IFS-AAS Project on
Developing an Enabling Scientific Equipment Policy in Africa

Ethiopia Country Study

(*Final Report*)

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Acronyms

AAS	African Academy of Sciences
ADLI	Agriculture-Development-Led Industrialization
AHRI	Armauer Hansen Research Institute
BSc	Bachelor of Science
CRGE	Climate Resilient Green Economy
DFID	Department for International Development (UK)
EIAR	Ethiopian Institute of Agricultural Research
EPHI	Ethiopian Public Health Institute
FDRE	Federal Democratic Republic of Ethiopia
FMHACA	Food, Medicine and Health Care Administration and Control Authority
GDP	Gross Domestic Product
GTP	Growth and Transformation Plan
HDI	Human Development Index
HEP	Higher Education Proclamation
HLI	Higher Learning Institutions
IFS	International Foundation for Science
MoFED	Ministry of Finance and Economic Development
MoST	Ministry of Science and Technology
MSc	Master of Science
NMIE	National Metrology Institute of Ethiopia
OEM	Original Equipment Manufacturers
PASDEP	Plan of Accelerated and Sustained Development for Eradication of Poverty
PFSA	Pharmaceuticals Fund and Supply Agency
RARI	Regional Agricultural Research Institutes
SEMS	Scientific Equipment Management System
STI	Science, Technology and Innovation
TCO	Total Cost of Ownership
TeCAT	Technology Capability Accumulation and Transfer
TVET	Technical and Vocational Education and Training
UNDP	United Nations Development Programme
WHO	World Health Organization

1. Country Context

With more than 85.9 million inhabitants (CSA, 2014), Ethiopia is the most populous nation in Eastern Africa and second to Nigeria in Africa. The average age of the population is 17 years. With an annual population growth of more than 2%, Ethiopia will have more than 120 million people by 2030 (FDRE, 2011). Altogether, there are around 80 different ethnic groups in the country. While only 17% of Ethiopians live in urban centers, nearly half of the urban population lives in the capital, Addis Ababa.

Ethiopia has nine Regional States and two City Administrations. Regions are further sub-divided into 556 Woredas (Districts). Woredas are the lowest unit of government responsible for administering public funds and provision of public services.

The constitution has set an explicit mandate for the federal government and regional states, both of which have legislative, executive and judicial power. The Regional States have the rights to administer their own affairs. They are empowered to formulate policies that are appropriate for their respective development; to lay the foundation for economic and social infrastructure; to play a leading role in development management; and to safeguard law and order in their own area. In the second generation of decentralization, Woredas also have the mandate to exercise the right to make decisions while zonal administrations are offices that liaise between the regional and district levels and provide technical assistance to district offices. This shows that important decisions, including resource allocation, are made at the three levels, i.e., Federal, Regional and District.

1.1 Socioeconomic Situation

Ethiopia is one of the least developed countries in the world. Agriculture is the source of livelihood for an overwhelming majority of the Ethiopian population and is the basis for the national economy, where small-scale and subsistence farming is predominant. In terms of sectoral distribution of GDP, the service sector has remained at its dominant position by accounting for 45.6% of GDP in 2011/12 (MoFED and UNDP, 2012). Agriculture and industry contributed about 44% and 11% to GDP, respectively. The agriculture sector employs more than 80% of the labor force and accounts for 45% of GDP and 85% of export revenue (MoFED, 2006). Ethiopian agriculture is heavily dependent on rainfall, with irrigated agriculture accounting for less than 1% of the country's total cultivated land. Thus, the amount and temporal distribution of rainfall and other climatic factors during the growing season are important influences on crop yields and can induce food shortages and famine.

The fundamental economic development objective of Ethiopia is to build free market economic systems in the country which will enable the economy to develop rapidly, to extricate itself from dependence on food aid and to enable poor people to be the main beneficiaries of economic growth. The rural-based development strategy derived from the Agriculture-Development-Led Industrialization (ADLI) strategy initiated in 1994 emphasizes the need to develop the agriculture sector to fuel the growth of other sectors of the economy as well as for assuring food security.

Economic growth registered in the first two years of the country's Growth and Transformation Plan (GTP) (2010/11 and 2011/12) has enabled the country to maintain an average annual economic growth rate of 11% over the last nine consecutive years between

2004 and 2012 (MoFED and UNDP, 2012). The source of this overall economic growth is mainly attributed to the agriculture and service sectors. As these sectors take the lion's share of the economy, improvements in the growth of these sectors boosts the growth of the overall economy. During the past nine years ending 2011/12, the service and agriculture sectors have grown on average by 13.2% and 7.7% per annum, respectively. Even though the growth in the agriculture sector is remarkable, Ethiopia's agriculture is still dominated by small-holder farming with low productivity.

The growth in the service sector mainly emanated from the expansion of hotels and restaurants, real estate and housing, transport and communication, banking and insurance, and trading activities. Similarly, under the industrial sector, the increment mainly emanated from the boom in the construction sector, and growth in energy. The growth of the manufacturing sector, particularly medium- and large-scale manufacturing, has been encouraging, albeit from a low level. Recognizing the challenge in the manufacturing industry, the government has responded through provision of special attention to it. In general, in order to sustain the rapid growth momentum, ensure structural transformation of the economy and thereby achieve the planned target over the remaining years of the GTP, it is imperative to increase the productivity of agriculture and expand investment in the medium- and large-scale manufacturing sector. Moreover, it is essential to promote the development and productivity of micro- and small-scale manufacturing enterprises (MoFED and UNDP, 2012).

1.2 Status of Science and Technology

Realizing that sustainable development is not possible without strong national and technological capabilities and benchmarking the South East Asian development path, Ethiopia adopted a new National Science, Technology and Innovation (STI) Policy in 2012. The policy sets the national STI vision of the country "to see Ethiopia entrenching the capabilities which enable rapid learning, adaptation and utilization of effective foreign technologies by the year 2022/23" (MoST, 2012).

The STI policy is aimed at promoting research that is geared towards technology learning and adaptation, defining the national science and technology landscape and strengthening linkages among the different actors in the national innovation system, among others. The policy has identified eleven critical issues based on analysis of the national STI situation. Policy directions and strategies have also been defined for each of the critical issues, which include technology transfer, human resources development, manufacturing and service enterprises, research, financing and incentive schemes, universities, research institutes, TVET institutions and industry linkages, intellectual property system, national quality infrastructure development, science and technology information, environmental development and protection, and international cooperation.

