



TOGETHER
for a sustainable future

OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.



TOGETHER
for a sustainable future

DISCLAIMER

This document has been produced without formal United Nations editing. The designations employed and the presentation of the material in this document do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations Industrial Development Organization (UNIDO) concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries, or its economic system or degree of development. Designations such as “developed”, “industrialized” and “developing” are intended for statistical convenience and do not necessarily express a judgment about the stage reached by a particular country or area in the development process. Mention of firm names or commercial products does not constitute an endorsement by UNIDO.

FAIR USE POLICY

Any part of this publication may be quoted and referenced for educational and research purposes without additional permission from UNIDO. However, those who make use of quoting and referencing this publication are requested to follow the Fair Use Policy of giving due credit to UNIDO.

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

18733

(Draft)

Development of Biotechnology in Ethiopia

**Report of a UNIDO Consultant Mission to Ethiopia
to Aid in Development of Policies and Programmes
in Biotechnology, Addis Ababa, December 1989**

By

**Yongyuth Yuthavong, Director, National Center for
Genetic Engineering and Biotechnology, Bangkok, Thailand**

CONTENTS

	Page
1. Needs of the Country	1
2. Current Institutions	3
3. Current Work in Progress and Status of the Institutions	5
3.1 Ethiopian Science and Technology Commission	6
3.2 Plant Genetic Resources Centre of Ethiopia	6
3.3 Holeta Institute of Agricultural Research	7
3.4 Forestry Research Centre	8
3.5 Artificial Insemination Centre	8
3.6 National Veterinary Research Institute	8
3.7 National Health Research Institute	9
3.8 Ministry of Health, Malaria and Vector-Borne Diseases	9
3.9 Addis Ababa University, Department of Biology	10
3.10 Addis Ababa University, Chemistry Department	11
3.11 Addis Ababa University, Faculty of Medicine	11
3.12 Addis Ababa University, Faculty of Veterinary Medicine	11
3.13 Alemaya University of Agriculture	12
3.14 Asmara University	12
3.15 Overall appraisal	13
4. Human Resources	13
5. Appropriate Goals	16
6. Appropriate Programmes and How to Plan Their Implementation	19
6.1 Outline of the programmes	19
6.2 The Ethiopia Science and Technology Commission (ESTC) as the sponsor of the national biotechnology development programme	20
6.3 Steps in initiating and implementing the programme	20
6.4 The National Committee on Biotechnology (NCB) and the Biotechnology Unit	21
6.5 The National Biotechnology Network	22
6.6 Possible organization plan	24

	Page
6.7 Manpower planning and possible central R&D/training facilities	25
6.8 Possible financial and human resources requirement	26
7. Need for Regional and International Co-operation	28
8. Interest in Regional Networking and What Ethiopia Expects from It	29
9. Acknowledgement	31
Appendix 1	32
Appendix 2	34
Appendix 3	36

1. Needs of the Country

Ethiopia is a country with a long cultural history and a record of many technological achievements in the past. However, during the past few hundred years the country has seen a decline in the application of technology, and is presently struggling to solve its myriad problems in immediate food and health needs, and to develop its industry and economy. In order to achieve these purposes, the country urgently needs to upgrade its technological capability, especially in the areas of agriculture, health and industry. There is increasing awareness of these needs in Ethiopia as witnessed, for example, from issues raised in the First National Conference on Science and Technology Policy of the People's Democratic Republic of Ethiopia (NACOSTEP I), held in June 1988. Together with this awareness is the increasing realization of the major constraints of the science and technology system in Ethiopia. Chief among these are insufficient scientific manpower, lack of resources for research and development, lack of well-defined policy and priorities in science and technology, and isolation of the producers from the users of technology.

Food and agriculture constitute the area of highest critical concern for Ethiopia. The land area suitable for rainfed cultivation is estimated as less than a quarter of the total, the rest being too arid, or consisting of terrain of too high an altitude, having too steep slopes or too badly eroded. Traditional modes of agricultural production could no longer serve the needs for subsistence of a rapidly growing population (2.9% per year). Low productivity is compounded by excessive pre- and post-harvest crop losses, estimated at 30-40% of the total yield. There are therefore urgent needs to increase productivity through use of improved genetic stocks and management practices. However, with over-exploitation of land increasing use of only a few superior crop varieties arise the potential problems of genetic erosion, the loss of valuable indigenous genetic materials. Ethiopia needs to deal with these various problems through many specific measures, utilizing both science and technology and other approaches. Biotechnology, being concerned with production of plants, animals and their products through science-based principles, can clearly be a major tool in solving these problems. However, before the

country is able to use biotechnology effectively to solve its problems in food and agriculture production, it needs to strengthen greatly its manpower base and technical infrastructure, both at the research and development end to produce and adapt new knowledge, and the extension end to transfer the new knowledge to the farmers and other potential users of the technology.

Major health problems in Ethiopia need to be seen in the context of a young population profile, with a quarter under five years of age, and of poor nutritional and general socio-economic status of a major portion of the population. Against this background, problems of infectious diseases assume great importance, ranging from malaria, schistosomiasis, onchocerciasis to gastro-intestinal infections. An infant mortality rate of 142/1000 and a life expectancy at birth of only 47 years underline the importance of health problems in Ethiopia. In dealing with these problems, the country needs to upgrade its primary health care system, and also needs to acquire and use new technologies for diagnosis, production of vaccines and drugs, and preventive measures such as destruction of pathogen vectors. Since many of these technologies fall into the realm of biotechnology, Ethiopia therefore needs to upgrade its biotechnological capability in the health-related areas.

Although the industrial sector presently accounts for only a small portion of G D P (11%) and workforce (0.7%) in Ethiopia at present, this needs to be developed in order to provide linkage with the agricultural sector, and to save foreign currency used for import of necessary industrial products. Biotechnology can play a key role in food and beverage, leather goods and textile industries, among other examples. It can also play a key role in the energy sector, especially at the rural level where, for example, biogas production is a potentially important source of household energy. Finally, biotechnology can also play an important role in protection of the environment in Ethiopia. Efforts at increasing forest area, presently estimated as only 3% of the country, require large scale propagation of trees, which can be achieved through the help of tissue culture. Pollution from household and industrial waste can

be treated through biotechnological processes. These and other uses for biotechnology can meet many needs in the important sectors of the Ethiopian economy. The country, in turn, needs to develop capabilities in the various areas of biotechnology. Fortunately, these various areas share common themes and common principles, so that Ethiopia can gain strength in the various areas rapidly once it has developed the basic capabilities common to all areas.

