutions, the report summarises gaps and needs with respect to manpower, facilities and other resources, policies and regulations.

Some modest biotechnology activities can be found in universities and research institutes. The survey has found applications related to livestock (artificial insemination, diagnostics and vaccine production), plant tissue culture and micropropagation, studies of biological nitrogen-fixation, biopesticides, biogas, and characterisation of biodiversity using isozymes and molecular methods. Involved scientific staff consider biotechnology to be neglected and under-utilized. Limitations include lack of qualified researchers and facilities, but also lack of policies and regulatory measures. Need of training in safe management of biotechnology is also mentioned.

Policies and legal/regulatory issues

A general **National Science and Technology Policy** was issued in 1994 identifying Biotechnology as one of the priority areas. This is followed up by Ethiopian Science and Technology Commission that has coordinated works to formulate a specific biotechnology policy for agriculture, environment, health and industry. The policy recognizes that Ethiopia needs biotechnology for its development challenges including the problem of food deficit.

The draft is submitted to the Council of Ministers and is awaiting approval. However, it is not considered exhaustive since some areas like pharmaceuticals and food safety are missing. It is therefore expected that the draft protocol will have to be complemented on those issues and updated on emerging technologies.

Also **Access Legislation** is on a drafting stage. According to the principles of the Convention on Biological Diversity, access to biodiversity will be linked to benefit sharing including access to and transfer of technologies, particularly biotechnology. Institute of Biodiversity Conservation and Research has developed **Material Transfer Agreements** through which germplasm exchange shall be facilitated. Other relevant policy documents include **National Environment Policy** (1997), **National Seed Industry Policy** (1992), and **National Health Policy** (1993). There is no specific law or regulation regarding food safety other than checking the product quality according to the market labels against the established standards. A national food and nutrition policy is not developed.

A proposal to ratify the **Cartagena Protocol on Biosafety** has been submitted to the Government. Once ratified, the Protocol requires biosafety legislation, scientific capacity, and monitoring and enforcement capabilities. Also capacity for negotiation must be built.

Institutional Framework

Ethiopia already has institutions to deal with the various public needs related to the new biotechnologies. The **Ethiopian Science and Technology Commission** is mandated to plan, promote, coordinate, finance and oversee technology activities in the country, and advice the government on issues of science and technology. The **Ethiopian Agricultural Research**

Organisation with its network of research stations all over the country is responsible for formulating research strategies and conduct research on crops, livestock, forestry, soil and water management, and dryland agriculture. **Institute of Biodiversity Conservation and Research** is mandated, inter alia, to explore and survey the diversity and distribution of the country's plant, animal and microbial genetic resources, keep a germplasm collection for conservation and utilization, and implement international conventions and agreements with respect to biodiversity. The institute is also authorised to issue permits to collect, dispatch, import or export biological specimens or samples. **Environment Protection Authority** is responsible for preparing and enforcing environment policies and laws including follow up of international environmental treaties such as the Cartagena Protocol on Biosafety. Other institutions that may play a role in controlling agricultural and food biotechnology applications include: **National Seed Industry Agency**, **National Health and Nutrition Research Institute**, and **The Quality and Standards Authority of Ethiopia.**

Scattered efforts are under way by each of the above institutions, but with insufficient coordination. It is hoped that this issue would be resolved when the Government has approved the proposed biotechnology policy.

Experts within these institutions point to shortcomings with respect to manpower and capacity, facilities and resources, policies and law regarding tasks related to the new biotechnologies. The institutions have huge responsibilities, but lack minimally-required resources.

Ethiopian delegates have been highly visible and influential in many international negotiations on environment issues. However, experts in the institutions that are responsible for follow-up and implementation are disappointed about lack of results with respect to transfer of needed technologies. Experts also express concern about lack of public awareness and understanding about risks and associated dangers of biotechnology.

Education

Ethiopian Universities include Addis Ababa University (1950), Alemaya University of Agriculture (1986) and four recently established regional universities. Scientists dealing with biotechnology related subjects consider that their institutions do not have the capacity and resources that are needed to educate manpower for development and management of biotechnologies in agriculture, industry, health and other services.

All the universities need to upgrade and expand on teaching in biotechnology related subjects, but for a rational and coordinated response to the many needs, a national "Centre of Excellence" is suggested.

1. Introduction

1.1 Definition and Background

The subject of Biotechnology is wide and complex and covers several types of technological advances within the fields of animal and plant production. It is applied for various purposes including food, medicine, and industry, among other things. The application ranges from the very simple to the complex ones. Biotechnology is not a new technology, but is as old as human culture. By definition, Biotechnology is any technique or technological application that uses living organisms or derivatives thereof from such organisms to make or modify products (to improve plants or animals or micro-organisms) or processes for specific uses (CBD 1992; Rege, 1998).

Biotechnology can be safely divided into "Classical Biotechnology" that includes conventional plant and animal breeding, selection of efficient microorganisms for different purposes (enzyme production, nitrogen fixation, alcohol and organic acid production, etc. The other one, which is referred to "Modern Biotechnology", encompasses cell and tissue culture, and genetic manipulation such as recombinant DNA technology with the production of new gene constructs of living things, Living Modified Organisms (LMO) or Genetically Modified Organisms (GMO). In fact, "Modern Biotechnology" would simply be an accelerated way of achieving better organisms that could otherwise be achieved through conventional selection programs ("Classical Biotechnology"). Modern Biotechnology is often associated with genetic engineering that enables one to recombine genetic material irrespective of species barriers, thus, traits from virtually any one organism can be transferred to another (Yibrah and Demissie 1998).

However, biotechnology is utilized in many different fields of applied biology and covers diverse applications including bioinformatics (genome mapping), micro-propagation including tissue culture, immunological techniques, molecular genetics, genetic transformation and recombinant DNA techniques in all facets of production (Wafula and Clark 2001). The 1990s have generally shown dramatic advances in the understanding of how biological organisms function at the molecular level. Our ability to analyse, understand and manipulate DNA molecules has also expanded. With this, there has been increased application of biotechnological methods in the fields of agriculture, environmental protection and industrial processes.

In agriculture, biotechnology serves as a tool to create new and high quality products through selection of plants and animals, and microorganisms through conventional means and genetic engineering. The use of tissue culture in the mass propagation of disease-free plants, and the creation of new traits by the transfer of important genes such as pest and disease resistance into crops are the important frontier in plant production sector.

The combination of embryo technology and gene transfer to produce more productive and disease resistant animals, and the use of monoclonal antibodies and DNA technologies to produce more effective and less expensive diagnostic tools and vaccines are a few of the outstanding contributions of agricultural biotechnology. The microbial part of agricultural biotechnology involves the manipulation of rumen microorganisms to degrade fiber, increase supply of cell protein, and degrade secondary plant compounds (anti nutritional factors) to improve nutrition in animal husbandry. Microorganisms are also manipulated to manufacture

amino acids in large quantities to enrich animal feeds, and for better nitrogen fixation for agricultural production.

Medical biotechnology also penetrates into the realm of human and animal health. Genetic engineering can facilitate the production of vaccines against major human viral pathogens, and chemotherapeutic agents against killer diseases. It also provides rapid, specific, sensitive and cost-effective diagnostic tools for early detection of diseases and routine surveillance of communicable and non-communicable diseases, and genetically inherited disorders. The production of animal vaccines and monoclonal antibodies is also used to reduce the morbidity and mortality of animals.

Fermentation biotechnology is one of the oldest technologies used by man. It involves microorganisms in the application of food and beverage industries. Many biotechnologically extracted enzymes, organic acids, and antibiotics are used as ingredients for different textile, tannery, detergent and other pharmaceutical industries. Generally, the contribution of biotechnology to these industries is to provide improved practices and greater sophistication in the use of microorganisms. Microorganisms could be altered through genetic manipulation to improve the yield and quality of existing industrial products and also provides new ones.

Environmental biotechnology also plays a very important role in the management of environmental problems, including waste treatment and pollution control. It enhances the use of preventive and curative technologies such as modifying and using microorganisms and plants as biofertilizers, biopesticides, and bioleaching agents and in bioremediation processes. Industrial and agricultural waste treatment activities can also be integrated with the generation of biogas as supplementary energy for small-scale farmers and urban centres.

In general, the relevance of biotechnology to development is now at the forefront of international interest. The perceived promise and perils of biotechnology are under intense public scrutiny. The debate is widespread, complex and, frequently, inconclusive. Discussions are sometimes scientific and impartial, at other times ideological, sensational and visceral. The challenge is both technological; that requires the development of new, high productivity, environmentally sustainable production system, and policy related, as favorable policies are demanded to strengthen the hitherto efforts of agricultural, industrial, and social development. An essential aspect of the responses to this challenge is to harness all instruments of sustainable agricultural growth one of which is Biotechnology.

The Convention on Biological Diversity (CBD) has recognized the discrepancy between industrial and developing countries in terms of access to genetic resources and technologies. Developing countries, known to be rich in biological diversity, generally face shortage of technologies. As a strategy to fill this gap, provisions were made in the CBD document to share benefits derived from the use of biodiversity, and technology transfer is one of them. However, the large and growing gap between industrial and many of the developing countries does not allow for the transfer of a fair share of biotechnology to developing countries. This calls for closer studies to identify ways and mechanisms for safe acquisition and responsible use of such technologies in developing countries.

Developing countries generally have ambitions of being able to conserve and utilize their biodiversity, and to add value through the use of modern technologies including biotechnology. The international community has promised to help facilitating such

developments through sharing of competence and transfer of technology in accordance with the commitment made in the Convention on Biological Diversity.

The importance of biotechnology for developing countries was reconfirmed during the World Food Summit held in Rome in June 2002. However, both the Norwegian statement and the Final Declaration demand that biotechnology should be used with due attention to *biosafety* and *food safety* issues. The latter requires within country capability to negotiate and make partnership with foreign agents, and it requires regulations and the existence of governmental authorities that have the capacity to enforce such regulations.

Biosafety mechanisms are aimed at ensuring the careful design and review of organisms with novel traits, as well as proper planning and regulation of environmental implications of introducing these organisms. Components of a biosafety regulation structures include: legislation, risk assessment and management systems, as well as control and monitoring mechanisms. (BIO-EARN[1], undated). Risk assessment is a key tool that offers a formalized evaluation of the hazard potential of an organism or the technology in question and its exposure to humans. A biosafety mechanism should enable one to keep the risk(s) at an acceptable level in cases where complete elimination is not possible.