2. Status of Research and Scientific Equipment Policy in Ethiopia

2.1 Introduction

Following the economic growth registered in the past decade, the number of universities, research institutes, specialized hospitals and clinical laboratories, technical and vocational schools, medium- and small-scale manufacturing industries, as well as product testing and inspecting laboratories, is increasing at a rapid pace. For insistence, Ethiopia now has 32 public universities, allocating 70% of student intake for science and technology and the rest for social sciences and other disciplines. With nearly half-a-million annual intake capacity of public and private universities, colleges and TVET institutions, the Human Development Index (HDI) of the country grew to 0.396 in 2013, making Ethiopia the third top mover (UNDP, 2012), although still low.

On the other hand, export of agricultural and semi-processed products is growing, requiring quality inspection and test certification to compete and succeed in the international market. Agricultural research institutes are also expanding to support agricultural productivity growth and sustainability. Ethiopian Primary Health Care Service coverage also reached 93% in 2012 (MoFED and UNDP, 2012). In general, the fact that 6 out of 8 MDGs are on the track shows that the country is registering a remarkable growth to become a middle-income country by 2025.

Economic growth would not be sustainable without effective utilization of appropriate technologies. Hence, the Ethiopian Government has promoted transfer and adaptation of technologies from abroad while building the essential capabilities at home. National research efforts are also envisaged to be geared towards supporting the technology transfer and learning capabilities of the nation. Therefore, the expanding universities and agricultural research institutes are charged with the responsibilities of supporting local communities in acquiring, learning and utilizing appropriate technologies. It is, therefore, obvious that the institutions need first to strengthen their capacities to fulfill what is expected from them.

Procurement of expensive scientific equipment is carried out in the country as part of expansion of universities, research institutes, hospitals, and clinical laboratories. Although accurate figures are hard to find, it is believed that a considerable amount of foreign currency is spent on acquisition of scientific equipment required for science and engineering education and research every year. However, the equipment do not fully provide the expected services mainly due to absence of proper management. The drawbacks of this are clearly observed as one of the challenges facing the scientific community in research and other scientific activities.

A recent study (Perry and Malkin, 2011) shows that around 37% of scientific equipment, excluding equipment used for medical diagnostics and therapy, is dysfunctional. Moreover, a study by the World Health Organization (WHO, 2003) indicates that around 50% of medical equipment including clinical laboratory equipment are non-functional in developing countries, thereby affecting performance of research activities or provision of scientific services.

It is not surprising to find that there is a direct relationship between research output and availability of functioning scientific equipment in an institution. Hence, this Country Study is focused at national understanding about the policy environment that affects how scientists get and use scientific equipment both at country and institutional levels. The outputs of the study are expected to contribute to the IFS-AAS Project on Developing an Enabling Scientific Equipment Policy in Africa.

2.2 Objectives

Research in Africa is not positively influencing the continent's economic development and scientific equipment are one of the major inputs for research. Absence of the required equipment or their mal-functioning greatly hinders research performance and effectiveness. The major objectives of the country study on developing an enabling scientific equipment policy are, therefore, to review:

- Existing national frameworks as entry points for scientific equipment policy development and change in Ethiopia
- Current research priorities in selected higher education and research institutions
- Status of current policies, guidelines and legislation concerning scientific equipment in Ethiopia
- Scientific equipment policy precedents and useful experiences in other sectors

2.3 Scope and Methodology

The Country Study was conducted through document review and gathering of data and information through structured interviews with officials and professionals of seven universities (Addis Ababa, Arba Minch, Bahir Dar, Hawassa, Jimma, Mekelle and Unity) and two research institutes (EIAR and EPHI). The main purpose of the interviews was to explore the existence of enabling institutional or national frameworks for scientific equipment policy development. The representatives were specifically asked to provide information on the status of scientific equipment, taking into account the full equipment life-cycle including management, budgeting, procurement, maintenance, calibration, institutional policies and guidelines, and disposal. Various documents, including relevant government policies and laws, were also reviewed to understand the situation of research and scientific equipment, both at national and institutional levels. The study assessed three aspects of the equipment life-cycle at each of the institutions visited, as shown in Table 1.

3. Highlights of Research Activities in Major Sectors

The Ethiopia STI policy indicates that research is required to address and resolve social and economic problems and thereby contribute to national development objectives. Acknowledging the gap between research focuses of higher learning and research institutes and the national development needs, the policy encourages the national research system to be orientated and strengthened to focus on learning, adapting and utilizing effective technologies.

The history of scientific research in Ethiopia goes back to the establishment of higher education institutions in the early 1950s. Although the national research capacity in the country is generally low, better organized research is practiced in the agriculture and health sectors. The following sections provide a brief overview of the status of research in various sectors of the country.

Table 1: Aspects of the equipment life-cycle assessed at the visited institutions

Acquisition	
• Equipment and investment planning • Technology assessment and specifications development • Safety of combination of devices and networks • Call for tenders • Ordering	• Contracting with external services • Installation preparation, including cooperation with architects and engineers • Acceptance tests • Installation • Final check and placing in operation
Operation (Utilization)	
• Consulting and training of users • Functional and safety checks • Calibration • Preventive maintenance • Repairs • Purchase of consumables	• Logistics and environmental protection concerning the supply, operation, and recycling or disposal of consumables • Documentation (e.g., inventory and device history) • Budgeting • Quality assurance
Disposal	
• Selling, disassembly, or disposal of device	

3.1 Research in Agriculture Sector

Agriculture is the major source of livelihood for the majority of Ethiopians and is the major source of foreign exchange for the country. Research plays an indispensable role in increasing agricultural productivity and in paving the way for agro-industries to flourish. The Ethiopian Institute of Agricultural Research (EIAR), Regional Agricultural Research Institutes (RARIs) and Higher Learning Institutions (HLIs) are the leading institutions involved in agricultural research. Currently there are around 55 research centers[1] and sites located across various agro-ecological zones throughout the country. These research centers vary in their experience, manpower, facilities, and other resource capacities. Some of the research centers and sites have one or more sub-centers and testing sites.