2. Current Institutions

Institutions doing R&D or technical service activities are placed under three categories of structures:

- 1) sectoral ministries and other state organs
- 2) the higher education institutions
- 3) administratively independent scientific establishments

Institutions doing work relevant to biotechnology are listed below

Sectoral ministries and other state organs

a) Ministry of Agriculture

- Forestry Research Centre
- Wood Utilization Research Centres
- Soil Conservation Research Centre
- National Veterinary Institute
- Artificial Insemination Centre

b) Ministry of Health

- National Health Research Institute
- Ethiopian Nutrition Institute
- Techno-centre (medical equipment maintenance and repair)

c) Ethiopian Science and Technology Commission

- National Science and Technology Information and Documentation Centre
- National Scientific Equipment Centre

The higher education institutions

a) Addis Ababa University

- Department of Biology
- Department of Chemistry

- Institute of Pathobiology
- National Herbarium
- b) Alemaya University of Agriculture
 - Debre Zeit Agricultural Experiment Centre
- c) Asmara University
 - Institute of Appropriate Technology
 - Marine Biology and Fisheries R&D Programme
 - Arid Zone Agriculture R&D Programme

Administratively Independent Scientific Establishments

- Institute of Agricultural Research, (IAR, with 11 zonal research centres and 5 sub-centres)
- Plant Genetic Resources Center (administratively supported by IAR)
- Armauer Hansen Research Institute
- All African Leprosy Research and Rehabilifation Centre (ALERT)
- International Livestock Centre for Africa (ILCA)
- Scientific Phytopathological Laboratory at Ambo (administratively supported by ESTC)

With some exceptions, the institutions are generally still weak in terms of qualified manpower, equipment, budget and infrastructural support. Furthermore, their effectiveness is hampered by structural and organizational constraints. The institutions under sectoral ministries, for example, are placed at "excessively subordinate" level where they are unable to operate effectively. There is furthermore no mechanism for linkage and co-ordination of research activities at various institutions, and no effective overall policy at the national level to guide them.

Of the total R&D expenditure of \$ 104 million during the period of 1974 - 1984 food and agriculture had by far the largest share (56%), followed by natural resources (23%) health (8%) and industry (6%). Due to the government's present aim of self-sufficiency in food production, the

R&D budget for agriculture has been recently increased substantially to about \$ 30 million per year. Table 1 gives the budget figures to various agricultural research institution compiled by the Institute of Agricultural Research

Table 1
Funding to agricultural R&D institutions, 1986/87

Organization	Source of fund (in' 000 Birr, approx. 2.1 Birr = \$1)		
	Treasury	Foreign	Total
Institute of Agricultural Research	32,967.7	18,813.4	51,781.1
Plant Genetic Resources Centre	1,257.7	211.9	1,337.6
Alemaya Univ. of Agriculture	3,108.4	2,749.9	5,856.3
Addis Ababa Univ.	554.4	220.0	804.4
Soviet Phytopathology Lab.	-	1,000.0	1,000.0
Total	37,918.2	22,995.2	60,913.4

Source : Ref. 17

It is noteworthy that the R&D institutions rely on funding from external sources as a major portion of their budget. A survey by ESTC indicated that during 1974-1984 about 40% of R&D expenditures in Ethiopia came from foreign sources. This figure reflects low input from the Ethiopian government rather than excessive foreign assistance in R&D and should prompt the government to increase this input in order to avoid over-reliance on foreign assistance.

3. Current Work in Progress and Status of the Institutions

Current work in progress in selected major R&D, educational and service institutions will be reported in brief to give an overall status of biotechnology in Ethiopia. In all cases, except Alemaya University of Agriculture and Asmara University, the current work has been appraised from visits to these institutions during the mission.

3.1 Ethiopian Science and Technology Commission

This is the principal body concerned with formulation of national science and technology policy and plans as well as overall promotion, stimulation and co-ordination of S&T activities of the country. It consists of the National Science and Technology Council, a sub-council in each sector of science and technology and a permanent secretariat. In addition, it has a mandate in proposition of reorganization, abolition or transfer to itself of any S&T institution in the interest of efficient utilization of manpower and other resources, and a mandate in co-operation with foreign national and international organizations having similar purposes. It is in connection with these mandates that the ESTC asked for co-operation from UNIDO with regard to development of biotechnology in Ethiopia, and its participation in the establishment of a regional network for biotechnology in Africa. ESTC is already preparing a biotechnology development plan which aims to create a Biotechnology Unit and the National Center for Biotechnology in phases.

3.2 Plant Genetic Resources Centre of Ethiopia

This Centre was established in 1976 as a semi-autonomous institute administratively supported by Institute of Agricultural Research. It collects, stores and continually tests the viability of germ plasms, especially those native to Ethiopia which are increasingly threatened by genetic erosion. It provides materials for national breeding programmes, and exchanges materials with other countries. Currently it has some 50,000 accessions from about 86 species, mainly cereals, legumes, oil crops and medicinal plants. The main conservation approach is ex situ, preserving appropriately dried seeds at 4° C or -10°C. Some materials such as coffee, which cannot be preserved dried and cooled, are maintained in field condition. The Centre has 6 field sites for such purpose, and for evaluation of preserved materials. It has a testing unit where seeds are evaluated for diseases, a cytogenetics laboratory and is starting a small tissue culture laboratory. It has a computerized data management system. The Centre has 23 scientific personnel (1 Ph.D., 7 M.Sc., 3 B.Sc. and 12

Diploma). It has an operating budget (1986/87) of about \$ 660,000, about 16% of which came from foreign sources, chiefly Federal Republic of Germany.

3.3 Holeta Institute of Agricultural Research

Located about 45 km. from Addis Ababa, the Holeta site is the largest of the 16 zonal research centres and sub-centres of the Institute of Agricultural Research. It is divided into 10 divisions, with 3 satellite stations and occupies about 400 hectares of land area. There are laboratories for plant and soil analysis, animal nutrition chemical analysis, entomology, mycology, and a mid-size library. It has plant breeding programmes for both field and horticultural crops. In crop breeding emphasis is put on three major areas, cereals, food legumes and oil seeds. In cereals, apart from work on barley and wheat, interesting work is in progress on cytogenetics and hybridization of teff (Eragrostis tef and E. pilosa), a crop uniquely known and widely used in Ethiopia. In oil seed crops, another unique plant noug (niger, Guizotia abyssinica) is being investigated. Its seeds have high oil content with high polyunsaturated fatty acid content. Both native teff and noug, however, have very small seeds and low yields. They are likely to be improved substantially through appropriate biotechnological methods such as plant tissue culture, in which this Centre still has no capability but aims to do so in the future. The Centre also has an animal breeding programme, with emphasis on crossbreeding of cattles between exotic and local stocks, and an animal nutrition programme.

This Centre has a total of 460 workers, about 40% of which are researchers (12 Ph. D., 18 M.Sc., 34 B.Sc., 5 expatriates). About 80% of the operational cost comes from government budget, while foreign assistance is used for import of equipment and supplies. It has a loan from World Bank, and grants from various sources including African Development Bank, IDRC, UNDP and SAREC.