1.2 Emerging Biotechnologies and their Implications for Africa

1.2.1 The Global/Regional Context

Africa is a continent rich with enormous diversity of biological resources. It is known to be home for some 25% of the world's biodiversity and many of its plant species occur nowhere else in the world (Wynberg, 2000). African people rely directly on biodiversity for food, medicine, shelter, fuel, household furniture, farm implements/tools and income. The local communities have generated and maintained diverse knowledge and technologies that enable them to conserve, manage and utilize the biological resources. Hence, Biodiversity is a matter of survival and both plants and animals play central role in the livelihood and economies of African countries. Besides subsistence, the bulk of employment, economic output and export earnings are generated from biological resources. Hosting a quarter of the global biodiversity, Africa presents a rich, profitable seam of raw material and knowledge for the development of new medicines, foods, cosmetics and other biodiversity products.

Traditional farming is practiced by the great majority of African farmers and over 90% of food in Sub-Saharan Africa is produced using customary farming practices that involve various forms of multiple cropping, farm saved seeds, and on-farm crop selection among others (Wynberg, 2000). Ownership of seeds, knowledge and technologies is usually held collectively and these resources are shared and/or exchanged among community members.

Africa's role in biotechnology has been overwhelmingly a supplier of raw materials used by research institutions and transnational corporations of the developed countries. A considerable range of useful plants of African origin have made significant contributions to world agriculture, including coffee, sorghum, pearl millet, finger millet, cowpea and palm oil as well as numerous medicinal plants. Africa has also supplied the genetic resources for breeding of Nile Tilapia, a fish species that is called the "aquatic chicken" because of its success in intensive fish farming, mainly in Asia. Wild biodiversity is the target of bioprospecting, i.e. the exploration of biodiversity for commercially valuable genetic and biochemical resources.

[1] BIO-EARN is an East African Regional Programme and Research Network for Biotechnology, Biosafety and Biotechnology Policy Development. Partner countries are Ethiopia, Kenya, Tanzania and Uganda.

At present, agricultural biotechnology is causing the most debate and controversy globally. Like any other technology, biotechnology has its *pros* and *cons*. Here is an example of what the proponents and sceptics view about agricultural biotechnology (BIO-EARN, undated) that we see are pertinent to developing countries and African countries in particular.

Proponents of agricultural biotechnology have referred to genetic engineering as an important tool in securing food supply facilitated by improved seeds (through accelerated and fine-tuned breeding), increased crop yields and improved harvest quality. They also argue that dependency on chemical pesticides and fertilizers could be reduced, thereby giving environmental gains in terms of less pollution. Increased productivity can also reduce pressure for extensive use of cultivated land and, therefore, contributes to economic development. Their position is that breeding activities using modern biotechnology are more safe, precise and predictable compared to the conventional approach.

Skeptics, on the other hand, emphasize on the environmental, economic and social risks associated with genetically modified organisms. The effectiveness of biotechnology in the context of food safety and in relation to addressing socio-economic structures has been questioned. The technology also has been called unsustainable. For instance, herbicide resistant crops might encourage increased use of herbicides and also might produce undesirable non-target effects on humans, soil fauna and the environment. The flow of potentially harmful genes from transgenic crops to their wild relatives may also cause undesirable effects. Displacement of valuable varieties of local crops is yet another serious concern. Hence, sceptics argue that transgenic organisms are associated with great and unpredictable risks.

While the biotech industry continues to pursue the development of genetically modified seeds, it also ensures control through increased scope of patenting biological materials and through technology protection systems. A genetically engineered switch mechanism can activate a gene that disrupts embryo development resulting in sterile seeds. Since the disrupter genes can be suppressed during seed multiplication the companies can produce seeds for sale to farmers, but the seeds become sterile when grown on farm. Such technology is not yet commercialised and is so far primarily known from description in patent applications. But the fact that such technology is invented has caused much debate uneasiness. Activist groups call this “suicide seeds” or “terminator technology” while it is called Genetic Use Restriction Technology (GURT) in technical jargon. Since this technology would effectively stop all on-farm seed saving and create total dependency on the industry for the supply of seeds, reactions are particularly strong in developing countries where most seed supply is produced on-farm. It may also be said that the technology is developed purely for control, it adds costs but does not add any productive value.

“Terminator is a real and present danger for global food security and biodiversity”, comments Hope Shand - the Research Director of the ETC Group[2]. The “terminator technology” has been widely condemned by civil society groups and farmers movements around the world as immoral technology with widespread public opposition.

[2] *ETC Group*:- the action group on Erosion, Technology and Concentration (formerly RAFI) is an international civil society organization headquartered in Canada. It is dedicated to the advancement of cultural and ecological diversity and human rights.

On the other hand, genetic contamination from transgenic plants could pose serious threats to landraces, and wild and weedy relatives. It is considered particularly important to protect centres of crop diversity like Ethiopia against such contamination of landraces. The risk of accidental transfer of transgenes from genetically modified maize to the maize landraces in Mexico is much debated. In another development, Canadian organic farmers were victimized by failing to certify their canola crop as GM-free due to the escape of trans-genes from genetically modified canola, reported the ETC group last January.

The ETC Group lists six reasons as to why GM contamination in gene banks or centres of diversity is a concern (ETC Feb 2, 2002):

Moral repugnance: some cultures or religious beliefs are morally opposed to eating transgenic species especially as food. Hence, people and sovereign nations have the right to say "no" to transgenics and scientists as well as governments must protect their right.
Environmental safety: there is debate going on about the impacts of new species on other organisms and the environment. Hence, as a precautionary measures GM contamination in centers of diversity needs to be protected.
Food safety:- It is not fully known yet about the impacts of GM traits especially of the second generation on food safety. Some foods might have allergenic property when produced from non-traditional sources. Hence, the diets of the poor people particularly in centres of diversity need to be protected from GM contamination.
Trust compromise: the international research centres that safeguard the world collections (about half a million seed samples) are faced with the challenge of keeping the trust materials free from GM pollution. These centres and FAO are obliged to protect the integrity of the trust materials.
Market security: Farmers who sell organic (GM-free) produce will face difficulty if GM pollen contaminates their crops. Incomes will be compromised for such farmers.
Monopoly risk: Since GM traits are patented, it would compromise distribution and management of germplasm by *ex situ* gene banks. Fear of lawsuits would, therefore, constrain access and use of gene bank materials.

Background Study Paper No 15 produced for the FAO Commission on Genetic Resources further elaborates and discusses "Potential Impacts of Genetic use Restriction Technologies (GURTs) on Agrobiodiversity and Agricultural Production Systems[3].

A recent case of the GMO issue in Africa is what is being debated with the incidence related to food aid destined to southern African countries worst affected by drought (Zimbabwe, Mozambique, Lesotho, Malawi and Swaziland). The debate got high profile with Zambia's rejection of food aid in the form of genetically modified maize that originated from the United States, July 2002. Mozambique and Zimbabwe also rejected to accept the food aid unless the corn is milled to avoid genetic contamination.

The major concerns related to the GM maize are that of: (i) genetic contamination of surrounding fields, and (ii), potential trade problem in the future due to genetic contamination. Some opponents claim that humanitarian assistance (food aid) is being used as a strategy to spread the GM crops around the world. Others (in favour) claim that the GMOs have no health hazard to humans as they were in North American market already for several years.

[3] www.fao.org/ag/cgrfa/docs.htm

Records show that over 70 genetically modified (transgenic) crop varieties are registered for commercial cultivation worldwide. These include varieties of cotton, potato, pumpkin, tobacco, tomato and clove (Wafula and Clark 2001). The same source documents that global area under these transgenic crops in 1999 was 40 million hectares mainly of corn, soya bean, cotton, canola (rapeseed) and potatoes. Eighty five percent of these were found in North America, USA and Canada. The remaining 15% is in developing countries notably Argentina, China, Mexico and South Africa. This indicates that large-scale application of the transgenic crop technology is concentrated in the developed countries. By 2000, the United States alone accounted for 70% of the global area under transgenic crops, while USA, Canada and Argentina together make up for 99% (BIO-EARN, undated).

On the positive side, the benefits of biotechnology should not be overlooked. Despite the concerns of the sceptics, biotechnology has a potential to contribute to national development when applied with necessary safety precautions. The key issues on making biotechnology useful to the poor countries in the developing world include the choice of technology and answers to the following fundamental questions: what competence is available within the recipient country to use the said technology? What kinds of safety mechanisms are in place and what gaps need to be improved?

1.2.2 The Ethiopian Context

Ethiopia has a total land area of 1.22 million hectares, with a topography varying from 116 m below sea level at the Afar triangle to 4533 m above sea level at mount Ras Dashen. The periphery encircling the country consists generally of lowland plains with elevations below 1500 m and a mean annual rainfall of less than 500 mm. This area makes 65 million hectare (61%) of the total surface, mainly pasture land and home of pastoralists who make up 12% of the population with 26% of the livestock found in the country. The central highland, with an annual rainfall ranging between 500 mm to 1000 mm, is suitable for crop cultivation, comprises 18 million hectare, and is inhabited by subsistence farmers.

Based on moisture and temperature relations, Ethiopia is divided into 18 agro-ecological zones. These zones vary markedly in terms of length of plant growing period (number of days per year), forage production, common plant association, as well as human and livestock carrying capacities. Over the last five decades the forest cover of the country was reduced from 40% to only 2%.

There are about 14 river basins in the country of which the Blue Nile, Awash, Wabishebele, Omo and Tekeze are the major ones. Hence, Ethiopia has a very huge potential for irrigated agriculture and hydroelectric power. Several minerals including gold, petroleum, marble, cement and coal are known to exist, but are not fully exploited. The country is endowed with rich diversity in flora and fauna. In fact, it is recognized as one of the 12 centres of plant genetic resources in the world. This gives it a comparative advantage for the development and application of biotechnology.

Thus, Ethiopia is an agrarian country with its economy predominantly dependent on agriculture. The Agricultural sector accounts for 85% of the employment, 52% of the GDP and 90% of the export. Livestock production is an important component of the national economy: it comprises 33% of the gross value of annual agricultural output, 15% of gross domestic product and 12% of gross annual export revenue, in a distant second after coffee. Ethiopia has the largest livestock population in Africa with 170 million heads.

Ethiopia is one of the Sub-Saharan countries where the great majority of the population (85%) is dependent on small scale farming whose production is barely sufficient for subsistence. Farm production is concentrated in the highlands and farmers largely depend on seeds saved from own harvest to sustain agricultural production. The small-scale farmers couldn't rely much on new seed supplies every year for a number of social, cultural and economic reasons. Their economic status is so poor, microenvironment so diverse, physical terrain difficult with valleys and gorges, size of individual landholding so small and cultural and food traditions so diverse that make large scale production of uniform crop varieties far from being a reality. Hence, peasant farmers couldn't realize the potential benefits from technological advancement in the fields of monoculture-based crop improvement and also from economies of scale in production as the situation doesn't allow these farmers to make adequate investment in agricultural production.

The same constraints and also shortage of feed and prevalence of livestock diseases limit the potential benefits that could have been realized from the livestock sector. Livestock play vital role in smallholder farm communities being sources of food, energy, fuel and clothing among others. However, the productivity is very low and the contribution of the sector to the national economy as a whole is low compared to the large number of livestock resource the country owns. Therefore, improving their productivity through possible technological and management options cannot be over-emphasized.