Improving agricultural productivity for food security, while upholding proper conservation of the integrity of natural resources and the environment, is the main focus of agricultural research. The expected outputs from the Ethiopian agricultural research system are varieties with improved agronomic and protection practices that can be used in crop diversification and specialization, for both traditional food crops, as well as high value crops such as vegetables, spices and other horticultural crops. Additional areas of research include livestock research, with a focus on improved forage varieties, and generating better information on husbandry, health care, and breed improvement as well as research on land and forestry management, fisheries and biotechnology.

[1]http://www.eiar.gov.et/

Agricultural biotechnology research in the EIAR focuses on technologies like tissue culture, mass propagation, marker-assisted breeding in crops and livestock, and promotion of useful microbial processes. Calibration of the major soil types of Ethiopia is also being conducted by the research system to better assess the amount of fertilizer required by different types of crops.

Research in the agricultural sector is also conducted on adaptation of high value crops to support specialization and diversification, food science, socioeconomic and post-harvest technology, dry land and pastoral agro-ecologies as well as farm implements.

3.2 Research in Health Sector

Health research in Ethiopia is older than the agricultural research activities. In terms of institutional capacity, there are only two national research institutes; namely, the Ethiopian Public Health Institute (EPHI) and Armauer Hansen Research Institute (AHRI), which are statutory institutions accountable to the Federal Ministry of Health.

EPHI was previously the Ethiopian Health and Nutrition Research Institute, first established in the early 1930s as the Imperial Medical Research Institute, which evolved to become the Ethiopian Health and Nutrition Institute in 1995. EPHI conducts research on health and nutrition, traditional herbal drugs and medical practices, along with modern drugs. Its research programs are mainly focused on infectious diseases (such as HIV, malaria and TB), food sciences and nutrition, and traditional medicines (their safety, efficacy and content used to treat community priority diseases). The Institute also provides high-tech referral diagnostic services.

On the other hand, AHRI was established in 1970 by a joint initiative of Save the Children Norway and Sweden in collaboration with University of Bergen. Its mission was to study the pathogenesis and immune-pathology of leprosy to contribute to the control and prevention of the disease. Its research activities expanded to leishmaniasis by 1985 and were shifted to tuberculosis in the 1990s, following better control of leprosy and emergence of TB as a global threat. As AHRI expanded its national collaboration in the late 1990s, a broader disease portfolio was increasingly apparent, covering meningococcal meningitis, malaria, HIV and sexually-transmitted infections. Basic biomedical research remained the backbone while applied methods gained increasing importance. It has also played a major role in capacity-building for operational research by providing regular courses every year to field physicians and disease control program experts (MoST, 2010).

Establishment of public health and medical schools in the 1950s and 1960s also provided a platform for health research for Ethiopian scholars. The opening of post-graduate training in-country in both clinical medicine and public health since the early 1980s has enabled the country to produce the necessary human resources for conducting health research. The establishment of the Ethiopian Science and Technology Commission (now Ministry) provided health research with formal government recognition and systems, which also promoted ethical principles and practices in health research. The establishment of Demographic and Health Research Surveillance sites, first in Butajira by Addis Ababa University and later by universities of Gondar, Jimma, Haramaya, Mekelle and Arba Minch, provided more opportunities for population-based and longitudinal research (Yemane, 2011).

However, considering the high prevalence of diseases in the country and the consequence for the productive sector of the society, the research efforts in the health sector are inadequate to meet societal demands. Besides, there is not a single traditional medicine research institute to scientifically upgrade the preventive practices used by the society despite the huge medicinal plant endowment of the country (MoST, 2010).

3.3 Research in Other Sectors

Some government organizations also undertake limited research activities in various fields of applied sciences and socioeconomic sectors such as water, renewable energy and anthropology. However, the manufacturing sector is not supported by industrial research activities to produce competitive products, with the exception of some research activities undertaken by higher learning institutions. In recent times, however, institutes of technology transfer and research are being established in government priority sectors including leather and leather products, textiles and garments, metals and metal products, cement and construction, chemicals and pharmaceuticals, and dairy and dairy products. This situation indicates that attention is being given to supporting agro-industry and manufacturing sectors by research targeted at technology learning and mastery.

3.4 Research in Higher Education Institutions

The Ethiopian government stipulated in its Higher Education Proclamation (HEP 605/2009) that promotion and enhancement of research focusing on knowledge and technology transfer consistent with the country’s priority needs are one of the objectives of higher education institutions. Moreover, the Proclamation states that undertaking and encouraging relevant studies, research and community service in national and local priority areas and disseminating the findings as well as undertaking, as may be necessary, joint academic and research projects with national and foreign institutions or research centers, are responsibilities of higher education institutions. Furthermore, Articles 24 and 25 of the Proclamation stipulate that the direction of research has to be in line with the priorities identified in the National STI Policy and provide the authority to universities to establish research and innovation funds.

On the other hand, as per GTP I, higher education intake capacity will reach to almost half-a-million at the end of 2015 with intake ratio 70/30 in favor of engineering, technology medicine and natural sciences. Graduate level students are specifically required to be research-oriented and problem-solving professionals in their respective fields. Therefore, it can be concluded that the country’s education policy, strategies and system are in favor of research to fulfill the objectives, responsibilities and duties of higher education in terms of contributing to the country’s growth and transformation.

3.5 Research Prioritization

The national framework for prioritization of research in Ethiopia is the National STI Policy issued by the Government in 2012. The policy puts emphasis on applied research to be undertaken to support technology transfer and learning by small, medium and large enterprises that are envisaged to lead the industrial development of the country. However, this does not mean that basic research will not be supported. From the policy, it can be understood that public funds for research will be channeled largely to research activities that support technology transfer and adaptation, instead of “wasting time and resources” to generate technologies locally.

Prioritization of research at institutional level is done based on the needs of the socioeconomic sectors to which the research entities are created to serve. Agricultural research, for instance, is geared to supporting implementation of the GTP through adaptive research. There are also some situations whereby research prioritization is influenced by availability of resources from donors and development partners.