3.4 Forestry Research Centre

This Centre, in the Ministry of Agriculture, was established in 1975 with assistance from UNDP. It concentrates on identification and large scale establishment of native species, chiefly pine, acacia, cypress, etc. The work originally put emphasis on drought-resistant species in the Northern provinces, but since 1983 also worked on non-drought areas in the West. Mycorrhiza inocula are used for pines. Other works include study of multipurpose tree species to help reduce soil erosions, produce fuel wood, etc. It has a seed germination laboratory, but still no capability for tissue culture.

The Centre has serious manpower problems, and presently has only 25 scientific workers (3 M.Sc., 7 B.Sc., 15 Diploma). It has to rely on foreign assistance for much of the operation, and has had assistance from various agencies including UNDP, FAO, IDRC and SIDA. SIDA has been assisting this Centre for the past 25 years and has helped in manpower training since 1985.

3.5 Artificial Insemination Centre

This is mainly a service centre under the Ministry of Agriculture. It collects, processes and distributes semen from exotic stocks for large scale artificial insemination. It has its own liquid nitrogen production facilities, and is relatively well equipped for routine work. Future work will include embryo transfer studies in collaboration with International Livestock Centre for Africa. It is also being designated as one of seven Regional Animal Germ Bank Centres of FAO, and will start work on preservation of semen of endangered animal species, including marine species with assistance from World Wildlife Fund. It also has collaborations with Finland, and Federal Republic of Germany. It has 80 workers, mostly at the technical and extension service level.

3.6 National Veterinary Research Institute

The Central Laboratory located in Debre Zeit about 45 km. from Addis Ababa, has the Biological Production Laboratory, the Research

and Diagnostic Laboratory, the Food and Mouth Disease Laboratory and the Biochemistry and Nutrition Laboratory. It is the national reference laboratory, and also the site for FAO Regional Office for Quality Control of Animal Vaccines. It has capacity for production of 5 viral vaccines (rinderpest, sheeppox, Newcastle, African horse sickness, foot and mouth disease) and 6 bacterial vaccines (bovine pleuropneumonia, anthrax, blackleg, 3 types of pasteurellosis) against animal diseases. The facilities include animal cell culture rooms, bacterial fermenters, freeze-drying and packaging facilities. It does some research on infectious diseases and nutritional deficiency survey, some in collaboration with the Institute of Pathobiology.

It has about 150 workers, of which 9 are DVM, 22 are technicians and 5 are expatriates. In addition to government budget, it has been assisted by France since 1963.

3.7 National Health Research Institute

The Institute is responsible for preparation of diagnostics and vaccines for infectious diseases, and quality control of food, water and drugs. It produces rabies vaccine (sheep brain technique), cholera and Salmonella vaccines, tuberculin tests, antigens, culture media and runs a well organized laboratory for AIDS tests (ELISA and Western blots). It has a training programme for 80 junior technicians (1 yr) and 30 senior technicians (2 yr). The major activities are therefore in routine service and training.

3.8 Ministry of Health (Malaria and Vector-Borne Diseases Unit)

This unit is responsible for monitoring of malaria and other vector-borne diseases situations in Ethiopia, and for appropriate control measures. Resistance to chloroquine and other drugs is monitored. Research is ongoing on effectiveness of larvivorous fishes in mosquito control.

3.9 Addis Ababa University, Department of Biology

a) Microbiology

This group is working on biological conversion of cellulose concentrating on characterization of enzymes from Cladosporium and Penicillium spp. It also has special interests in obtaining industrial thermophilic enzymes from hot spring sources. Another part of the group is working on bioactive chemicals from mushrooms. Yet another is working on upgrading of traditional fermented foods such as injara (from teff/Lactobacillus), kocho (from Ensete ventricosum stalk/S. faecalis, Pediococcus, etc.), dabo (from cereals). It has 2 Ph.D., 1M. Sc., 3 Ph.D. students being trained abroad, 5 M.Sc. students, 1 Diploma technician. The group is supported by SAREC, IFS, Ethiopian Nutrition Institute and ESTC. It has linkage with Lund University (Sweden).

b) Genetics

This group is working on genetics of teff (Eragrostis tef) by characterization of protein content and composition of the seeds from various parts of the country. Methods range from protein and enzyme electrophoresis, amino acid composition, dye binding, IR analysis to restriction mapping of chloroplast DNA. Approximately 4,000 out of 15,000 lines have been characterized. The group has 1 Ph.D., 1 Ph.D. student, 2 technicians, and 1 new Ph.D. expected. It has support from SAREC and IFS, and has linkages with Free University Brussel Belgium and University of Wurzburg, Federal Republic of Germany.

c) Plant tissue culture and physiology

This group cooperates with the Forestry Reserch Centre in works on mass propagation of endangered tree species through tissue culture of materials from shoot tips, axillary buds or seeds. It also studies the physiological characteristics of young plants. The species studied so far are zhibga (Podocarpus gracilior), kosso (Hagenia abyssinica), wanza (Cordia africana), weira (Olea africana), loll (Ekbergia capensis) and kererro (Anigeria adolfi-friederici). It has a tissue culture laboratory,

a greenhouse and an open testing site. It has funding from IFS.

3.10 Addis Ababa University, Chemistry Department

This group of natural product chemists work on characterization of active ingredients from marketed local plants used for fumigation, fragrances or medication. For example, *Taverniera abyssinica* used as painkiller was shown to have pterocarpan and isoflavonoids, both known and new. Other studies focus on natural-product-based chemical industries and seedling chemistry. The group has excellent chemical equipment and a bioassay laboratory. It is funded by SAREC. Dr. Abegaz, the group leader, is the editor of internationally known Bulletin of the Chemical Society of Ethiopia.

3.11 Addis Ababa University, Faculty of Medicine

A graduate training programme is to start in Feb. 1990, with extensive co-operation from Karolinska Institute Sweden, and financial assistance from SAREC. In the first phase, students will be admitted to 2-year M.Sc. and longer Ph.D. programmes in biochemistry (2), physiology (2) microbiology (4) and pathobiology (2). The second phase will include pharmacology and anatomy. Laboratories are being constructed and adequate equipment is arriving. The long-term objective of this programme is to build biomedical science researchers and teachers in Ethiopia to a self-sufficient level.

3.12 Addis Ababa University, Faculty of Veterinary Medicine

This young Faculty is located at Debre Zeit, next to the National Veterinary Research Institute. It teaches 3-year diploma course, and 6-year D.V. M. course (20 students per yr). Students do research in the last year on animal health and reproduction mostly in field condition. Some research is done in co-operation with the Institute of Pathobiology, mostly on parasitic diseases. A staff member is doing research on post-partum hormone levels in cows with IAEA assistance. It has assistance in teaching from World Bank, British Council and other sources.