The country suffers from recurrent droughts, deforestation and destruction of the ecosystems on account of population pressures and incompatible development strategies. The population estimate in 2001 was 63 million. It is growing at a rate of about 3% or more. With this growth rate, it is projected that the population may grow to 90 million by 2010 and to over 129 million by year 2025. The urban population is growing at a faster rate (5.4%) for various reasons. If the present trend persists, the urban population will grow from the present 17.6% to 30% of the total population by 2020 (EPA, 2001, pp. 3-4). The implications for food, health and other social services are enormous. The health system provides very low coverage, especially in rural areas. Infant and maternal mortality rates are unacceptably high.

Politically, a federal system of government is adopted. Decentralization and democratisation processes are under way after successive repressive regimes. The country is divided into 9 self-governing National Regional States and one city administration under the Federal Democratic Republic of Ethiopia. It is a nation of multi-ethnic and multi cultural composition and this has been taken into account in the set up of the Federal Constitution of Ethiopia. There is serious debate going on with respect to the use of ethnicity as a primary factor in creating the regional states.

The long-term objective of development in Ethiopia is the transformation of agriculture in which the relative weight of agriculture, industry and services changes significantly towards the latter two. To this effect, a strategy known as agricultural development-led industrialization (ALDI) was adopted. The strategy envisages the improvement of productivity in small farm holdings and the establishment of large-scale farms.

Ethiopia is a centre of diversity for a number of food crops, oil and industrial crops, medicinal plants as well as wild and domestic animals. The diversity in agroecological zones including terrain, soil, topography, rainfall regime; settlement pattern and human races has helped the country to host a wide range of diversity in plant and animal genetic resources. Communities of various ethnic and cultural backgrounds have been utilizing these biological resources in

diversified forms. Diversity in genetic resources has enabled farm communities in different parts of the country to cope with the various hazards and vagaries of nature that prevail every now and then. However, the once rich sources of plant genetic diversity have been deteriorating over time due to genetic erosion from natural and human induced factors. Efforts are being made to reverse the rate of genetic erosion and promote genetic resources conservation through *ex situ* and *in situ* strategies.

Ethiopia has been part of the global discussions concerning biodiversity and biosafety issues since the 1980s. It is signatory to international conventions and treaties including the Convention on Biological Diversity (CBD). Following these, national policies and strategies have been and are being developed so as to benefit from the provisions made in these conventions and treaties. Technology transfer and sharing of technical competence were considered among the means to share benefits indicated in the Convention. In conclusion, biotechnology can have wide ranging applications to agriculture, industry and the environment sectors. The shortcomings of biotechnology can be handled through the introduction and implementation of biosafety measures and capacity building in the institutions engaged in biotechnology and related activities.

1.3 Purpose and Scope of the Study

The study was commissioned by the Norwegian Agency for Development Cooperation (NORAD) in order to assess biotechnology related development needs focusing on Africa with case studies from Ethiopia and Tanzania. Its aim is to point out ways on how to enhance technology transfer and the negotiating capacity of developing countries in international forums leading to various conventions and treaties as well as facilitating their subsequent implementation as translated to national action plans. The outcome is, therefore, expected to indicate possible ways for strengthening the management capacity and technical competence of developing countries pertaining to biotechnology in order to make fruitful negotiations that are in line with the needs and aspirations of developing countries in general and the respective countries in particular. In more specific terms, the objectives of the study are:

1. To make an overview of existing and emerging technologies that are currently discussed or demanded,
2. To identify relevant safety precautions and needs for regulations and management,
3. To identify current limits and gaps in laws, regulations and management capacities,
4. To elaborate on what regulations and management capacities that the country must have to deal with the controversial issues in a responsible and safe way.
5. To assess the existing capabilities for training bio-technologists in the national universities, and
6. To draw conclusions and recommendations for strengthening management and negotiating competence in the transfer of emerging technologies.

For the purpose of the study, biotechnology is limited to “modern biotechnologies” including cell and tissue cultures and gene technologies. It will primarily be considered for its applications in plant, animal and food sciences to some extent. However, it is not the intention of this study to deal with controversial issues at length. What are considered as controversial issues here are Intellectual Property Rights, Farmers’ Rights and benefit sharing arising from the use of biological resources. The question of how to compensate indigenous communities and small-scale farmers for their work in developing and maintaining plant genetic diversity

is still on the global agenda. The intention of the study is, thus, to identify ways that would enable developing countries deal with controversial issues in a safe and responsible way.

In Ethiopia, a number of institutions were visited to interview relevant staff and collect pertinent documents. The following interview checklist was used to guide the discussions. We are very pleased to report that the cooperation we received from the consulted institutions was remarkable. We had faced no restrictions to available information and documents. The profiles of the institutions visited are presented and discussed in Chapter 2.

Checklist of questions used for interviews:

1. What types of emerging (modern technologies) are entering Ethiopia through the market, development assistance and other means?
2. Which institutions are involved in the transfer, development and application of emerging technologies in Ethiopia?
3. How active is the country in international negotiations?
4. Are there policies, laws and regulations that are enforced in the management of biotechnology?
5. What are the needs or gaps in the existing laws and regulations?
6. What is the status of the technical and legal capacities available to manage biotechnology in Ethiopia?
7. How are biotechnology activities coordinated in Ethiopia?
8. What are the needs of the training institutions (Universities) that are engaged in the training of biotechnologists?
9. What are the critical biotechnology related issues that are of concern to the country, nationally and internationally?
10. Any recommendations?

The study by no means gives an exhaustive answer to these questions. It attempts to highlight the status of the institutions dealing with biotechnology and related issues, what their capacity is, what the major gaps are, and what is being done to strengthen the application of biotechnology in combating poverty and food insecurity in Ethiopia.

2. Profile of Institutions Involved in Biotechnology

2.1 Ethiopian Science and Technology Commission (ESTC)

The Ethiopian Science and Technology Commission (ESTC) is a government institution established in 1975 and headed by a Commissioner. It is the national body empowered with responsibilities and mandates to plan, promote, coordinate, finance and oversee science and technology activities of the country. It is also responsible to advise the government on issues of science and technology, implement the government's science and technology policy, and follow-up the application of research and development results.

The overall objective of the Commission is to encourage and enhance Science and Technology activities that enable the realization of the country's socio-economic development objectives. The Commission has the mandate to organize different science and technology councils composed of renowned professionals, research and development representatives from economic and service sectors, to assist in the formulation of science and technology policies and priorities as well as screening projects eligible for research grants.

The Commission has the powers and duties to: (i) support and encourage research and development centers and institutions that contribute to the promotion of science and technology, (ii) develop the capability and establish the system for searching, selecting, negotiating, procuring and importing technologies that are appropriate to socio-economic conditions in Ethiopia, and (iii) encourage and ensure the application of studies and research and development activities towards improving and developing indigenous technologies.

ESTC's specific powers and responsibilities with respect to natural resources are:

- Formulate policies and seek funding for research on environmental issues in collaboration with the EPA, MOA, MOE and higher education institutions;
- Provide specialist services, such as the procurement and maintenance of specialist equipment and information, to support research and environmental monitoring in collaboration with the EPA, MOE, and MOH;
- Assist in promoting environmental awareness through popularisation of Science in collaboration with EPA, MOE, MOIC and MOA.

ESTC has developed a national science and technology policy in December 1993 and was issued in 1994 in order to build the national science and technology capability, coordinate related activities and enhance their contribution to national economic activities. It was aimed to serve as a springboard to initiate the formulation of detailed policies and prioritise action plans for different economic and service giving sectors. It also serves as a basis for international cooperation on scientific and technology matters. The Policy pays attention to biotechnology but the achievements thus far are minimal.

In the efforts made to build up or strengthen the national science and technology capability, the Commission mobilizes funds within and outside the country to support research activities, training of human resources and strengthening the science and technology infrastructure. A major donor in this respect has been the Swedish International Agency and Research Cooperation (SIDA-SAREC).

2.2 The Ethiopian Agricultural Research Organization

The Ethiopian Agricultural Research Organization (EARO) was established in June 1997 by proclamation No. 79/1997 of the Federal Democratic Republic of Ethiopia (FDRE). Formerly it was known as the Institute of Agricultural Research. EARO is a government institution responsible for research on agricultural technology development as a means to raise production and productivity towards achieving the overall goal of economic development. The objectives of the organization are to:

i. generate, develop and adapt agricultural technologies that focus on the needs of the overall agricultural development and its beneficiaries,
ii. coordinate research activities of agricultural research centers or higher learning institutes and other related establishments which undertake agricultural research on contractual basis,
iii. build up a national research capacity and establish a system that will make agricultural research efficient, effective and based on development needs, and
iv. popularise agricultural research results.

Among the major duties and responsibilities of EARO are:

- formulating agricultural research strategies and determining research priorities based on the country's policies for science and technology, agricultural development and research;
- following-up the implementation of agricultural research policies, making improvements and/or initiating new policies as appropriate;
- establishing a system in collaboration with all stakeholders for popularisation of research results and promoting wider use by respective end users;
- collecting, organizing and disseminating information on agricultural research activities and results;
- developing and coordinating information exchange mechanisms;
- establishing a national research project review meeting with relevant regional governments to avoid unnecessary duplication of efforts and subsequent wastage of resources; and
- establishing networks to cooperate and conclude agreements with international and regional organizations having similar objectives.

The agricultural research programs of EARO come under the following five main directorates: (i) Crops, (ii) Animal Science, (iii) Forestry, (iv) Soil and Water Management, and (v) Dryland Agriculture. These research programs are implemented through a network of main research centres and sub-centres located in different agroecological zones of the country. These are categorized into 3 categories: i) federal research centres and sub-centres, ii) regional research centres and sub-centres under regional agricultural bureaus, and iii) higher learning institutions research centres and trial sites under university and colleges. The federal ones comprise 14 research centres and 11 sub-centres. The main centres have special national mandate for certain research commodities.

2.3 Institute of Biodiversity Conservation and Research (IBCR)

The Institute of Biodiversity Conservation and Research (IBCR) was initially established in 1976 as a Plant Genetic Resources Center of Ethiopia (PGRC/E). By then, the activities of the gene bank focused on the collection and conservation of crops that have high international scientific and economic importance. Priorities were given to crops facing immediate danger of genetic erosion. Series of plant exploration and collection missions were launched to collect and conserve important crop types and their wild relatives. To date, some 61,000 accessions representing 104 plant species were collected.

IBCR, as a new structure, was established by proclamation on June 25, 1999 as an autonomous body and its mandate now covers all forms of biological resources (plants, animals and microbial resources). The general objective of the Institute currently is to undertake conservation and research, and promote the development and sustainable utilization of the country's biological resources. Given the importance of biodiversity and the dependence on biological resources, the conservation efforts give emphasis to local and national needs and values.