4. Existence of Enabling Factors for Scientific Equipment Policy Development

Scientific equipment and technologies are acquired through various means to support research activities to produce tangible outputs. If care is not taken to ensure that they are not carefully selected, acquired, installed, commissioned, utilized, maintained, and disposed, the research activities will pay heavy prices in terms of resources and quality of outputs. This has been confirmed by reviewing experiences of institutions covered in this study.

A number of enabling factors exist in the development and adoption of policy on acquisition, utilization, maintenance and disposal of scientific equipment in Ethiopia. The major enabling factors could be the existing policy framework and the rising demand for services throughout the scientific equipment life-cycle. The section below takes account of the major enabling factors.

4.1 National Science, Technology and Innovation Policy

The National STI Policy envisages creation of a national framework for selection, adaptation and utilization of appropriate and effective foreign technologies on the one hand and strengthening of the national innovation system on the other. The policy has seven major objectives of which the following constitute its founding principles (MoST, 2012):

- Establish and implement an appropriate national Technology Capability Accumulation and Transfer (TeCAT) system
- Promote research that is geared towards technology learning and adaptation
- Develop, promote and commercialize useful indigenous knowledge and technologies
- Define the national science and technology landscape and strengthen linkages among the different actors in the national innovation system
- Create a conducive environment to strengthen the role of the private sector in technology transfer activities sustainably

According to the policy, research conducted in Ethiopian institutions (including universities) would be geared towards technology learning and adaptation that support the country’s economic development. The other important point to be noted from the policy is the focus on strengthening the national science and technology landscape and to develop the national TeCAT. It goes without saying that strengthening a national innovation system and technology capacity accumulation system encompasses the issue of strengthening the capacity to acquire, understand, use, modify and dispose equipment as a means of enhancing research outputs and scientific activities in the country.

In addition to the National STI Policy, the National Science, Technology and Innovation Council chaired by the Deputy Prime Minister has adopted various guidelines to provide details for the implementation of the policy. The guidelines include:

- National STI Policy implementation strategy
- Guidelines to foster linkage between university and industry
- Guidelines for establishment of a National Research Council

It can, therefore, be concluded that the national policy, and the strategies and guidelines adopted to implement it, are supportive of having a specific policy aimed at addressing the problems related to scientific equipment.

4.2 NMIE as a National Scientific Equipment Capacity Builder

The Government of the Federal Democratic Republic of Ethiopia has mandated the National Metrology Institute of Ethiopia (NMIE), by the Council of Ministers Directive 194/2010, to focus on issues of scientific equipment capacity-building apart from its national metrology system maintenance and development endeavors. This decision was made taking into consideration the following situations prevailing in the country:

- Existence of potential problems of scientific equipment throughout the equipment life-cycle
- Expansion of universities; research institutes; and testing, inspection, measuring and analysis laboratories is triggering acquisition of more and more scientific equipment
- Absence of structure, manpower and system to provide for institution-level scientific equipment technical services in universities and research institutes or laboratories
- Absence or low involvement of Original Equipment Manufacturers (OEMs) in the provision of after-sales technical services, and
- Low capacity of the private third party equipment firms as installation, commissioning and maintenance service providers

Hence, the NMIE has the following specific duties and responsibilities with respect to scientific equipment:

- Provide consultancy services to users on selection and acquisition, handling and use, maintenance, repair and disposal of scientific equipment
- Provide training to scientific equipment users on acquisition, handling and use, maintenance, and disposal of scientific equipment
- Support scientific instrument user institutions in establishing their own maintenance workshops through providing training and support, and issuing certificates of competence to trainees
- Verify competency of scientific equipment maintenance workshops
- Provide maintenance services for scientific instruments which are beyond the capability of user institutions

In line with the duties outlined above, the NMIE is making efforts to extend its technical services, including repair and maintenance of scientific equipment, to all requesting institutions. However, the Institute does not believe that its technical services satisfy or reach all institutions in the country. Therefore, the Institute is pursuing the idea of establishing technical service provision units or centers in every user institution depending upon the number and technological complexity of scientific equipment they possess.

The efforts of NMIE to bring universities, research centers and other specialized laboratories on board to have their own functional equipment management systems could be considered as one of the enabling factors for national scientific equipment policy development.

4.3 Regulatory and Other Legislation

In the process of conducting research, the use of scientific equipment and supplies is inevitable. These kinds of research inputs require resources for their acquisition and management throughout the equipment life-cycle and regulatory follow-ups, depending on the nature of the research and the equipment used for that particular end. In Ethiopia, there is legislation that in one way or other affect research activities apart from the STI Policy. For instance, all public universities and research institutes are required to follow the federal government’s (regional government as applicable) procurement and property administration proclamation and series of directives issued by the pertinent regulatory authority. Procurement of scientific equipment is, therefore, envisaged to be conducted in strict compliance with the directives and the working manuals that set the procedures and processes for national and international competitive bidding in the process of procurement. The impact of practicing this regulation on procurement of scientific equipment and supplies is discussed in the following sections.

Scientific equipment are different from other ordinary equipment and materials that have to be procured under the prevailing general government procurement procedures. First of all, they are different in their principle of operation, design concepts, purpose and the environment they are used in. There are, in fact, equipment and materials that could harm the user and the environment unless handled and utilized properly and carefully. Therefore, regulatory follow-ups are usually instituted during procurement and transportation, installation and commissioning, use and maintenance, and disposal of such equipment. For instance, the Ethiopian Radiation Protection Legislation requires that every research institute or university notify of any ionizing radiation equipment under its possession. The legislation also requires the equipment owner to regularly monitor and report the amount of radioactivity around the equipment installation and obliges the user to wear protective clothing and to use a radiation dose meter.

The issue of calibration is another aspect of scientific equipment. Researchers have to use calibrated equipment to ensure consistency of measurements in their research undertakings. Scientific equipment can be calibrated and the uncertainty of measurements could be calculated using the quality infrastructure. The impact of calibration on the quality of research output is in fact immense.