3.13 Alemaya University of Agriculture

Created in 1953 as a College of Agriculture, this institution was part of the Addis Ababa University until 1985 when it was made an independent university. It has substations at various locations. It has done extensive work on cereals and legumes (durum wheat, teff and pulses), including pioneering breeding techniques for teff. Many varieties of cereals, legumes, maize, sorghum and horticultural crops have been improved and released to the farmers. In the livestock sector, it introduced noug cake and molasses as animal feeds, and screened the adaptability of various poultry and cattle breeds.

It receives relatively high budget allocations (about \$ 2.9 million for 1986/87), reflecting the government's emphasis on agriculture. Almost half (47%) of the budget was World Bank loan. Several international organisations including UNDP, FAO, SAREC, and ICRISAT have also given assistance in various programmes.

3.14 Asmara University

This was founded as a private Catholic institution in 1958 and became a national university in 1979. It is important as the only university in the Northern Regions comprising Eritrea, Tigrai and parts of Wollo and Gondar. Works related with biotechnology are found in Institute of Appropriate Technology, Arid Zone Agriculture Programme and Marine Biology and Fisheries Programme. Biogas digesters have been built both in laboratory and village settings for extension to the farmers. Germplasms from Northern Ethiopia have been collected and evaluated. Genetics of drought resistance in some cereals are studied. Works on marine biology concentrate on ecology and taxonomy of marine and mangrove ecosystems of the Red Sea.

This young university with limited resources need to increase both the quantity and standard of its staff members. It is in the process of commencing post-graduate programmes. Negotiations are in an advanced stage for a World Bank loan for construction and equipment, mostly in mechanical and industrial engineering. Financial assistance is also

anticipated from the Italian government.

3.15 Overall appraisal

There is much actual and latent capability in the university system which should be put to use in biotechnology development in Ethiopia. The agricultural research institutions appear to have a range of capability levels, some of which are already quite high and relevant to the potential biotechnology development programme. The health sector institutions are doing routine service works well but need much further research strengthening. The new biomedical science graduate programme may be an important key to this strengthening, and therefore deserves consideration for support.

4. Human Resources

The human resources in Ethiopia are scarce for scientific and technological education and services in general, and especially scarce for R&D. The situation is especially acute for an emerging technology like biotechnology, where almost no trained manpower can be found. According to ESTC, the manpower can be found. According to ESTC, the scientific manpower engaged in R&D work in Ethiopia totaled only about 587 in 1984. For a country of only 47 million people, the R&D manpower is exceedingly low. Another study (H. Gebre-Mariam, 1987) provides the breakdown of scientific and technical personnel in Ethiopian R&D institutions (Table 2), which show that there are very few with advanced degrees. In most institutions the manpower does not reach a critical mass which can generate substantial productivity.

Table 2

Number of scientific and technical personnel in R&D
institutions in Ethiopia, 1987*

Sector/Institute	PhD	MD or DVM	MSc	BSc
Agriculture and Food	20	14	114	197
Agriculture Development Dept. (MOA)	-	-	5	-
Ambo Phytopathology Laboratory	2	-	6	-
Institute of Agricultural Research**	15	2	60	150
Ministry of Coffee and Tea	1	-	2	-
Ministry of State Farm Development	2	-	26	14
Veterinary Medicine (MOA)	-	10	-	-
Ethiopian Nutrition Institute	-	2	15	20
Health	5	15	21	52
All Africa Leprosy and Rehabilitation Training Centre	1	7	-	2
Arnauer Hansen Research Institute	-	2	-	2
Malaria and other Vector-Borne Diseases Control Programme	1	1	5	10
National Research Institute of Health	3	5	16	38
Natural Resources	8	-	62	323
Ethiopian National Energy Committee	2	-	2	30
Forestry Research Centre (MOA)	-	-	2	2
Ethiopian Institute of Geological Surveys	2	-	35	270
Land Use Planning and Regulatory Dept.	1	-	8	5
Plant Genetic Resources Centre	1	-	7	2
National Meteorological Services	1	-	3	5
Soil Conservation Research Programme	-	-	1	-
National Urban Planning Institute	1	-	4	8
Industry	1	-	3	36
Total	<u>34</u>	<u>29</u>	<u>200</u>	<u>608</u>

* Number of scientific and technical personnel include only Ethiopian nationals

** IAR staff number is for 1986/87 fiscal year.

Source : Ref. 4

Table 3
Enrollments in science and technology in Ethiopian
universities (1986/87, excluding freshman programme)

	<u>B.Sc.</u>	<u>Post Graduate</u>
<u>Addis Ababa University</u>		
Biology	270	20
Chemistry	283	27
Chemical Engineering	29	-
<u>Alemaya University of Agriculture</u>		
Animal science	115	13
Plant science	191	6
Agronomy	-	34
Animal Production	-	18
Crop Protection	-	13
<u>Asmara University</u>		
Biology	128	-
Chemistry	130	-

Source : Ref.9

The total number of trained manpower in science and technology is very low. Furthermore, the problem is compounded by high attrition rates in such important sectors as the agricultural sector. It has been estimated that of the approximately 3000 graduates from Alemaya University of Agriculture, only about 30% are now working in the agriculture sector in the country.

The poor human resources situation is not likely to improve in the future, unless appropriate new measures are taken. The capacity for production of graduates in biotechnology-related subjects can give a glimpse of the magnitude of the problem. The figures in Table 3 give total enrollment figures for B.Sc. and graduate degrees (mostly M.Sc.)

5. Appropriate Goals

Goals and priority areas in biotechnology as an emerging technology have been put forward in the National Science and Technology Proposal (NACOSTEP I) (vol. II, 1988, Ref. 15, p.29) as follows

" - Development of the know-how and facilities in the application and absorption of results of biotechnological research obtained abroad for the development and improvement of agriculture, pharmaceutical and chemical industry, health care and environmental management

- Strengthening the few...biotechnological research, development and service activities that are currently being carried out, encouraging and initiating new and imaginative ideas in the fields

- The training of large number of...geneticists and microbiologists

- Establishment of R&D facilities for biotechnology

- Establishment of a unit within National Science Centre (when it is set up) where not only fundamental research but also "purely or potentially applied" research of multidisciplinary nature in...biotechnology would be undertaken."

These priority areas have been established in conjunction with priority areas in the agricultural, health, industry, energy, environmental, basic sciences and other sectors (NACOSTEP I, Vol. II, 1988, Ref.15 pp. 15-28). A selection of these priority areas relevant to biotechnology is given as follows

Agricultural sector

"- Development and regular release of high yielding and disease and drought resistant varieties for the different agro-ecological zones of the country. This shall concentrate on all priority crops of the country.