The powers and duties of the Institute, among, others are to:

a) explore and survey the diversity and distribution of the country's plant, animal and microbial genetic resources, collect samples for *ex situ* conservation and facilitate the utilization of these genetic resources for research and development,
b) implement international conventions, agreements and obligations on biodiversity, to which Ethiopia is a party and to take part in domestic and international conferences and seminars dealing with biodiversity issues,
c) maintain and develop international relations with bilateral and multilateral bodies having the potential of providing aid and technical assistance for supporting biodiversity conservation and development,
d) devise and conduct research which will enable it to assess and determine the diversity and distribution of the country's biological resources, to use appropriate conservation and implementation methods, and to enrich and sustainably use these resources,
e) study traditional knowledge and integrate the knowledge with scientific approaches for further development,
f) design strategies and develop information network system to collect, document and utilize information on the country's biodiversity, and
g) in cooperation with appropriate institutions, acquire sufficient trained human resources and build capacity for biodiversity conservation, development and utilization by closely working with the mass media and educational institutions.

The Institute is also empowered with the authority to issue permits for collecting, dispatching, importing or exporting any biological specimen or sample (Articles 6 (20) and 12). To engage in any of these activities without securing a permit constitutes a criminal offence.

IBCR has a total of 11 departments, five of which fall under the Plant Genetic Resources Center (PGRC). These include: Field crops genetic resources, Pasture and forage plant genetic resources, Horticultural crop genetic resources, Forest and aquatic genetic resources, and Medicinal plant genetic resources departments. The other six departments are Animal genetic resources, Microbial genetic resources, Ecosystems conservation and research, Ethnobiology, and Biotechnology and biosafety department. Major objectives of the latter department are making the conservation and utilization of genetic resources rational, cost effective and sustainable, and also supplying users with well-characterized and evaluated initial materials they need. The department needs to develop its human resources (in terms of number and technical expertise), upgrade its laboratory facilities and financial resources to render the services it is ought to provide to other departments of the Institute and those from outside.

2.4. The Environmental Protection Authority (EPA)

EPA was established in 1995 with the following aim: "To ensure that all matters pertaining to the country's social and economic development activities are carried out in a manner that will protect the welfare of human beings as well as sustainably protect, develop and utilize the resource base on which they depend for survival". It has only a short span of life as an autonomous institution with far reaching responsibilities. The mandates of the Authority are outlined as follows:

(a) Prepare environmental protection policy and laws; and upon approval follow up their implementation;
(b) Develop and enforce an environmental impact assessment system;

(c) Prepare standards for soil, water and air as well as the biological systems they support;
(d) Carry out studies required to combat desertification and, in cooperation with the other concerned organs, create favourable conditions for their implementation;
(e) Make recommendations on incentive and punitive measures for better protection of the environment;
(f) Provide informal and non-formal education to enhance awareness of the need for environmental protection;
(g) Follow up the implementation of international treaties on environmental protection to which the country is a part;
(h) Render advice and technical support to Regions on environmental protection;
(i) Carry out such other activities as necessary for the fulfilment of its objectives.

It is interesting to note the international treaties of concern to EPA. These are:

- The United Nations Convention to Combat Desertification;
- The Convention on Biological Diversity;
- United Nations Framework Convention on Climate Change;
- The Montreal Protocol on Ozone Depleting Substance;
- Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES);
- The Basel Convention on Transboundary Hazardous and Toxic Wastes; and
- Global Environmental Facility (GEF).

EPA, through its General Manager, has been on the forefront in the negotiations on the Protocol on Biosafety.

The enforcement of government laws and regulations with respect to environmental protection is the responsibility of federal and regional courts and administrations. The Environmental Protection Authority (EPA) has the mandate to ensure the enforcement and for the overall coordination of environmental matters in the country. Thus, EPA is entrusted with the responsibility of formulating environmental policies, strategies and developing environmental impact assessment (EIA) procedure and guidelines as well as coordinating relevant organizations with the aim of protecting the environment. It is accountable to the Council of Ministers.

The Regional Governments are mandated to exercise far greater autonomy than ever before including environmental management. With respect to the environment:

- Regional Governments are empowered to administer land and the use of other natural resources in accordance with Federal laws;
- They ensure that laws and directives issued in relation to the protection, conservation and utilization of water, forestry, and wildlife are respected in the respective regions;
- They supervise the implementation, within the regions, of directives issued regarding the control of damages to be caused by the depletion of natural resources, and the prevention of water, soil and air pollution.

At EPA and other Federal as well as regional institutions there is a lack of capacity and competence to implement the Environment Policy. Since EPA is the lead institution it is incumbent upon EPA to strengthen its organizational capacity and competence through institution building efforts to fulfil its mandate and at the same time provide support to concerned national and regional authorities to play their share of responsibility in the promotion of environmental protection and sound management of natural resources. The

efforts of the concerned governmental agencies and NGOs as well as the local communities are vital for environmental protection.

EPA has to be well equipped with staff having relevant qualifications and experiences. Under the present set up, there are 103 approved positions. These positions have been filled by employees who were transferred from various government institutions many of whom have limited orientation concerning what their present assignments requires. Any way, 44 of the available staffs are professionals 20 are support staff and 29 positions are vacant of which the majority are support staffs. The effectiveness and efficiency of EPA would fall short of expectations unless measures are taken to create enabling conditions that will strengthen the Authority. The priority considerations in this regard are the training of the staff, procurement of equipment and supplies, including computers, vehicles, relevant books and publications as well as establishment of environmental laboratory and information system.

2.5 National Seed Industry Agency (NSIA)

The National Seed Industry Agency was established in 1992 by Proclamation No. 56/1992 as autonomous government Agency accountable to the Council of Ministers. The objective of the Agency is to provide farmers with high quality seeds of improved verities, increase agricultural production, sustain the biodiversity, conserve plant genetic resources, undertake research, streamline seed industries and implement the national seed policy. It also formulates regulatory and information dissemination infrastructures and see to implementation of it.

Currently, NSIA is undergoing restructuring once again to cover other agricultural inputs, particularly fertlisers. The proposed new proclamation is under consideration by the Federal Parliament. The objectives under the previous, Proclamation which would continue to be relevant in the new setup, were:

a) to oversee and ensure that the seed industry develops and operates efficiently,
b) to ensure that producers, the farming community, industries using agricultural raw materials as well as exporters of agricultural produces benefit from the seed industry, and
c) to create an enabling environment for capacity building in research, development and training in the fields of genetic resources conservation, crop improvement and seed technology. Increasing the production of improved seeds is seen as a key tool for raising agricultural production and productivity towards achieving the goal of food self-sufficiency.

The powers and duties of NSIA as provided were:

- Issue regulations, guidelines and procedures for variety evaluation and releases by governmental and non-governmental organizations, and monitor the proper implementation thereof;
- Effect the promulgation of a seed legislation to protect the rights of breeders and seed users, develop a system for seed marketing as well as the establishment and control of seed quality standards and ensure the implementation of the seed legislation.
- In cooperation with other appropriate government institutions, assist in the implementation of plant quarantine regulations;
- Follow up the implementation of rules and procedures regulating seed producers;

- Ensure the proper implementation of regulation and guidelines regarding the import and export of seeds;
- Control importation of genetically modified organisms (GMOs) with potential hazards to human, animal, plant, and the environment after exhaustive testing following appropriate quarantine procedures;
- Prepare a list on non-restricted and restricted crops, varieties and hybrids for use by foreign seed companies and joint ventures and when approved ensure its implementation;
- Establish a central seed data and information system;
- On behalf of the Government and in cooperation with relevant government institutions negotiate and sign agreements with local and foreign organizations pertaining to seed-related loans and grants.

Seed Proclamation No. 206/2000 provides a legal framework for the protection and control of the interests of users, originators, processors, wholesalers, and retailers of plant seeds. The collection, conservation, development and rational use of plant genetic resources are areas of high national interest and priority.

In order to facilitate the efforts being made by various research institutions to raise production and productivity, NSIA has developed a national variety release procedure and mechanisms. The guideline is aimed at enabling researchers to develop and release new varieties that would improve the quality and quantity of production. Specific objectives of the National Variety Release Committee are:

i. to review data supporting the release of a new hybrid or variety,
ii. to determine the uniqueness and production potential of the variety under the Ethiopian condition,
iii. to provide the mechanism for approval and proper release of varieties and hybrids, and
iv. to register the released varieties and hybrids.

The National Variety Release Committee is mandated with the tasks of being involved in testing the new or improved variety as well as approving the subsequent release to farmers through the formal research-extension system. Members of the committee come from different government organizations and adequate professional mix is maintained. The requirements are that breeders, agronomist/physiologist, entomologist, pathologist, economist, food scientist, and research-extension specialists are represented in the committee. Detail procedures are developed concerning field crops, vegetable and root crops as well as perennial crops (NSIA 2001).

The other service NSIA provides is variety information to farmers, private investors, public enterprises and state farms. The Agency encourages the active participation of private sector (investors) in the production and distribution of high quality seeds. NSIA has been regularly producing a registry of released crop varieties every year since 1998. The last one was issued in October 2001. Newly released varieties are recorded along with details of agronomic and morphological descriptions while the earlier releases are indicated by year of release and source of seed. Hence, it enables users to grow each of the varieties in the right place and use it for the right purpose.

NSIA also devised a seed system development project that works closely with farmer communities. This farmer-based seed production and marketing scheme encourages small

holder farmers to produce improved seeds for commercial purpose as the public sector was not able to meet the national demand. The regional agricultural bureaus are actively involved in the implementation of the scheme while the Agency provides technical and financial support accompanied by field supervision and inspection to ensure that seed quality is maintained to the acceptable standard.

2.6 National Health and Nutrition Research Institute (NHNRI)

The Ethiopian Health and Nutrition Research Institute (EHNRI) is a government institution established in April 1995 following the merger of the former three independent institutions, namely, the National Institute of Health, the Ethiopian Nutrition Institute and the department of Traditional Medicine of the Ministry of Health. EHNRI was established to conduct research in priority areas concerning health and nutrition problems in the country. The merger was geared towards pooling available resources, integrating fragmented efforts being made by various sisterly institutions and avoiding duplication of efforts.

Major objectives of EHNRI are to:

- conduct research on infectious and non-infectious diseases, nutritional problems, traditional medicines and medical practices and modern drugs, and thereby support the activities for the improvement of health in the country,
- contribute to the development of health science and technology, and
- promote hi-tech laboratory diagnostic services (referral) and produce biological substances including human rabies vaccine.