It can, therefore, be concluded that in Ethiopia some legislation related to scientific equipment is in place with appropriate governmental structures to make sure that they are enforced. The policies and strategies of the government are also in favor of enhancing research activities. Accordingly, universities and higher education institutions are given leeway to engage in research activities based on the country's development needs and their comparative competency. A limited capacity is also available to support higher education and research institutions to build their own capacity to manage scientific equipment from procurement to disposal. However, the major issue of concern remains how well the national efforts are synchronized to support and create a "hassle-free" environment for research and development so that the outputs contribute to the country's development.

5. Discussion and Results of the Survey

5.1 Data Collection

The survey was conducted involving sample universities and research institutes to capture and map the existing situation with regard to the alignment of scientific equipment and associated supplies and accessories to the national and institutional research priorities. The limited survey discussed scientific equipment and research with resource persons who have ample knowledge and experience in managing scientific equipment in their respective institutions. The following were the main issues discussed in the structured interview with the informants.

- Research priorities, management and funding (national/institutional)
- Organizational framework related to scientific equipment management (e.g., structure, manpower, system, budget)
- Legislation, policies, guidelines (national/institutional)
- Scientific equipment related issues throughout the equipment life-cycle, i.e., from acquisition and operation (utilization) to disposal

5.2 General Discussion

The expansion of universities, hospitals, research institutes and specialized medical and non-medical laboratories has intensified acquisition (includes through donations) of scientific equipment for research; medical diagnosis and therapy; product testing and inspection; and physical quantity measurement, analysis and control.

The findings of this study cannot conclude on the correlation between the investments in scientific equipment as an input for research or scientific services and research outputs. However, it can be inferred that the problems around scientific equipment have a direct impact on research outputs and/or can cause research to be postponed or totally abandoned, which could be frustrating for an individual researcher, the research institution, and the country.

The problems of scientific equipment are prevalent throughout the equipment life-cycle. They begin during the acquisition phase and continue until equipment is disposed. This study captured the major problems along the spectrum of selection, acquisition, installation, utilization, maintenance and disposal of scientific equipment. The following are major cross-cutting issues and challenges identified through the structured interviews:

- Original Equipment Manufacturers (OEM) have limited technical representation in Ethiopia. Moreover, after-sales service required from OEMs is unattainable and financially prohibitive for most Ethiopian research institutions.
- Most research institutions are hesitant to set up an organizational unit and a functioning system that provides in-house scientific equipment technical services including administering outsourced contracts; conducting acceptance tests and environmental and public health compliance of equipment; and preparation of disposal and replacement plans.
- Shortage of technical manpower, which is mainly due to absence of proper training for mid- and high-level programs dealing with instrumentation engineering.
- Participation of the private sector in providing scientific equipment technical services is low in comparison to sales of equipment. In 2013, only two competency certifications were given for scientific equipment installation, maintenance and commissioning services while 54 companies were certified for importation of scientific equipment.
- Donation as a means of acquiring scientific equipment in most cases comes with no technical or legal documents that allow the recipient institution to analyze the offer and accept or reject it based on the technical requirements set in advance by the recipient.
- It is common to see diversified types of equipment from different manufacturers and origins in all research laboratories. This makes equipment management and contract administration challenging. Hence, the issue of standardization comes in here.
- Insufficient annual budgets are allocated for scientific equipment management in institutions.

5.3 Summary of the Major Findings of the Study

5.3.1 Institutions Involved in Scientific Research

- **Ethiopian Institute of Agricultural Research (EIAR)**

  EIAR is one of the largest research establishments in Ethiopia, with around 15 Research Centers in different areas of the country. EIAR also runs more than 40 research laboratories supporting the research endeavor. The Institute focuses on agricultural research. Regional Agricultural Research Institutes (RARIs) are also involved in agricultural research in accordance with the mandates given by the regional states depending on development priorities of the respective regions. RARIs have organized laboratories that support their prioritized research programs.

- **Ethiopian Public Health Institute (EPHI)**

  The Institute is the long-serving governmental research establishment involved in research activities in health, indigenous medicinal plants and nutrition. The Institute also provides scientific services in terms of clinical investigations. The Institute owns various laboratories with state-of-the-art scientific and clinical laboratory equipment for supporting its activities.

- **Higher Learning Institutions and Universities**

  These are places where research is expected to be conducted along with educational activities. Currently there are 32 public and two private universities in Ethiopia. Although private colleges and universities are increasing in number, they are more focused on education and training than research activities. Universities are given the freedom to choose their areas of research in accordance with the country's development priorities and their own comparative competency and academic advantages. Many of them have developed various laboratories equipped with scientific equipment ranging from basic to advanced, which are used for teaching and research purposes at the same time.

5.3.2 Research Priorities

Agricultural and animal productivity, innovation and adaptation of appropriate technologies, water and soil resources assessment and management, infectious diseases, climate change, alternative and renewable energy technologies, geological investigations, culture and language are some of the prioritized thematic areas for research at universities. Each university has identified thematic areas which have been prioritized in accordance with the university's competitive advantages.

5.3.3 Governance

The governance of research in all higher learning institutions is similar. Research Directorates under the office of the Vice President for Research and Community Affairs are responsible for coordination and managing budget allocations for research programs. The sectoral research institutes in agriculture and health are accountable to the respective ministries and regional bureaus as appropriate.

5.3.4 Budget Allocation for Research

No consolidated data were found on annual capital budget and recurrent expenditures for scientific equipment although it was observed that a 9-12 million Birr recurrent budget is allocated for research activities every year per university. In fact, most of the universities do not have laboratories dedicated only to research and consequently laboratories are used both for teaching and research. It was, hence, difficult to know annual budgets specifically allocated for scientific equipment procurement and up-keep.

5.3.5 Type and Number of Equipment at Universities and Research Institutes

No consolidated data were available from universities and research institutes regarding the numbers, types, origins and manufacturers of scientific equipment used in their laboratories. Respondents indicated that laboratories are managed in a decentralized manner under each school, institute or college, making availability of university-wide information difficult. It was indicated that diversity of scientific equipment in a laboratory in terms of type and origin of technology is making equipment management difficult, especially in acquiring spare parts, accessories and other inputs from equipment vendors for smooth operation of scientific equipment.