- Livestock and poultry breeding, feeding, management and disease control as well as animal feeds and range development, processing of livestock products and development of zonation and specialization of livestock production systems.

- Development of marine as well as fresh-water fisheries.

- Collection, conservation, development and rational utilization of both plant and animal genetic resources of the country

- Development of appropriate crop protection technologies.

- Development and introduction of appropriate post-harvest technologies to reduce the current heavy losses of produce through excessive wastage and development and transfer of appropriate food processing technologies as well as technologies for processing of agricultural waste and by-products.

- Development and preparation of packages of improved technologies suitable to the various agro-ecological zones of the country.

- Study development and implementation of an effective mechanism for the dissemination of improved and appropriate technologies to the peasant sector.

- Study the ways and means by which the quantity and quality of the trained agricultural manpower can be accelerated in the shortest time possible.

- Forestry R&D activities, especially on identification and adaptation of fast-growing tree species, energy plantation, arid zone afforestation, community woodlot, introduction of suitable fast growing exotics, genetic improvement of indigenous forest trees, range and wild-life management, agroforestry, watershed management and mountain ecology conservation and development would be stepped up and strengthened."

Health and population sector

- "...Survey and collection of reliable data in the distribution and extent of major health problems and diseases affecting the population.

- Development of capability and techniques for the control of communicable diseases prevalent in the country.

- .Development of capability of manufacturing, maintaining and repairing medical tools and equipment.

- Launching a nationwide study program on traditional medicine and devising effective mechanism for widespread use of local herbs, plant

and other products, etc. for medicinal purposes by carefully regulating their harmful effects and promotion of appropriate technologies to produce drugs from herbs and local materials.

- Devising efficient drug production, distribution and effective utilization mechanisms as well as strengthening R&D capabilities in the production of drugs, medical equipment and supplies.

- Strengthening and expansion of the training of health R&D personnel, and supporting technicians.

- Strengthening the organization of health research and training institutions.

- Creation of data-base for traditional medicine and other data in the field of health to support R&D activities."

Industrial sector

".- Assessment of the existing industries for purposes of identifying areas of improvement and establishing a more cost-effective production.

- Development of the capacities for effective selection, adaptation, utilization and assimilation of imported technologies.

- Development and strengthening of workshops in selected corporations and enterprises, to conduct efficient repair, maintenance and adaptation activities..... Particular attention will be given to the development of technological capabilities in food, textiles, leather.

- Creation of capacities for the production of inputs that are crucial to the development of the agricultural sector.

- Development of techniques for the prevention or minimization of the effect of industrial effluents and wastes on the environment."

Energy sector

"...Undertaking intensive S&T activities on the appropriate development and utilization of renewable energy resources, in particular biomass, the production of ethanol, the use of biogas plants,...."

Environmental sector

"...Environmental studies in order to work out effective measure for minimum disturbance of the eco-system...."

Natural or basic sciences sector

"...Survey and evaluation of the flora and fauna of the country: biomedical research; biotechnology tissue culture; ecology systematics and evolutionary research.

- Development of S&T facilities in higher education institutions and creation of the National Science Centre to train researchers and carry out R&D activities.

- Training of manpower in adequate quality and quantity in the basic sciences and creation of attractive career prospects...."

6. Appropriate Programmes and How to Plan Their Implementation

6.1 Outline of the programmes

Given the priority areas as described above, with a background of present institutional and manpower status, appropriate programmes can be set up for implementation. There are two main options that may be chosen with regard to development of biotechnology in Ethiopia,

1) setting up a national biotechnology network, with national objectives on manpower and R&D to be fulfilled by participating institutions in the network

2) setting up central R&D and training facilities

The two approaches given need not be mutually exclusive. Indeed, the policy objective in the long run may be to adopt both approaches together. However, a gradual implementation might be necessary. Hence, the national biotechnology network might be set up first, while a time span of, say, five to ten years is set for establishment of the central facilities. The major constraints against immediate establishment of the central facilities are lack of qualified manpower, and the high cost involved in constructing and equipping the facilities. Hence the central facilities should be set up only when the country has acquired a certain

capability level and is ready to move to a higher level.

6.2 The Ethiopian Science and Technology Commission (ESTC) as the sponsor of the national biotechnology development programme

The Ethiopian Science and Technology Commission (ESTC) should be the body responsible for setting up the national biotechnology development programme including giving personnel, management and financial support for the programme. The main reasons are as follows:

- 1) ESTC is the central body responsible for the formulation and elaboration of national science and technology policies for planning and for organizing research and development activities in the country
- 2) Biotechnology is transdisciplinary in nature, requiring participation from such wide-ranging professionals as microbiologists, geneticists, biochemists and engineers. It therefore needs a sponsoring agency which has a broad mission like ESTC
- 3) Establishment of a Biotechnology Unit within the National Science Center has been proposed (NACOSTEP I). This Center has been planned to be supported by the ESTC.

6.3 Steps in initiating and implementing the programme

There is no fixed recipe for initiating and implementing the programme. The following stepwise procedure is given only as an example.

- 1) Establishment of National Committee on Biotechnology (NCB) by the ESTC, with ESTC Commissioner as the Chairman and the proposed Biotechnology Unit director as the secretary
- 2) Formulation of the national biotechnology development programme by the NCB. An essential part of this programme is the establishment of the Biotechnology Unit to serve as the focal point for programme implementation.
- 3) Formation of the national biotechnology network comprising a number of existing institutions working in different areas of biotechnology.

4) Formulation of the manpower development plan, taking into account present and future needs of the national biotechnology development programme, the needs of the network members and the Biotechnology Unit itself.

5) Formulation of the plan for central R&D and training facilities of the Biotechnology Unit. This should be launched only when there is enough qualified manpower, budget and infrastructural support.

6.4 The National Committee on Biotechnology (NCB) and the Biotechnology Unit

The National Committee on Biotechnology (NCB), responsible for formulation of the national biotechnology development programme, should be chaired by the ESTC Commissioner, and have as members representatives from government agencies dealing with agriculture, health, industries, and higher education, as well as individuals of high calibre active in the areas related to biotechnology. It should also have active liaison with government agencies responsible for national planning and resources allocation.

The Biotechnology Unit, whose director should be NCB secretary, should be an autonomous organization governed by the National Committee on Biotechnology (NCB) and supported by ESTC, but free from bureaucratic controls. The Unit should have a Charter which allows it to have an autonomous structure to be able to obtain highly capable and highly motivated personnel, to negotiate with donor agencies, and to enter into contracts with industries.

The main functions of the Biotechnology Unit should be as follows

- 1) To prepare for consideration of the NCB and the ESTC policy and workplans for development of biotechnology in Ethiopia
- 2) To select and support network institutions. The support may be in the forms of information support, R&D grants, technology transfer, projects scholarships and fellowships, etc

3) To initiate and co-ordinate biotechnology activities in various network institutions in line with the national biotechnology development programme

4) To serve as the focal point for interaction with the regional network for biotechnology in Africa and other international foreign institutions and agencies concerned with biotechnology.