The activities of the Institute focus primarily on research and service provision that is limited to only hi-tech referral diagnostic services that are not available in the public health institutions. The Institute has three departments and two service units. The departments include: the infectious and non-infectious disease research, food science and nutrition research, and drugs research departments. The services are: (i) the epidemiological and bio-statistics service and (ii) the core laboratory. Each of the research departments have laboratories to carry out their routine activities and providing referral services that come on request. Among others, the core laboratory serves all research departments in matters pertaining to producing and using laboratory animals, organizing and maintaining laboratory equipment and instruments. The institute uses some of the advanced biotechnological tools in fulfilling its day-to-day routine services.

The Ministry of Health is the national body playing the regulatory role in the importation of medicines. It has quality control and quarantine departments responsible for issuing permits and works closely with the Quality and Standards Authority and the Health and Nutrition Institute.

2.7 The Quality and Standards Authority of Ethiopia (QSAE)

The Quality and Standards Authority of Ethiopia (QSAE) is the national standards body that became operational in 1972. Since then, it has gone through several restructuring of which the latest one was in February 1998. The new mandate resulting from Proclamation No. 102/1998 of the Federal government included effective promotion of quality management in addition to standards development, certification, metrology and testing. It has 10 branches and representative offices in various parts of the country and in Djibouti. QASE's vision is to be

an internationally recognized quality, standards, metrology and testing organization that supports the national effort for economic development and social progress.

The basic organizational objectives are to:

i. promote and assist the establishment of appropriate quality management practices as an integral yet distinct management function in the social and economic sector,
ii. assist in the improvement of the quality of products and processes through the promotion and application of Ethiopian standards,
iii. promote and coordinate standardization at all levels in the country,
iv. establish a sound meteorological system as a basic structure of economic development, and
v. strengthen, promote and enhance the reliability of testing laboratories nationwide.

QSAE is engaged in the following core business areas: Ethiopian Standards development, regulation enforcement (compulsory product certification and legal metrology), calibration, laboratory testing, batch product inspection, training and standards information. It has developed 1100 Ethiopian Standards in about 15 fields of which agriculture and food technology, textile and leather technology constitute the major shares (some 70%). QSAE operates a well-equipped and modern testing laboratory capable of carrying out vast number of tests (about 600) in mechanical, electrical, chemical and microbiological testing. It gives services to government organization, industry and other users. Moreover, it carries out laboratory tests as part of its standards development program.

Through its activities, QSAE tries to help in the introduction of appropriate technologies, safeguard the general safety of the consumer society, make domestic products competitive in the international market and protect the country from being a landing spot for sub-standard or even potentially harmful products. Concerning industrial products, inspection is carried out through out the whole process i.e beginning from the raw material stage to the whole manufacturing, packaging and distribution processes. In order to promote the concept of quality, QSAE staff participated in international training forums and also delivered in-country training to staff of various government offices in Addis Ababa, regional bureaus and private sectors.

QSAE safeguards Ethiopia's interest in international standardization through participation in technical committees, especially in the fields of agriculture and food. The authority maintains working relationships with quality promotion and standardizing bodies, professional associations and quality societies as well as certification bodies. Among these, it is a member of the International Organization for Standardization (ISO), International Organization for Meteorology (OIML), International Electro-technical Commission (IEC), and Codex Alimentarius Commission (CAC). It is also a founding member of the African Regional Organization for Standardization (ARSO).

2.8 The International Livestock Research Institute

The International Livestock Research Institute (ILRI) is part of the Consultative Group in International Agricultural Research (CGIAR) system with a branch office in Ethiopia. The mission of the Institute is to reduce poverty, hunger and environmental degradation through livestock research to enhance productivity and sustainability of agricultural systems in the developing world.

The mandate of ILRI is to measurably and sustainably improve the livelihood of resource-poor livestock keepers, make animal products more affordable and accessible for the poor, conserve natural resources in developing countries through partnership and alliances for innovative livestock research, training and information exchange. Major geographical emphasis is in sub-Saharan Africa due to large number of poor (food insecure) people dependent on livestock. Livestock play vital function in livelihood of rural communities being sources of food, income and in asset building. ILRI's research based technologies and interventions benefit the poor while protecting the natural resource base for future generations.

Through interdisciplinary strategic planning, the following areas were identified as focal areas for ILRI's future activities: people, livestock and the environment, economic valuation of animal genetic resources, capacity building and training resources for crop-livestock systems and animal genetic resources, and the development of a virtual system-wide livestock program network.

ILRI has a full-fledged branch office in Ethiopia stationed at Debre Zeit, some 50 km South-East of Addis Ababa. Its research activities include the following disciplinary fields: feed and nutrition, forage genetic resources, seed technology, dairy cattle improvement, dairy production technology, sheep production, animal health (reproduction), socio-economics and policy research, and integrated natural resource management. Some of these activities involve the use of modern biotechnology.

Biotechnological tools are potentially useful in the fields of animal nutrition, health, genetics and breeding. Concerning biodiversity and biosafety issues, ILRI abides by international conventions such as the Convention on Biological Diversity. The Institute strives to ensure that the benefits derived from the conservation and enhancement of genetic diversity for food and agriculture to be made available to those that developed and nurtured these resources.

ILRI follows national biosafety regulations for movement of germplasm or biological materials and for containment of disease organisms used in its research projects. It pays due attention to the welfare of livestock and laboratory animals used in research. It adheres to the most stringent operating procedures for experimental animals based on the British Animals (Scientific Procedures) Act of 1986.

To the extent possible, ILRI attempts to avoid negative consequences of its technologies on environment, human and animal health as well as biological resources. This is done through: full experimentation and testing on station in secure contained conditions before they are released for field testing, *ex ante* assessment of the impact of new technologies on the environment and diversity before release for use, and carrying out risk assessment of those products or biological materials which have been genetically modified.

2.9 The Universities

2.9.1 History and development of higher education in Ethiopia

Higher education saw its beginning with the establishment of Addis Ababa University, the oldest institution of higher learning in Ethiopia. It was founded in 1950 as the University College of Addis Ababa. In 1961 it was merged with other tertiary education institutions to create the Haile Selassie I University (HSIU), later named as Addis Ababa University (AAU)

after the military regime took power in 1974. AAU used to cover essentially all fields including agriculture and has since 1978 established a range of graduate programs. The graduate programs were initiated primarily to meet the needs of higher education institutions and research organizations. Today, several of the graduate programs offer Ph.D studies.

In the 1980s, AAU had expanded to over 14 faculties and five research institutes serving over 20,000 students in both the regular and evening extension programs. In 1986, the College of Agriculture at Alemaya was upgraded to a university level and separated from AAU. After 1995, other faculties were also brought directly under the administration of the Ministry of Education (MOE). Following the decentralization policy and expansion of regional universities, AAU has been scaled down to include only the faculties based in Addis Ababa and the Faculty of Veterinary Medicine in Debre Zeit.

As a major input to the necessary manpower requirement in order to address the aforementioned problems, the present government is introducing considerable changes in higher education. Since the year 2000, 4 new universities were established, including the Debub and Mekelle University. However, the student intake capacity of the 6 universities in the country is very small. The number of students who could join a university annually is reported to be around 200 000. As of this year, several medium level colleges were opened to train students to diploma level. Most of the universities have manpower shortage; the available teaching staff is less than 50 % of the required number. The essential problem confronted by Ethiopian universities is that the quality of university education is significantly declining as a result of dwindling resources and growing enrolments. Research is coordinated at national level by the Ethiopian Science and Technology Commission and Ethiopian Agricultural Research Organization (EARO).

The development of higher education is therefore among the highest national priorities and will be the major instrument in achieving food security and alleviating poverty and other social and technological problems the country is facing. These key development building blocks are highly related and require a multidisciplinary approach to research, capacity building and better-informed policy and implementation decisions[4]. Capacity building is taken to comprise the development of human resources, building and strengthening of institutions, and establishment of effective working practices in combination. The program is to be implemented in relation to smallholder agriculture, the private sector, and the public sector, including the judiciary. The training needs of regional and district administrations will receive special attention.[5]"

2.9.2 Addis Ababa University

As noted above Addis Ababa University has been scaled down and limited to the campuses located in Addis Ababa and Debre Zeit. The present total enrollment is around 6000. A few hundred students are enrolled in the graduate programs within 27 disciplines. The annual candidates that complete the graduate programs is reportedly around 150. The expansion of local graduate programs is considered extremely important for various reasons. One of the reasons is that it helps to curtail brain drain. Over the years, AAU has lost hundreds of its staff to foreign countries and institutions.

The Biology Department of the Faculty of Science is by far the biggest and most well-developed unit of the University and works very closely with the Institute of Pathobiology.

[4] Ibid, pp. 88-89.
[5] Ibid, pp. 87-88.

The following research activities are recorded:

- Molecular characterization of durum wheat, barley, and sorghum
- Screening, isolation and characterization of industrially important microorganisms
- Screening of rhizobia
- Protein analysis
- Tissue culture of indigenous tree species
- Biomass conversion biotechnology (enzymes)
- Isoenzyme analysis on teff
- Application of biochemical markers for different crops
- Fungal secondary metabolites
- Biogas production and bioconversion

The National Veterinary Institute and Faculty of Veterinary Medicine, based in Debre Zeit, are part of the Addis Ababa University. These have research and production divisions. The research division of the Institute concentrates on studying and screening micro-organisms for antibiotics or other biological compounds that can be used as vaccines or curing medicines. It is also engaged in the development of vaccines for livestock. The production division, on the other hand, produces viral vaccines against Rinderpest, Sheep pox, Newcastle, African horse sickness, Foot and mouth disease, as well as bacterial vaccines against Bovine pleuropneumonia, Anthrax, and the like. These activities involve some of the molecular biological techniques. The Faculty is a teaching institution.

Collaborative biotechnology related activities include the following:

- Vaccine development (Veterinary Institute)
- Artificial Insemination (with ILRI)
- Tissue culture for regeneration and cryopreservation
- Studies on biopesticides at Ambo (NCPRS)
- Enset (IAEA with EARO)
- Molecular marker-assisted selection of teff (Texas Tech. University, Debre Zeit Research Centre, McKnight Foundation)
- Study on diversity of crops (IBCR with GEF)

2.9.3 Debub University

Debub University is located 275 km. South of Addis Ababa in the Southern Nations Nationalities and Peoples' Region (SNNPR). It was established in 2000 by merging three colleges namely; Awassa College of Agriculture (ACA), Wondo Genet College of Forestry (WGCF), and Dilla College of Teachers' Education and Health Sciences. The nucleus of the university remains to be ACA that was founded in 1976 under the Addis Ababa University. ACA now serves as the administrative centre of the University.

After operating at the diploma level for several years, ACA upgraded four of its departments to offer degree programs, namely, Animal Production and Rangeland Management (APRM), Agricultural Engineering and Mechanization (AgEM), Plant Production and Dry-land Farming (PPDF), and Rural Development and Family Sciences (RDFS). There are new programs in the pipeline. These include: Food Sciences and Post-harvest Technology; Cooperatives, Agricultural Resource Economics and Management (AREM), Veterinary Medicine and Hotel Management.