5.3.6 Status of Scientific Equipment

Consolidated data on scientific equipment are not available and it was difficult to obtain institution-wide information on number, type, origin, status and related information. It was also observed that there were a number of broken and unused equipment in many laboratories; although the percentage against the total available is unknown. Many respondents believe that unless an equipment inventory is conducted within universities by responsible bodies, it would be difficult to compile information required even for decision-making purposes related to scientific equipment.

5.3.7 Existence of Institutional Policies, Guidelines or Directives for Scientific Equipment Management

No university or institute-wide policy, guideline or directive is in use for scientific equipment and related technologies management. The general response was that universities are forced to procure products and services in strict compliance with the Government's procurement and property administration proclamations and directives.

5.3.8 Existence of Organizational Structure for Scientific Equipment Management

A closer look at universities' organizational structures does not show a specific responsible unit for scientific equipment management. Activities related to scientific equipment, including maintenance, are considered as support services that can be procured whenever required. All respondents in every institution agreed that not having such a unit in their organizational structure is an important missing ingredient.

Cognizant of the fact that the scientific equipment impact on agricultural research is considerable, EIAR started a study aimed at mitigating the problems related to scientific equipment. On the other hand, the EPHI is the only government research organization whose organizational structure comprises a specific unit for scientific equipment maintenance and related technical services.

5.3.9 Acquisition of Scientific Equipment

Procurement and donation are the two modes of scientific equipment acquisition in universities and research institutes, both using public procurement directives. Researchers complain that the procurement directive itself creates a problem since it requires purchase of least-price equipment through bidding. It seems that there is a misunderstanding in interpreting and applying the essence of the directive. The directive provides for conditions whereby least-price purchase is applied only for equipment that meet all the specifications set by the purchasing body. With respect to receiving donations, universities and research institutes have no written guidelines for accepting or rejecting offers of donations.

Procuring scientific equipment and related technical services including repair and maintenance from overseas manufacturers was described to be difficult as it requires foreign currency and has to pass through the customs processes according to the procurement directive.

Another area of weakness is that researchers do not widely and actively participate in the process of defining their requirements for scientific equipment acquisition. There were instances where preparing technical specifications that meet the researcher's requirements is considered as a simple task tantamount to searching and compiling information from the internet or acquiring the information from other similar laboratories. Moreover, there was a tendency to consider scientific equipment as other materials, and their procurement was left for procurement units without paying special attention to the peculiar characteristics that need to be handled by researchers.

It was also found that universities and research institutes lack the technical capability to prepare technical specifications, evaluate the vendor's experience and evaluate offers that bring difference in effectively acquiring the required equipment. As a result of this, it is not uncommon to observe over- and under-specified equipment in laboratories.

Training on new technology or equipment for technologists and maintenance engineers, installation, and acceptance testing are issues of concern as they are widely neglected from being special parts of bid documents. Assessment of technology that fits the requirements of users, and accessibility of reagents and accessories in the local market, and manufacturer support during operation, are also issues not given due attention by non-technical procurement personnel in universities or research institutes. Furthermore, equipment installation and commissioning (acceptance testing) are not given due attention in the process of procurement or acceptance of donations. As a result, there are occasions when equipment is uninstalled for lengthy periods of time. Universities and research institutes have no procedures or even technical capability for checking conformity of supplied equipment against the specification after installation.

Another problem indicated by all respondents is that there are various types of equipment from different manufacturers and countries of origin in the laboratories of the universities and research institutes, making laboratory equipment management difficult.

The fact that customs duties and clearance procedures do not differentiate between scientific equipment used for research and other commercial equipment was also pointed out to complicate the acquisition process. Customs duty is imposed on donated equipment and every institution has to clearly identify who covers the duty before accepting donated equipment. It was indicated that customs duties are usually high for institutes unless the donors are involved in settling the bills.

5.3.10 Scientific Equipment Operation (Utilization)

Universities and research institutes have no scientific equipment management system that enforces inclusion of training components for users and maintenance personnel whenever new equipment is acquired. Consequently, untrained users could be sources of equipment malfunctioning. There are a number of unused or broken equipment in the universities and research institutes because of reasons originating from inadequate training.

Pre-assessment of availability of reagents and supplies in the local market during new acquisitions is not practiced in many laboratories. The gravity of this gap is seen with technologically advanced and critical equipment that require special inputs and interventions from original equipment manufacturers.

Calibration of equipment and instruments to ensure compatibility of values with known standards is also a challenging activity for universities and research institutes.

5.3.11 Maintenance and Repair

Universities and research centers have no established institution-wide scientific equipment management system including maintenance and repair. They also do not have organizational structures that provide technical and administrative services with regard to scientific equipment. As a result, they are unable to ensure availability of fully equipped and operational laboratories and workshops with required scientific equipment, and trained manpower competent to handle activities throughout the equipment life-cycle, including maintenance and repair of existing scientific equipment, and monitoring of outsourced technical services. Acquiring spare parts, accessories and reagents from the local market is also a huge challenge for most research institutes and centers.

5.3.12 Disposal

Research and educational laboratories in the universities and research institutes are forced to be repositories of unused equipment mainly due to the absence of mechanisms by which unused and/or obsolete equipment are disposed in a timely manner. Moreover, universities and research institutes lack clear understanding of the Government's property disposal directive. Respondents argue that equipment cannot be easily disposed unless first cleared from registration, as each piece of equipment in laboratories is registered and full responsibility rests on the individual researcher or laboratory technologist who is managing it. The amount of available laboratory working space is being reduced constantly as a consequence of this, impacting the overall performance of laboratories. Moreover, there is lack of awareness of disposing equipment without affecting the environment and public health.

6. Lessons to Learn from Other Sectors

Lessons relevant to scientific equipment management can be drawn from the medical sector. Medical equipment has been defined by the WHO as equipment used for the specific purposes of diagnosis and treatment of disease or rehabilitation following disease or injury. Medical devices require, like scientific equipment, calibration, maintenance, repair, user training, and decommissioning. Relevant lessons are summarized below.