The Unit director should be chosen carefully for the following characteristics : a) a scientist or technologist with high standing in the national S&T community b) a good knowledge of both national and international biotechnology scene. c) capability in developing relations with outside agencies, including various government agencies, universities, industries and donor agencies.

The staff of the proposed Biotechnology Unit need not be large in size. A core staff of 5-10 people would be enough for management and administration, information services, R&D support and co-ordination, and local and international network co-ordination. Individuals in network institutions can, in addition, be selected to perform special tasks as, for examples, organization of workshops and seminars, expert study of selected subareas of biotechnology, organization of training courses, establishment of specialized laboratories, etc.

Since the Biotechnology Unit will utilize the network concept to form essentially a "centre without walls," the Unit will only need initially only a small space for management, administration and co-ordination work. This can be located within the ESTC compound, or elsewhere so long as it has easy access to communication with ESTC and other network institutions.

6.5 The National Biotechnology Network

In the "centre without walls" concept, the Biotechnology Unit acts as a nucleus for support and co-ordination of biotechnology activities implemented by the various member institutions of the biotechnology network. The member institutions should be selected on the basis of their existing expertise, their designated missions and relationship with

biotechnology, and their willingness to invest their own resources to biotechnology development. The support should be given by ESTC, through the Biotechnology Unit, to the network institutions for collaborative R&D projects, student fellowships, information and other logistic services. In some cases, some network institutions may be designated as specialized laboratories of the Biotechnology Unit, with specific missions such as applied plant genetics, health-related biotechnology, microbial fermentation technology.

A network institution may have support for more than one project depending on the groups doing active work. On the other hand, a chosen specialized laboratory should be supported for the programme of work originally agreed upon. Both projects to be granted to research groups within the network institutions, and programme support for specialized laboratories should be thoroughly reviewed before approval, and continually evaluated for the progress in new knowledge, knowhows and in applicability and technology transfer to users. Review and evaluation of projects should be made by scientific experts in the fields, and whenever appropriate the appraisal from international reviewers should be sought.

The network institutions should act as the technical arm of the Biotechnology Unit, implementing the R&D training and technology transfer activities as commonly agreed upon. Any benefits resulting from, eg., technology transfer to industries resulting from projects supported by the Unit should be shared by the Unit and the network institutions.

With regard to negotiations for support from donor agencies, the network institutions should have the right, within their missions, to initiate and conclude agreements, so long as the Biotechnology Unit is informed of these activities. Alternately, the Biotechnology Unit may, with consent from the network institutions, initiate and conclude agreements with donor agencies. It is anticipated that this will be the preferred mechanism for projects which involve more than one participating institutions.

In the beginning stage, there should be only about 5 and not more than 10 institutions designated as network members, based on their

expertise and relevance to biotechnology. All network members should be entitled to project support and other support, while one or two of the members might be additionally selected as specialized laboratories/sub-units of the Biotechnology Unit, enabling them to be given programme (mission) support as deemed appropriate

6.6 Possible organization plan

Chart 1 shows a possible organization plan for structural development in biotechnology.

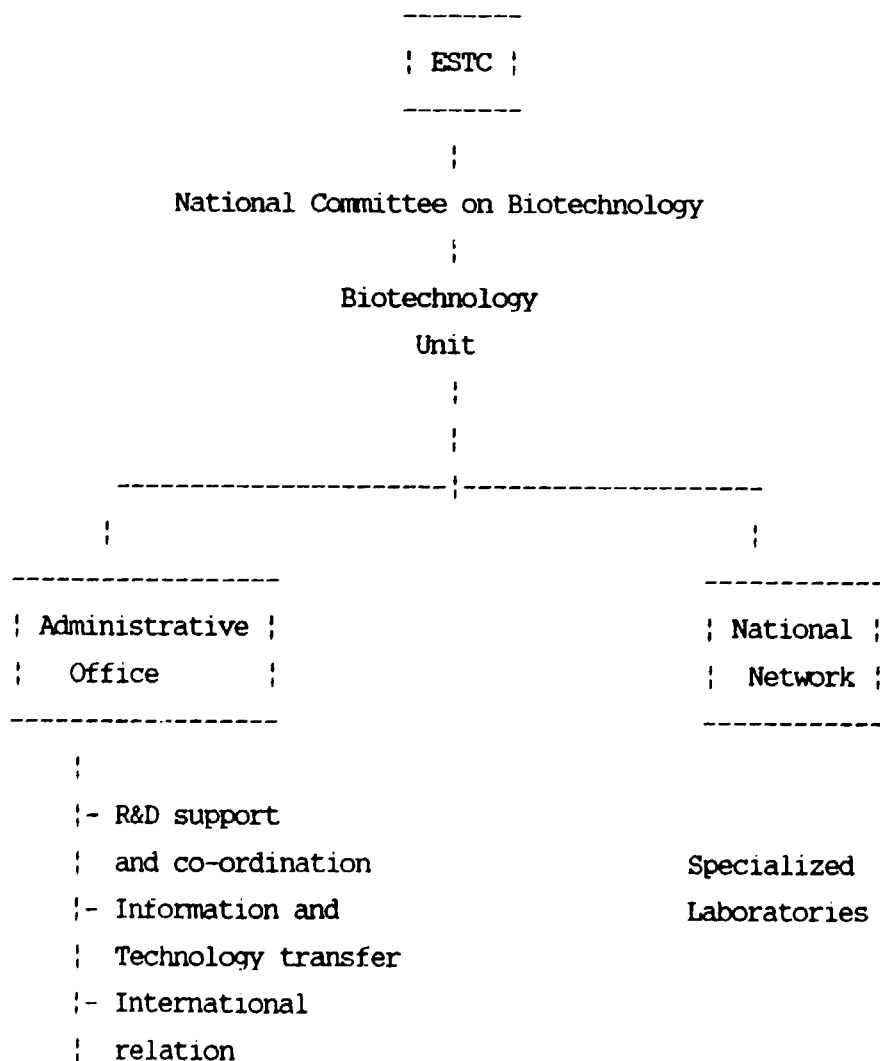


Chart 1

6.7 Manpower planning and possible central R&D/training facilities

As seen in section (5), Ethiopia has clear goals in training of a large number of biotechnology personnel, and in establishing R&D facilities for biotechnology. The national biotechnology development programme, to be elaborated by the proposed National Committee for Biotechnology with the Biotechnology Unit as the secretariat, must therefore cover manpower planning and plans for establishment of central facilities. It is essential that the core of required manpower exists prior to the establishment of the central facilities, since the latter cannot be successful without the former. As seen in section (4) the human resources for biotechnology in Ethiopia are still rather limited at present. There is a strong need, therefore, for the government to be committed and to invest substantially in the building up of required human resources for the future. This should be done both through local graduate training programmes and through a special programme for sending students abroad for higher degrees.