The other faculties of Debub University that are based in Awassa are:

1) Faculty of Social Sciences with departments of English, Accounting, Business Management, Marketing Management, and Law;
2) Faculty of Natural Sciences with departments of Chemistry, Biology, Physics, Mathematics, Engineering, and Computer Sciences;
3) Faculty of Medical Sciences (under planning).

Debub University is prepared to launch M.Sc programs in Animal Production and Plant Production as of the 2003/4 academic year.

Awassa College of Agriculture has long standing cooperation with the Agricultural University of Norway since 1988. Several staff members were trained at PhD and M.Sc levels over the years. Most of these graduates have taken up responsible scientific and leadership positions at Debub University. Interestingly, there are several joint research programs initiated by these staff with their former supervisors. Wondo Genet College of Forestry has been receiving support from SIDA for many years and continues to do so. It runs programs at diploma, degree and postgraduate programs. Dilla College of Teacher's Education and Health Sciences is the youngest institution.

The research activities of ACA are well organized and collaborate with many national and international organizations. The research programs focus on food production, rural development, environmental protection, family welfare, and improved productivity of arid and semi-arid zones. There is a growing interest in biotechnology related research with some modest beginnings. However, the University lacks capacity to carry out advanced research. Some of the staff have participated in the formulation of the Biotechnology Policy which is submitted to the Council of Ministers for approval.

2.10 Summary of Findings from Interviews made with Leaders/Staff of Institutions Visited

The following are the main points and comments gathered from the interviews made with leaders/staff of institutions visited. They are outlined at random.

1. Biotechnological research is one of the most neglected and under-utilised areas of research. The country lacks both the manpower and facilities to do any meaningful work in biotechnology.
2. There some scattered activities carried out in different research and academic institutions. The coverage is very limited in scope and depth. A lot of benefit can be drawn from biotechnology to increase agricultural production and productivity, if all concerned parties pay serious attention.
3. The major shortcomings include inadequate human resource, inadequate facilities, absence of biotechnology policy, and related regulatory measures. The concerned institutions and their staff are waiting for the approval of the national biotechnology policy with keen interest.
4. There is a need for scientific and technical training in the proper and safe management of biotechnology as well as in the methods of risk management.
5. The biotechnology courses and related subjects that are currently offered in the higher education institutions will have to be reviewed and updated in order to produce competent manpower for the development of biotechnology and its application in agriculture, industry, health and other social services in general. University curricula should address the key issues in the transfer and application of biotechnology. Needs assessment in terms of manpower and infrastructure requirements should be made.

6. EPA has a mandate to regulate the application of biotechnology from the environmental point of view. It has assumed a huge responsibility without the necessary resources. There is also no competent capacity for full management and monitoring of biotechnology in other concerned institutions.
7. The private sector is very weak to help promote the development and management of biotechnology. There is a need to strengthen public-private partnership in the development and use of biotechnology.
8. Ethiopia has been very successful in international negotiations. But, in practical terms, there has to be seen fair international negotiations to facilitate transfer of technologies that benefit the country.
9. Biosafety protocol has been formulated and presented to the Council of Ministers and is expected to be approved very soon. Pharmaceuticals are not covered in the proposed protocol. This will help to address Ethiopia's international obligations as well.
10. It has become very difficult to check and regulate trans-boundary movements with respect to biotechnology. The institutions charged with such responsibilities are incapable both in terms of technical competence and the legal instruments to fully enforce the required control measures.
11. There is a need to establish a database for the genetic resources of the country.
12. The institutional basis to effectively coordinate biotechnology and related activities is lacking. There is insufficient effort to integrate the knowledge and manpower available to maximize the potential benefits of biotechnology.
13. There is no public awareness and understanding about the risks and associated dangers biotechnology.

3. Biotechnology and Related Policies in Ethiopia

National policies are necessary to control the importation and export of biotechnology products and the technology itself to make use in a safe and responsible way. Linked with these frameworks, proper regulatory mechanism that gives due attention to biosafety issues is required to effectively implement the policies and associated laws. Effective policy framework also requires communication among scientists working with the technology, policy makers and other stakeholders.

This section briefly introduces the existing and proposed biotechnology related policies in Ethiopia.

3.1 The National Science and Technology Policy

The National Science and Technology Policy, issued in 1994, provides guidance for the development of science and technology in Ethiopia. The policy document comprises of policy objectives and strategies to be followed, and the priority sectors and programs to be undertaken. The main objectives are: (a) to build national capability to research, generate, select, import, develop, disseminate and apply appropriate technologies for the realization of the country’s socio-economic objectives and to nationally conserve and utilize its natural and human resources; (b) to improve and develop the knowledge, culture and scientific and technological awareness of the people for rational utilization of its resources; and (c) to make science and technology activities more productive, efficient and development oriented. It sets out policy directives, strategies and priority sectors and programs giving due emphasis on building national science and technology capability.

Environment and biodiversity are among the priority sectors and programs. Undertaking of inventory on biodiversity resource, promotion of methods that help conservation and management of forestry resources and forest ecosystem, promotion of research on how to acquire, introduce and develop tree varieties, encouragement of environmental quality and rehabilitation works constitutes the major components.

3.2 The National Biotechnology Policy

Biotechnology was one of the priority areas considered when the National Science and Technology Policy of Ethiopia was formulated in 1993 with a view of enhancing its application in the fields of agriculture, industry, health and environment. Nevertheless, there have been very little gains made in this respect except for the scattered efforts of a few departments of the universities and research centres.

Efforts were and are being made by ESTC and other institutions to develop a national biotechnology policy framework that would help address Ethiopia's obligations attached to the international conventions and treaties. As a lead organization, ESTC plays the coordinating role and attempts were made to address the four main sectors: agriculture, environment, health and industry in developing the national biotechnology policy. Along this line, the draft protocol was prepared by a team of experts cooperating from different concerned government ministries and offices (ESTC, IBCR, EPA, EHNRI, Ministry of Industry, Ministry of Health, etc), and submitted to the Council of Ministers and is awaiting approval. The draft protocol, however, is commented to be not exhaustive as some areas like pharmaceuticals and food safety are missing. At some point, it needs to be elaborated further, updated and enriched so as to include those aspects that are missing and also accommodate emerging technological advances. It would also be imperative to work out corresponding implementation strategies.

The national biotechnology policy is conceived as the overall guiding document. It clarifies the main responsibilities and mandates of key government institutions that have direct involvement in the regulation and use of advanced biotechnologies. Thus, it would help to avoid duplication of efforts and enhance better coordination for effective utilization of available human and financial resources. Detailed operational strategies will be worked out soon after approval of the policy in order to facilitate implementation of the policy towards meeting national development needs that make use of biotechnology.

The draft policy recognizes the need for development of biotechnology in Ethiopia as one of the mechanism to ward of, say, food deficit. It underscores the fact that the apparent means of developing the capability is by facilitating the transfer of technology. It also recognizes the caution that should be exercised given the risk associated with biotechnology.

The East African Regional Program and Research Network for Biotechnology, Biosafety and Biotechnology Policy Development (BIO-EARN), financially supported by the Swedish International Development Cooperation Agency/Department of Research Cooperation (SIDA/ SAREC), has contributed a lot in local capacity building since 1998. The three thematic areas that are supported through BIO-EARN are research and capacity building in biotechnology, biosafety and biotechnology policy. Partner institutions benefiting from the program include, ESTC, IBCR, EPA and Addis Ababa University (biology department).

3.3 The Agricultural Biotechnology Policy

Agricultural research activities in the public sector are directed by the agricultural research policy and strategy issued in 1993. The overall objective is to direct public sector agricultural research and application for the enhancement of national development. The specific objectives are stated as:

- to generate and select agricultural technologies
- to enhance the productivity of the agricultural sector, integrate research programs and be targeted as well as diversified to solve major agricultural problems and
- the conservation and development of the environment.

Specifically, research on generation and selection of technologies meant for conservation and proper utilization of agricultural related natural resources, environmentally appropriateness of agricultural chemicals and how to add value to crop landraces (farmer varieties) are the major focus areas. Specific strategies are: undertaking of study and inventories on resources, identifying major ecosystems in the country, conducting research to generate techniques on sustainable and rational utilization of resources. EARO is paying serious attention to research and development in biotechnology in the context of the Biotechnology Protocol discussed above.

3.4 The National Biodiversity Conservation and Research Policy

The National Biodiversity Conservation and Research Policy was formulated subsequent to the Environmental Policy of Ethiopia and approved in April 1998 by the Council of Ministers. The National Biodiversity Conservation and Research Policy focuses on the conservation, development and sustainable utilization of the country's biodiversity.

The overall objective of the policy together with the specific policy directions is to ensure the effective conservation, rational development and sustainable utilization of the country's biodiversity. Integrating conservation into development initiatives, respect for traditional knowledge, public participation, benefit sharing, regional and international cooperation, capacity enhancement, development and sustainable utilization of genetic resources and ecosystems, and developing mechanisms as well as implementation are the underlying considerations of the Policy.

The national policy on biodiversity conservation and research was formulated based on the rationale that the conservation of biodiversity is one of the conditions for overall socio-economic development and sustainable environmental management goals. The preamble states that lack of comprehensive guidelines, awareness and appreciation on plant, animal and microbial genetic resources importation, exportation and exchange activities has resulted in the movement of genetic resources into and out of the country in unregulated and uncoordinated manner. This has resulted in the loss of benefits from valuable indigenous resources and in the introduction of unverified genetic materials, diseases, pests and weeds into the country.

Among others, the specific objectives of the policy were:

i. to ensure that the Ethiopian plant, animal and microbial genetic resources and ecosystems as a whole are conserved, developed, managed and sustainably utilized,

ii. to build national scientific capacities and capabilities to explore, collect, characterize, evaluate and utilize the biodiversity of the country,
iii. to recognize, foster and augment the indigenous knowledge and methods relevant to the conservation, development and sustainable use of biodiversity, and promote and encourage the development and putting into practice of new and emerging technologies such as biotechnology, and
iv. promote regional and international cooperation in biodiversity conservation, development and sustainable use.

3.4.1 National Access Legislation

The Convention on Biological Diversity has made provisions for the first time to recognize the sovereign rights of states to regulate access to biological resources under its jurisdiction. Till then, biological resources were considered "common heritage of mankind". As a result, biological resources of the country were being accessed freely.

In line with the provisions of the CBD, a national biodiversity conservation policy was adopted and a proclamation that requires permit to access biological resources was issued. Efforts are being made to develop a comprehensive national access legislation (i.e work out the detail requirements and conditions for permits) by drawing a team of experts from relevant government organization and offices. The draft document is being reviewed to get its final shape soon. The potential benefits that may be obtained from regulating access include: up front payments, participation in scientific research, equitable sharing of the research and development of the resource including the granting to the source country of priority access to and transfer of technologies, particularly biotechnology; and the sharing of financial benefits accrued from the exploitation of the resources (Mengiste 2001).