6.1 Regulatory Framework

The FDRE Ministry of Health is responsible for ensuring and directing the accessibility of quality health service to all citizens in Ethiopia. The regulatory functions related to health care, including medical devices and technologies, are the responsibility of the Food, Medicine and Health Care Administration and Control Authority (FMHACA) according to Proclamation No. 661/2009. Core elements of the FMHACA regulatory activities include standards setting, inspection and licensing, and product quality assessment. So far, the Authority has, among other initiatives, issued medical equipment guidelines, compiled lists of essential medical equipment, and enforced licensing and registration system for medical equipment professionals, apart from the regulatory monitoring of imported medical equipment. This is one of the most important steps taken in the health sector, which could be transferred to the scientific equipment sector.

6.2 Central Medical Equipment Supply

The Government of Ethiopia established Pharmaceuticals Fund and Supply Agency (PFSA) in 2007 to promote sustainable, quality, affordable and properly managed supply of pharmaceuticals, medical supplies and medical equipment. It is believed that the Agency plays an important role in strengthening and expanding health services by ensuring timely and sustainable supply of pharmaceuticals, medical supplies and medical equipment through the Revolving Drug Fund.

The Country Study identified the inability to procure scientific equipment due to insufficient participation of suppliers for individual bids by universities as one of the challenges facing research establishments. Collective efforts through well defined lines of communication between universities and research institutes encourage manufacturers and suppliers to participate in national competitive bids. This practice could, therefore, be extended to universities and research centers whenever their equipment requirements are similar. The major benefit of such a system is attraction to big suppliers and maintaining strong relationships with manufacturers to ensure availability of technical services, consumables and spare parts.

7. Conclusions and Recommendations

Scientific research has been given due attention by the Government of Ethiopia. The STI Policy stipulates that research is a strategic component to quickly learn foreign technologies, adapt them to the local environment, effectively use them and transfer knowledge through university-industry linkage. The outputs of research activities are expected to make a difference in the country's development. However, there are a number of constraints that have to be addressed to create an environment that is conducive to growth and effectiveness of research and development.

One of the major inputs, and perhaps the most costly and not being properly managed by the research institutions and universities, is scientific equipment. However, almost all higher learning institutions covered by the study seem not to appreciate its critical role as an essential component of the research system, with the exception of research institutions to some extent. Most of the researchers get frustrated when newly acquired equipment lays idle without serving its purposes or the available equipment is inadequate to carry out meaningful research activities. Equipment may also fail to function in the middle of research data analysis. Reagents or other supplies are not easily available on the local market. Moreover, trained personnel may be lacking to fix malfunctioning equipment and costs of expatriate repair and maintenance services may be beyond the financial capability of the institution. Most higher learning institutions know the sources of these problems and their consequences although they do not manage to tackle the problems and find solutions to them.

7.1 Conclusions

If scientific research is expected to contribute to the national economy, the role of scientific equipment has to be well understood and given due attention. The following are the major conclusions of the Country Study on the status of scientific equipment in Ethiopia:

- There is a lack of adequate appreciation of the correlation between scientific equipment and scientific research, education and services at universities and research institutes in Ethiopia. Consequently, they are not in the best position to either properly manage scientific instruments and equipment or bear the costs associated with their ownership throughout the entire life-cycle from acquiring the equipment, maximizing the operation, maintaining the performance, and determining when to properly dispose.
- Procurement is regarded as a major source of problems related to scientific equipment. Many items of equipment lay idle, broken, uninstalled or abandoned. Most of the universities are unable to characterize the methods of procurement that suit scientific equipment because they do not have the technical capability to define requirements, prepare technical specifications, assess technology, evaluate vendor's capability, select appropriate equipment and conduct acceptance testing procedures.
- Although uncoordinated efforts are being practiced, organizational structures and functioning systems that create enabling situations for scientific equipment and technology management throughout the scientific equipment life-cycle are the missing essential ingredients of the research systems of the majority of research institutes and universities. This has, in turn, resulted in the absence of institution-wide information required for decision-taking, and duplication of efforts and resources is also common.
- Technical capability to procure, select, accept donations, install, maintain, and dispose of scientific equipment is weak and the status of scientific equipment for research is deteriorating constantly. This is mainly because there is a shortage of qualified human resources required for proper management of scientific equipment, which is related to absence of academic programs in Scientific Instrumentation Engineering.
- Universities and research institutions lack institutional policies, guidelines and/or procedures that help to address problems related to cross-cutting scientific equipment management. They are also seen to be unable to develop the required human resources capable of managing the scientific equipment they acquire through various means.

7.2 Recommendations

7.2.1 Creating an Enabling Scientific Equipment Management System (SEMS)

Scientific equipment are costly resources that need to be managed properly. Considerable amounts of equipment are currently out of order or are not in use in many institutions. On the other hand, there is a general consensus that investment in scientific equipment could alter the quality of scientific research and education. All higher learning institutions and research institutes, without exception, need to establish an enabling scientific equipment management system to mitigate the problems faced throughout the equipment life-cycle. A functioning equipment management system may include development of working procedures, guidelines, rules, organizational structures, human resources, and conditioned and fully-equipped maintenance workshops.

7.2.2 Creating Institutional and National Centers for Scientific Equipment Management

One of the major issues that has been discussed with universities and research institutes and identified by all of them as a major gap is absence of an institutional center for scientific equipment management. It is, therefore, highly recommended that every institution establishes a scientific equipment center responsible for carrying out all activities throughout the life-cycle of scientific equipment within the institution. It is believed that up to 70% of scientific equipment problems could be handled by having such a center. The remaining 30% of problems together with standardizations and refresher trainings can be carried out by a national center fully dedicated to supporting management of scientific equipment. Establishment of a center in each institution requires detailed study of the existing situation at that specific institution.

7.2.3 Human Resources Development and Capacity-building

The shortage of trained technical manpower needs to be addressed through proper human resources development in higher learning institutions as well as capacity-building activities for mid-level technical staff on the job but with insufficient capacity. Both approaches can be combined to get impactful results in the shortest possible time. The human resources development aspect calls for higher learning institutions to design relevant curricula and start training programs at undergraduate and postgraduate levels.