Some recommendations for building up of human resources in biotechnology as a part of the biological sciences programme have already been made in the proposal for establishment of the National Science Center (ESTC, 1987, Ref. 16). More generally, proposals have been made (NACOSTEP I, Vol. II, 1988, Ref. 15) for creation of conducive service conditions and work environment for S&T manpower. These proposals should be re-evaluated in the light of specific requirements of the future national biotechnology development programme.

A proposal has also been made (NACOSTEP I, Vol. II, 1988, Ref. 15) to create a biotechnology R&D unit within the proposed National Science Centre. This and other options should be explored in the future biotechnology development programme. It may be noted that the central R&D/training unit can be created in the future irrespective of the broader missions of the National Science Centre. Indeed, creation of the biotechnology R&D/training unit can serve as a nucleus for implementation of the broader National Science Center programme. The major requirements

for the creation of the future central R&D/training unit are

1) Existence of a core of biotechnology personnel, to be created in the biotechnology development programme.

2) an autonomous administrative structure provided by the Charter of the Biotechnology Unit. This will be necessary to create the conducive working environment.

3) a close relationship with a leading university so as to be near the knowledge front

4) a close relationship with the extension system and industries so that technology can be effectively transferred to farmers and other public users, as well as to specific industrial partners.

It is envisaged that the central R&D/training facilities can be established only after the Biotechnology Unit and the National Network have been in existence for at least five years, since it will take time for the buildup of required personnel, and for planning of a substantial investment required for building, equipment and the R&D training programmes.

6.8 Possible financial and human resources requirement

Possible financial requirement per year for the proposed setup in the beginning stage is given in Table 4.

Table 4
Possible financial requirement for the
initial stage of the proposed programme

A) Operating Cost

	Birr/yr.
	(Approx 2.1 Birr = \$1)
Support to 20 projects at average of 20,000 each	400,000
Support to 2 specialized laboratories at 50,000 each	100,000
Fellowships to local students	40,000
Network and Unit support cost (planning, project management and evaluation, co-ordination, information support, meetings, etc.)	60,000
Total	600,000 =====

B) Fixed Cost for Unit and Network Office organization 200,000 Birr
=====

Note : This excludes personnel cost (5-10) and office cost, both of which are expected to be provided by ESTC.

As for manpower development over the next 5 years, if the central R&D/training facilities is to be established, it may be suitable to aim to have a total of 50 Ph.D. 's trained abroad. Ten students might be sent each year over a period of 5 years. The required manpower will be achieved in 5-10 years time. This manpower should be distributed both in the network institutions and in the central facilities so as to have an interacting pool.

Since the proposed programme will need new financial and human resources over many years it should be taken up in the Ten-Year Plan of Ethiopia as early as possible. In addition to budget from the government, assistance from donor agencies should be sought both for network activities and the manpower programme.

7. Need for Regional and International Co-operation

Since biotechnology is a rapidly moving field, there is a great need for Ethiopia to join the regional and international co-operation programmes to keep abreast with new development, and to study examples of success in other countries and apply them to the Ethiopian situation. In turn, the success of biotechnology development programme together with the establishment of necessary infrastructure as outlined in section (6) can also serve as a model for other countries to study.

Regional co-operation is furthermore necessary in the sense that many biotechnology activities are region specific. For example, a project for development of drought-resistant plants would be advantageous for Ethiopia as well as for other African countries with similar flora and environmental conditions. Collaborative R&D and training programmes would therefore serve the interest of both Ethiopia and other collaborating countries.

Three main types of need can be identified for regional and international co-operation : a) need for information b) need for regional and international training courses and c) need for south-south and north-south collaborative research. Like other developing countries, Ethiopia can gain from a better information system, not only on technical progress in various areas of biotechnology and their applications, but also on management and comparative approaches to problems common to developing countries. The need for training is obvious from the fact that there is a very small number of biotechnology personnel in Ethiopia at present and the knowledge front is moving very rapidly. The need for collaborative research originates from the international and transdisciplinary nature of biotechnology, requiring different types of expertise which may not be available locally.

The proposed Ethiopian Biotechnology Unit can ideally serve as the focal point for bilateral, regional and international collaboration. Collaborative programmes can be developed between the proposed Biotechnology Unit and National Network with outside agencies, both

private, national and international, in areas where there is great need in the country, or where the country has unique assets. An example might be a programme on biotechnology for hunger needs; another might be a programme on plant biotechnology under arid conditions. In short and medium term, international and regional collaboration should be directed towards biotechnology areas which fulfill basic needs of the country, while in the long term the collaboration should be aimed towards utilizing the unique assets of the country to derive special benefits both to the public at large and to the industrial sector.

8. Interest in Regional Networking and What Ethiopia Expects from It.

Interest in regional networking results from the three types of need as described in section (7), namely, need for information, need for training and need for joint R&D. In answering to these three types of need, regional networking can help in giving focus to problems common to African countries, and solutions which may have common aspects. There are numerous examples which illustrate how regional networking might address the common needs effectively, such as, use of biotechnology to evaluate and develop traditional medicines from plants, diagnostic biotechnology for tropical diseases, conservation of African plant and animal genetic resources, post-harvest biotechnology, biopesticides and biocontrol agents. For Ethiopia, the major interests would be in the areas of immediate concern for subsistence of the population, needs in nutrition and health, increase of agricultural productivity and improvement of livelihood of the general population.

Below is the list of some specific benefits which Ethiopia should gain from regional networking. Compiled from opinions of selected individuals, the list is merely illustrative and not exhaustive.

Benefits concerning information

- Access to biotechnological and other technical information relevant to Ethiopia's problems. Avoidance of "re-inventing the wheel".

- Access to comparative information on policy management and development programmes for biotechnology in various African countries. This information will be useful not only for the technologists, but also policy administrations and these concerned with resources allocation.

- Access to information on regulatory procedures for environmental release and release of new biotechnology products for public consumption.

- Better interaction with international and foreign organization/donor agencies, so as to address Ethiopian problems more effectively through biotechnology.

Benefits concerning training

- Sending of technicians and scientists to regional training courses outside Ethiopia

- Organization of regional training courses within Ethiopia in areas where special expertise exist, eg., conservation of plant genetic resources.

- Designation of Ethiopian institutions as regional training centers in areas where special expertise exist.

- Training needs for Ethiopia : Plant tissue culture, plant molecular genetics, animal embryo transfer, biopesticides, molecular diagnostics and vaccines, fermentation technology, biosafety regulations

Benefits concerning collaborative R&D

- More efficiency and effectiveness in meeting the objectives of R&D

- Access to international resources for R&D

- Gaining of better perspectives and expertise by Ethiopian researchers through exchange visits, etc.