3.4.2 Material Transfer Agreement

IBCR has developed material transfer agreement to deal with germplasm collections. The transfer agreement is a contract signed to authorize relationships between the provider of biological resources and the users by defining their respective obligations. The agreement is being used to regulate the relationship of the two parties both within the country and other countries. However, little effort was made to make use of the convention as a guide towards incorporating the provisions of CBD to ensure that long terms benefits arising from the material transfer are shared fairly. Improvements are needed to make the agreement comprehensive, clear and uniform in order to enhance the conservation of biological resources of the country and at the same time ensure sharing of benefits arising from their exploitation. Building national capacity could possibly be incorporated into such agreements.

3.4.3 The National Environmental Policy

The Environmental Protection Authority has developed a national environmental policy issued in 1997. The overall goal of the policy is to improve and enhance the health and quality of life of the people and promote sustainable social and economic development through the sound management and use of natural, human-made and cultural resources and the environment as a whole so as to meet the needs of the present generation without compromising the ability of future generations to meet their own needs. The policy document elaborates specific policy objectives as well as sectoral and cross-sectoral environmental policies. It has also taken into account the national and international dimensions of sustainable development.

The overall objective of the Policy is to promote sustainable social and economic development of the country through conservation and sustainable utilization of natural, manmade and cultural resources and the environment. It specifies the policy objectives, key guiding principles, sectoral and multi-sectoral policy frameworks and implementation strategies that help realize the sought overall and specific objectives. The Environmental policy of Ethiopia has five major sections. The first section is on the resource base and justification for the policy. The second deals with policy goals, objectives and guiding principles. The third is directed to sectoral environmental policies while the fourth deals with cross-sectoral environmental policies; and the fifth and last section propounds upon policy implementation.

The policies dealing with multi-sector affairs includes population, participation, resources use rights, land use planning, social and gender issues, environmental economics, research, impact assessment, and environmental education and awareness. The sectoral environmental issues consist of soil resources, agriculture, forest resource, biodiversity, water resources, energy, mineral resources, urban environment and environmental health, pollution, cultural and natural resources.

The environmental policy seeks to ensure that essential ecological processes and life support systems are sustained, biological diversity is preserved and renewable natural resources are used in such a way that their regenerability and productive capabilities are maintained and where possible enhanced so that the satisfaction of needs of future generations is not compromised.

3.5 The National Seed Industry Policy

The National Seed Industry Policy was approved on October 1992. Its mission is developing a healthy national seed industry. It focuses on conservation and development of plant genetic resources, and the production and supply of seeds.

The objectives of the policy focuses on ensuring the collection, preservation, evaluation, development and utilization and registration of plant genetic resources and germplasms. Moreover, it encourages the participation of farmers in germplasm conservation, seed production and supply system, and in sharing economic benefits accrued therefrom and regulating seed quality standards, trade, quarantine and other related issues. The basic guiding principles are rational use, countering extinction of genetic erosion, disease, pests and weeds; ensuring safety, participation of farmers, research, standardization, establishing a clearing house and reserve seed stock.

3.6 Quality and Standards Policy

The quality and standards authority deals with import and export certification for those items whose standards are already established. Standards are basically adapted from the international codex. The inspection and verification service does the regular inspection of items ready to be imported into the country or exported out of the country. Depending on the case, items not meeting the quality standards are not allowed either to be imported or exported.

There is no specific law or regulation concerning food safety (food act) other than checking the product quality according to the marked labels against the established standards. The

Authority has some level of awareness about food safety issues and some members of the Authority have participated in international workshop and seminars. Local food processing industries also received some orientation on food quality and food safety issues. The authority uses the mass media (radio program) to inform the general public about quality standards and safety precautions concerning some selected consumer goods that are widely used both by urban and rural communities.

3.7 The National Health Policy

The government accords high priority for the health sector as human health including physical, mental and social well-being is a prerequisite for the enjoyment of life and for attaining optimal productivity. It was realized that health policy can not be considered in isolation from policies addressing population dynamics, food availability, acceptable living conditions and other requisites essential for health improvement. Health development, therefore, is considered an essential component of the package of social and economic development as well as being an instrument of social justice and equity particularly to the less privileged.

To this effect, a national health policy was adopted in 1993. It was designed after critical examination of the nature, magnitude and root causes of the prevailing health problems and awareness of newly emerging ones. The goal of the policy were to restructure and expand the health care system to make it responsive to the needs of the less privileged and rural population that constitute the overwhelming majority of the population and the major productive force of the nation. Accordingly, eight priority areas were identified and pertinent strategies were designed respectively for each of the priority areas.

3.8 National Food and Nutrition Policy

Though there is increased awareness about the need for a national food and nutrition policy, it is not yet developed. Fragmented efforts were being made in the past, but these need to be consolidated and coordinated so as to realize the formulation of a national policy in the near future. The activities of the Health and Nutrition Research Institute in this respect are important to generate timely and reliable information that would help to assess the status of food security, develop appropriate intervention strategies and formulate a national food and nutrition policy. Good quality nutritional research is essential in order to formulate national policies and design programs tailored towards alleviating nutritional deficiency disorders prevailing in the country.

4. Status of Biotechnology Activities in Ethiopia

Biotechnological activities in Ethiopia are distributed in a few institutions. The national institutes with potentials to undertake biotechnology programs are:

- Addis Ababa University (AAU),
- Alemaya University of Agriculture (AUA),
- Ethiopian Health Nutrition Research Institute (EHNRI),
- Ethiopian Agriculture Research Organization (EARO),
- National Veterinary Institute (NVI),
- Institute of Pathobiology (IPB),
- Institute of Biodiversity Conservation and Research (IBCR) and

- Some of the regional Teaching and Research Institutes.

The following are some of the modest biotechnology activities and potentials present in Ethiopia.

- Use of DNA probes in Tropical Zoonotic disease diagnosis.
- Micropropagation and improved seed technology on indigenous tree species.
- Somaclonal variation; Protoplast culturing and fusion studies of crop plants*.
- Molecular techniques including DNA sequencing for genetic characterization*.
- Research on bioactive compounds from submerged cultures in tropical fungi.
- RFLP techniques to localize on the chromosome quantitative trait loci (QTL) in teff*.
- Biotechnology applied in diagnosis and detection of viral pathogens.
- Micropropagation and tissue culture in indigenous trees and shrubs.
- Selection of indigenous trees and shrubs for nitrogen fixation.
- Exotic trees *(Leucaena, Gliricidia)* for afforestation and agroforestry.
- Selection of indigenous trees for agroforestry.
- Isolation and characterization of waste celluloses into industrially useful products.
- Evaluation of substrate and microorganisms for biogas production.
- Low cost tannery wastewater treatment selection of sulphur oxidizing bacteria from a tannery waste treatment system*.
- Efficient removal of nitrogen from a tannery wastewater*.
- Tse-tse eradication program*.

5. Institutional Arrangements for Biotechnology Management in Ethiopia

ESTC supports technology development and facilitates its promotional aspects. The institutional set up of ESTC is at central (federal) level and has no structure that links the different regional states.

EPA plays the central regulatory role at national level concerning environmental issues. Presently, Environmental Coordination units are being established at regional and local levels. Environmental units were established in Amhara, Oromiya and Addis Ababa regions while SNNP and Tigray regions are in the process of finalizing. These need technical backup from EPA until they develop/attain the required competence and also receive relevant updates on emerging biotechnology/environmental issues.

The benefits and risks of biotechnology were among the important issues that attracted much attention of the international environmental negotiations of the late 1980s and early 1990s. Consequently, the Convention on Biological Diversity enshrined enabling provisions on how the benefits of biotechnology should be distributed and its potential risks managed.

Article 19 sub-article 3 of CBD informs parties to formulate a protocol on the safe transfer, handling and use of GMOs. This article elaborated Paragraph (g) of Article 8 and demands each party to regulate, manage or control risks associated with the use and release of GMOs.

Along with the advancement of genetic engineering, a concern about biosafety has grown complex and it calls for a regulatory system. Implementation of safety precautions requires effective regulatory infrastructure comprising of systems and organizations deployed to ensure biosafety. Such infrastructure includes national safety policy and legislation, safety evaluation and inspection system, safety experts and facilities, and safety culture.

Development and application of safety measures is of paramount importance to enable genetic engineering bring about improvements in human well being and the environment.

The Safety Protocol applies to the safe transboundary movement, transit, handling and use of GMOs that may have adverse effects on the conservation and sustainable use of biological diversity, taking into account risks to human health. However, GMOs that are pharmaceuticals for humans are excluded from the scope of the Protocol if another international agreement or arrangement covers them.

Currently a proposal to ratify the Protocol is submitted to the Government. When the Government ratifies the Protocol, Ethiopia will assume an international obligation towards ensuring that the rules and procedures set out in the Protocol are put into practice.

There are commitments that a country assumes as a result of becoming a party to the Protocol. In this regard, the major ones can be summarized as follows: to prevent adverse effects of GMOs and to prevent unintentional transboundary movement. The exporting party will furnish this risk assessment report. The importing party evaluates the report and makes decision thereon. This exclusion, however, does not imply that countries may not regulate their import.

Capacity for negotiations must be built up for theimplementation of the Biosafety Protocol will be an on-going process. There are also issues on liability and redress, and identification of GMOs for food, feed or processing which still have to be finalized, and translated into the national operative framework. Developing countries in particular need to build up their capacity on three key fronts: biosafety legislation, scientific capacity, and monitoring and enforcement capabilities. EPA has been involved in international negotiations and is spearheading the national efforts for promoting and ensuring the implementation of the Biosafety Protocol.

EARO, being a public institution dealing with the technology development, has produced the national policy and corresponding strategy document pertaining to agricultural biotechnology. It has a coordination office for agricultural biotechnology research and development based in Addis Ababa. Efforts were made to raise awareness on biotechnology related topics and internet-based discussion group that involves professionals from eastern African countries was formed. The network is named as the African Biotechnology Forum.

Concerning IBCR's capacity, the Biotechnology and Biosafety Department is in place. Much of the work being carried out to date is more or less concentrated in plant genetic resources conservation, characterization and evaluation to a certain extent. Biotechnology in general terms is needed for the following major component activities:

a) for *conservation*:- among others, tissue culture could be used in forestry, root and tuber crops, crops having recalcitrant seeds as well as medicinal plants.
b) to *complement ex situ conservation* activities by enhancing regeneration of seeds maintained *ex situ*.
c) for *diversity assessment*:- among biotechnology tools, molecular markers would facilitate such studies substantially in identifying economically important genes. So far only physiological/morphological characters are used in crop genetic resource evaluation activities.

d) for *research*:- biotech tools are useful to speed up the screening of crop varieties and/or accessions. Conventional methods require longer time and, hence financial resources to go through the large number of accessions collected would be enormous.
e) for *identification and classification*:- this is linked to biosafety issues. Biotech tools would be applied to check that materials are free from disease and also inspect that they are not transgenic (GMOs). The latter requires that proper facilities and technical competence be instituted.