7.2.4 Acquisition of Scientific Equipment through Procurement and Donations

Public research institutes, universities, specialized laboratories and scientific service-providing establishments follow the public procurement directive of the Federal Government. This directive, apart from describing the procurement process for products and services through national and international competitive bidding procedures, specifies the general responsibilities of buyers and suppliers together with procurement governance. In fact, no institution was observed to have an alternative procedure for product and service procurement. During interviews with the informants, it was identified that there is a gap in fully understanding and applying the appropriate procurement method to get the best that the market provides for the money invested. It was noted that the diversity of scientific equipment in terms of makes, types and origins is hindering management of equipment as a result of irregularities in equipment acquisition. Standardization, as an issue of limiting the type of equipment to a reasonable level, is therefore recommended to effectively manage scientific equipment.

7.2.5 Total Cost of Ownership (TCO)

Credible data could not be found to analyze the impact of scientific equipment on research in terms of finance, quality of research output or the outcomes of research. An obvious fact is that scientific equipment is an integral part of research activity that could affect the overall progress of research programs.

A research entity should manage and optimize costs associated with instrument and equipment ownership throughout the entire life-cycle. Total cost of ownership (McNeil, 2008) is a concept used to represent all of the costs, including direct and indirect (preventive maintenance, corrective maintenance, training, upgrades and application support, regulatory and quality compliance, consumables, accessories and supplies) associated with owning scientific equipment or instruments (capital assets) required to support a given research program or laboratory operation. TCO seeks to identify and quantify all of the people, processes, tools and related expenses needed to operate and maintain instruments and equipment for the laboratory, so that organizations can make more informed decisions on new purchases and disposition based upon financial and non-financial factors. It is, therefore, strongly recommended to explore the concept of TCO during procurement and accepting donations of scientific equipment.

7.2.6 Utilization of Scientific Equipment

Management of scientific equipment requires a functional system that starts from taking detailed inventories. However, such information was not readily available in any of the institutions covered by the Country Study. Therefore, it is recommended that a scientific equipment database be developed first at institutional level and then at country level. To ensure effective and efficient use of equipment, preventive maintenance programs should be designed and regularly executed based on manufacturers' recommendations. Calibration of equipment also has to be conducted on a regular basis. Moreover, technical documentation, appropriate testing and measuring instruments and repair tools that match the existing complexity of scientific equipment should be made available for maintenance. Critical spare parts and components should be made available through established channels of communication with equipment suppliers. Uninterrupted supply of reagents and consumables has to be ensured from the inception of the equipment procurement process.

Short-, medium- and long-term strategies need to be designed to develop qualified manpower required to properly manage and ensure optimal utilization of scientific equipment in research institutes and universities. This has to be done by strengthening existing initiatives and introducing Diploma, BSc and MSc programs in selected higher education institutions.

7.2.7 Disposal of Scientific Equipment

There is a large amount of unused scientific equipment in every laboratory of the research institutes and higher learning institutions surveyed. For equipment to be withdrawn from service, there must be certain rules and justifications. Although there is a property disposal directive of the government, it does not fully address the peculiar characteristics of scientific equipment. It is, therefore, recommended that institutions prepare specific guidelines that do not contradict the government directives for disposal of scientific equipment.

7.2.8 National Policy on Scientific Equipment

Although establishment of a center for scientific equipment management at institutional level provides a system for standardizing the process of selection, procurement, use and disposal of equipment, there are critical issues that need to be addressed nationally. Hence, adoption of a national policy framework is imperative. The policy should cover all aspects of scientific equipment and strategically guide procurement, donation, standardization, disposal, maintenance, documentation, contract administration, and manpower development. Effective scientific equipment policy could enhance scientific research and quality of education by minimizing expenditures for equipment up-keep and encouraging local capacity-building to select, use and dispose of scientific equipment.

References

CSA 2014 Press Conference on Population Projection for Ethiopia, 9 June 2014, Addis Ababa, Ethiopia.

DFID 2007 Research Strategy (2008-2013) Consultation – Africa.

FDRE 2007 Proclamation No. 553/2007, Drug Fund and Pharmaceutical Supply Agency Establishment Proclamation. Addis Ababa, Ethiopia.

FDRE 2010 Federal Public Procurement Directive, Ministry of Finance and Economic Development, June, Addis Ababa, Ethiopia.

FDRE 2011 Ethiopia's Climate-Resilient Green Economy: Green Economy Strategy, Addis Ababa, Ethiopia.

Fonjungo, N, Peter, Y K, et al 2011 Laboratory Equipment Maintenance: A critical bottleneck for strengthening health systems in sub-Saharan Africa. *Journal of Public Health Policy Vol. 33 (1), 34-45,* Macmillan Publishers Ltd.

McNeill, D 2008 Total Cost of Ownership, July 21, http://www.labmanager.com/laboratory-technology/2008/07/total-cost-of-ownership.

FMHACA 2012 Medical Equipment Donation Directive, Addis Ababa, Ethiopia.

MoFED 2006 Ethiopia: Building on Progress, a Plan for Accelerated and Sustained Development to End Poverty (PASDEP) (2005/06-2009/10).

MoFED 2010 Federal Government Directives on Finance and Property Administration of Ethiopia, Amharic Version.

MoFED 2010 Growth and Transformation Plan (2010/11-2014/15). Addis Ababa, Ethiopia.

MoFED and UNDP 2012 Assessing Progress towards the Millennium Development Goals: Ethiopia MDGs Report 2012. Addis Ababa, Ethiopia.

MoST 2005 R&D Survey. Addis Ababa, Ethiopia.

MoST 2010 Green Paper on "Building Competitiveness through Innovation" (Background Document to the National Science, Technology and Innovation Policy). Addis Ababa, Ethiopia.

MoST 2012 National Science, Technology and Innovation Policy, Addis Ababa, Ethiopia.

Perry, L and Malkin, R 2011 Effectiveness of Medical Equipment Donations to Improve Health Systems: how much medical equipment is broken in the developing world? Med Biol Eng Comput (2011) 49:719–722; DOI 10.1007/s11517-011-0786-3; International Federation for Medical and Biological Engineering.

UNDP 2012 United Nations Development Programme in Ethiopia. Annual Report 2012. Addis Ababa, Ethiopia.

WHO 2003 Medical Device Regulation: Global Overview and Guiding Principles. Geneva.

Yemane, B 2011 Status of Health Research in Ethiopia and the Way Forward. Paper Presented to the First Science Congress of the Ethiopian Academy of Sciences, 15-16 December 2011, Addis Ababa, Ethiopia.