- Possibility for Ethiopian institutions to be regional R&D centres in selected areas

- Topics of interest for R&D collaboration : genetics of drought resistance improvement of unique Ethiopian crops such as teff (Eragrostis tef)

noug (Guizotia abyssinica), thermophilic microorganisms and enzymes, plant medicinals, conservation of endangered plant and animal germplasms, tropical human and animal diseases, upgrading of traditional fermentation.

9. Acknowledgement

I am indebted to the staff of ESTC, whose names are given in Appendix 1, for arranging the programme of visits very effectively inspite of the short duration of my stay. In particular, the assistance of Dr. Assefa Mebrate is gratefully acknowledged, both for programme arrangement, provision of source materials and discussions of possible biotechnology development programmes.

Appendix 1

Names of individuals contacted and interviewed

UNIDO Addis Ababa

Mr. G. Dossi

ESTC

Cde. Abebe Muluneh, Cde. Getaneh Yemane, Dr. Taye Teferedega,
Dr. Assefa Mebrate, Cde. Abebe Teshager, Cde. Girma Yoseph,
Cde. Getnet Hunegnaw, Cde. Solomon Makonnen, Cde. Tesfaye Bekele

Plant Genetic Resources Center of Ethiopia

Cde. Abebe Demissie

Holeta Institute of Agricultural Research

Dr. Hailu, G.-Mariam, Cde. Hailu Gebre, Dr. Glyn Jones

Forestry Research Center

Cde. Mebrate Mihretu

Artificial Insemination Center

Cde. Bruk Yemane

National Veterinary Research Institute

Dr. Fikre Yoseph, Dr. Mebratu Giylsus

National Health Research Institute

Dr. Haile Selassie

Ministry of Health, Malaria and Vector-Borne Diseases

Dr. Assefa Nega Tulu

Addis Ababa University, Department of Biology

- a) Microbiology
Dr. Berhanu Abegaz Gashe
- b) Genetic
Dr. Endashaw Bekele
- c) Plant tissue culture and physiology
Dr. Legesse Negash

Addis Ababa University, Chemistry Department

Dr. Berhanu Abegaz

Addis Ababa University, Faculty of Medicine

Dr. Legesse Zerihun

Addis Ababa University, Faculty of Veterinary Medicine

Dr. Gevessu, Dr. Merga Bekana

Appendix 2
Programme of Visits

<u>Date/Time</u>	<u>Institution</u>	<u>Individuals</u>	<u>ESTC Contact person</u>
Thursday, 14 Dec.			
2:00 - 3:00 p.m.	ESTC	Dr. Assefa Mebrate	-
Friday, 15 Dec.			
8:30 - 9:30 a.m.	UNIDO	Mr. G. Dossi	Cde. Girma
10:00 - 11:00 a.m.	Plant Genetics Resource	Cde. Abebe Demissie	Cde. Girma
2:00 - 3:00 p.m.	Artificial Insemination Centre	Cde. Bruk Yemane	Dr. Solomon
3:00 - 3.30 p.m.	Forestry Research Cen.	Cde. Mebrate Mihretu	Cde. Girma
Sunday, 17 Dec.			
9:00 - 13:00 a.m.	Holleta Institute of Agricultural Research	Dr. Hailu G/Mariam	Cde. Tesfaye

<u>Date/Time</u>	<u>Institution</u>	<u>Individuals</u>	<u>ESTC Contact person</u>
Monday, 18 Dec.			
8:30 - 9:30 a.m.	AAU, Dept. of Biology	Dr. Berhanu Abegaz Gashe	Cde. Getnet
9:30 - 10:00 a.m.	"-----"	Dr. Endeshaw Bekela	
10:00 - 10:30 a.m.	"-----"	Dr. Legesse Negash	
10:30 - 11:00 a.m.	AAU, Dept. of Chemistry	Dr. Berhanu Abegaz Molla	
11:00 - 12:00 a.m.	AAU, Dept. of Biology	Dr. Beyene Petros	
2:00 - 3:00 p.m.	ESTC	Cde. Abebe Muluneh	
Tuesday, 19 Dec.			
8:30 - 9:30 a.m.	National Health Research Institute	Dr. Haile Selassie	Dr. Yemane
9:30 - 10:00 a.m.	Ministry of Health	Dr. Assefa Nega Tulu	
10:00 - 11:30 a.m.	AAU, Faculty of Medicine	Dr. Legesse Zerihun	
2:00 - 3:00 p.m.	National Veterinary Research Institute	Dr. Giyesus Mebratu	
3:00 - 4:00 p.m.	Veterinary Faculty	Dr. Gevessu	Dr. Yemane
Wednesday, 20 Dec			
9:00 - 10:00 a.m.	Briefing ESTC		

Appendix 3

Source materials

1. Health Science and Technology in Ethiopia, A Review of the State of the Art and Direction For Future Development (M., Hailu; Z., Debrework and T., Nebiat - MOH).
2. An Assesment of the Peasant Agricultural Development Policies, Plans and Strategies and their Implications for Science and technology Development of the Sector and the Application of Science and Technology for the Development of the Peasant Sector in Ethiopia (MOA).
3. Research and Development in Addis Ababa University (AAU).
4. The R&D Environment in Research Institutions (Gebre-Mariam, Hailu).
5. Research in Institutions of Higher Education in Ethiopia (A., Berhanu-ESTC).
6. National Economic, Science and Technology Priorities (H.M., Abebe-ESTC).
7. Emerging Technologies and their Implications to Ethiopias Development: Biotechnology (W., Melaku & M., Tesfaye-PGRC).
8. Research and Development in Asmara University (AU).
9. High-Level Man-Power Training Programme and the Role of Science and Technology (Commission for Higher Education).
10. Introductory note on the Existing Structure and Organization of the Science and Technology System in Ethiopia (U.T., Mohammed-ESTC).
11. Finance of Science and Technology (B., Lakew-ESTC).

12. Research and Development in Junior Colleges (Commission for Higher Education).
13. A Critical Assesment of the Energy Resources Development Policies, Plans and Strategies, and the Role of S&T in Achieving the Development Goals of the Energy Sector of Ethiopia (Ministry of Mines and Energy).
14. Assessment of Current Situation and Problems of S&T in Ethiopia (First National Conferrence on S&T Policy, Vol. I-ESTC).
15. National Science and Technology Policy Proposals (First Naitonal Conferrence on S&T Policy, Vol. II-ESTC).
16. Establishment of the National Science Center (A Proposal For the Establishment of a National Science Center-ESTC).
17. Research and Development in Agriculture (D., Seme-IAR).
18. S&T Activities at Alemaya University of Agriculture (M., Dejene-AUA).