The Ethiopian Health and Nutrition Research Institute uses molecular biology based technologies in screening pathogenic bacteria using restriction fragment length polymorphism (RFLP) and PCR technologies. It is also involved in the study of epidemiology and drug resistance of micro-organisms. Laboratories of the institute are equipped with the basic facilities to perform some level of molecular technologies required for their day-to-day routines. However, it lacks the proper equipment to run advanced level technology such as cloning and sequencing technologies.

Pertaining to animal genetic resources, advanced biotechnologies are potentially useful for conservation, enhancement, utilization and genetic diversity studies. Molecular markers can be used to study diversity of animals and also identify genotypes with valuable traits for use in breeding programs. Disease diagnostics systems such as poly- and monoclonal antibodies contribute a lot in the control of animal diseases (bacterial, viral and parasitic) and safeguard animal health. Cryopreservation helps to facilitate the safe transporting of animal reproductive organs for use in breeding (Tegegne et al., 1993).

In animal nutrition, biotechnology aims to improve the efficiency of animal productivity through manipulation of the feed base, the animal's digestive system and animal's metabolism. Earlier studies showed that the predominant feed sources and forages consumed by ruminants in developing countries are usually below 55% digestibility. Hence, improving the protein to energy ratio in animal feed would significantly improve efficiency of feed utilization.

Artificial insemination (AI) is the most widely used biotechnology globally. In Ethiopia, a national AI centre was established in 1981 to organize and coordinate national AI activities and direct breeding programs. Despite its long history of use, a lot remains to increase efficiency of the service provided. To this effect, the Center has planned to introduce embryo transfer technologies in the near future.

The National Veterinary Institute is one of the institutions using some biotechnological tools. It is using biotechnology mainly for disease diagnostics and sub-unit vaccine production. Among others, it uses PCR technology in the production of animal vaccines. The Faculty of Veterinary Medicine is an educational institute and tries to acquaint students with some of the advanced biotechnologies available in disease investigation. The course focuses more on theoretical aspects so far mainly due to constraints in acquiring the necessary laboratory equipment, chemical supplies and running expenses involved in practical experiments.

6. Need for Capacity Building

Although biotechnology has enormous potential for application in agriculture, health, environment and industry, developing countries by large face great difficulties in realizing this potential because of constraints in terms of financial resources, facilities and equipment, skilled human resources and information system. The same holds true for Ethiopia.

The various organizations consulted have individually carried out organizational need assessment studies concerning biotechnology issues. The gaps identified by the various institutions consulted were more or less similar. Hence, the summary is presented here to indicate focal areas and avoid unnecessary repetitions.

6.1 Policy gaps

National biotechnology policy is not yet in place. The draft policy needs to be finalized soon providing institutions with clear mandates.
The national access legislation also needs to be finalized and the existing material transfer agreement needs improvement.

6.2 Institutional capacity gap

a) Infrastructure and facilities gap:- Laboratory facilities of the various institutions need improvement. There is no GMO detection laboratory in the country and, hence, no technical guideline that defines the corresponding safety standards.
b) Gap on risk assessment:- Risk assessment capacity in relation to biotechnology use and importation is low and needs to be built up. Assessment of risks related to environment, health impacts, etc of the technology in question is crucial so as to hold back undesirable impacts.
c) Gap in implementation and management competence:- Technical competence of high level professionals, mid level and lower level technical staff needs to be continually upgraded to acquaint with the newly emerging technologies. Adequate competence is needed to make information available and use a particular technology in a safe and effective way.
d) Gap in negotiating competence:- a few, in most cases only one individual participates in international negotiating forums representing the country, at times even the region (Africa). An individual cannot have all the competence to deal with issues arising from the various disciplinary fields such as plants, animals, industry, health and environment. Hence, it appears vividly difficult to reflect national interests fully and make fruitful negotiations as such.
e) Financial resource gap:- financial shortage is the major bottleneck that hinders the importation and use of any particular biotechnology including the purchase of the required laboratory facilities and supplies (mainly chemicals), cover other running costs of institutions as well as training professionals.

6.3 Gap on Safety Mechanisms

Biosafety laws and regulatory mechanisms are either missing or loose in many cases, and enforcement mechanisms are not effective in most cases due mainly to missing safety standards and/or lack of effective institutional frameworks. It is not possible to make

enforcement of legislations effective through the efforts of a single institution. Hence, it calls for concerted and coordinated effort of all concerned institutions.

6.4 Knowledge/Information Gap

i. Gap for implementation and management:- refers to knowledge as to what type of biotechnology is available (i.e know state of the art), identify what is useful to one's national context, and on ways to acquire the desired technology, etc. These by large are dispersed among individuals in the various institutions of whom some experts have left the field of biotechnology and, hence, do not make significant impact.
ii. Inventory and distribution of the diversity of biological resources of the country is fragmentary. Such information is vital to realize potential benefits from using the resources by involving biotechnological tools/techniques.
iii. Information gap concerning the potential values or contributions of some biotechnological tools and/or products,
iv. Information gap as to the probable hazards of biotechnological products and the safety precautions,
v. Awareness gap among stakeholder institutions and policy makers. Awareness is generally not satisfactory among policy makers to make informed decisions, and
vi. Public awareness concerning impacts of biotechnology is negligible to a great extent.

7. CONCLUSION AND RECOMMENDATIONS

It should be emphasized here that biotechnology has potentially positive contribution to national development and enhancing food security. However, it is not a complete solution on its own, rather it offers only one part of the solution towards attaining food security provided that the necessary safety precautions are there. Hence, a dynamic process must be in place to evaluate thoroughly the potential uses of new and emerging biotechnologies in relation to national interests over time i.e in the short and long run.

Developing countries generally need to build their biotechnology research capability in order to adapt and/or develop appropriate technology suitable for their own national needs. This in turn calls for a policy framework that includes effective biosafety oversight mechanisms. Policies developed in line with the international conventions and treaties should be able to protect national interests to a greater extent possible. Effective policy framework requires effective regulatory mechanisms in place. It also demands continuous communication or information feedback among scientists, policy makers, and other stakeholders. Related to this, prioritizing research efforts in biotechnology and sharing of responsibilities among different institutions helps to avoid duplication of efforts and effectively utilize human, material and financial resources.

Biotechnology by its very nature is cross-cutting issue among various sectors of the economy and, hence, among different government institutional set-ups. There is no single recipe that would be applied to make biotechnology useful and beneficial to all countries. However, the key points that we feel need to be given due attention concerning the importation and use of biotechnology are presented in this section.

First, national policy instruments that are in harmony with international conventions and treaties should be developed in a way that gives equal consideration to all stakeholders

(government bodies, NGOs, private sector and the public by large). To this effect, diversified approaches need to be employed to devise effective implementation and management strategies emanating from the policy directives. Secondly, the required technical competence, infrastructure and facilities should be made available to make the right use of any particular biotechnological process or its products. Thirdly, effective mechanism for carrying out risk assessment studies and also monitoring safety standards need to be in place. Information sharing and keeping regular flow of feedback concerning the application of a particular biotechnology is another important area that deserves due consideration.

Based on what has been learnt from the different organizations and individual expertise, the study makes the following recommendations.

1) Capacity Building – Human Resources and Facilities

1.1 *Human resource development*

i. Short and long term targeted and specialized training for higher level and lower level technical staff working with biotechnology related issues. In this regard, local universities could play a role in producing mid and lower level technical expertise. For instance, biotechnology is incorporated into the curriculum of Addis Ababa University (biology department) to run graduate program in selected fields. The same holds true for the faculty of veterinary medicine. Such an effort would help to ensure that trained personnel would be produced on regular basis.
ii. Exchange programs to share experiences, learn from countries that have established effective regulatory systems.
iii. Short term exposure visits for experience sharing,
iv. Technical assistance of expatriates to acquaint local personnel of biotechnological applications, risk assessment studies, etc, on specific fields,
v. Incentive system (awards, remuneration in recognition of contributions made, and the like) is valuable to encourage dedication and innovativeness.
vi. Improving working environment (designing attractive career prospects) to raise commitment levels and minimize staff turn-over.

1.2 *Infrastructure, laboratory facilities and supplies*
1.3 *Financial resource*:- mobilizing resources from public and private sector, from local and external donor sources.

2) Having a Centre of Excellence

Establishing a centre is expected to have the following advantages:

a) play the central coordinating role and promote institutional linkages among partners at various levels,
b) pool available resources (finance, material and key expertise),
c) avoid duplication of efforts and share institutional responsibilities,
d) ensure serious thinking in strategy planning and prioritisation, and
e) make serious commitments focusing on safety issues.

3) National Policies and Regulatory Mechanisms

Effective policy directives and legislations as well as monitoring and regulatory mechanisms are required to:

a) Have clear mandates and sharing of responsibilities among relevant stakeholders,
b) Enhance implementation and monitoring competence, and
c) Organize concerted action of various institutions and using existing structures that reach from the national (federal) level to the smallest local community groups.

4) Raising Public Awareness

The policy makers need to have adequate insight about biotechnology (prospective benefit and associated risks) so as to make informed decisions. The public at large also needs to have general awareness like food safety issues, short and long term benefits and risks associated with biotechnology products. To this end, various formal and informal forums could be used. Moreover, development NGOs and local community based organizations could be used as promotional agents in awareness creation.

5) Enhance Negotiating Competence

Suggestions to enhance this include:

i. one institution to take the leading role to coordinate and carry out fund raising activities exploring various options available (suggestion: ESTC, EPA or IBCR),
ii. maintaining adequate professional mix among participants,
iii. maintaining continuity in participation of expertise from key organizations so that participants are familiar with what is going on,
iv. create feedback forum/mechanism for all stakeholders before and after negotiating forums. This would ensure adequate preparation for active participation in negotiations and also disseminate the outcomes from each negotiation.

6) Promote Networking

Networking with Regional and international institutions/organization is vital to:

i. learn from the experience of other countries having similar national interests,
ii. exchange information about the state-of-the-art, potential benefits and risks of the technology in question, and
iii. raise funds for importation, implementation and management of the use of biotechnology.

7) Database Development and Resource Mapping

This is essential to know the status of the national gene-pool, what is available, which of these are economically important and also enhance utilization of the biological resources. This would to help to generate and compile relevant information as well as adding values to the resources.

8) Promote the Involvement of Private Sector

So far the participation of private sector in the importation and use of biotechnology is very minimal. Policy and other incentive measures need to be provided to attract the private sector funding in partnership with the public sector.

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