DEVELOPING AN ENABLING SCIENTIFIC EQUIPMENT POLICY IN AFRICA: THE GHANA COUNTRY STUDY

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Acronyms

AAS	African Academy of Sciences
ARI	Animal Research Institute
AUC	African Union Commission
BRRI	Building and Roads Research Institute
CRI	Crop Research Institute
CSIR	Council for Scientific and Industrial Research
ECOWAS	Economic Community of West African States
ECOPOST	ECOWAS Policy on Science and Technology
EPA	Environmental Protection Agency
FASDEP	Food and Agriculture Sector Development Project
FDA	Food and Drugs Authority
FORIG	Forest Research Institute of Ghana
FRI	Food Research Institute
GAAS	Ghana Academy of Arts and Sciences
GAEC	Ghana Atomic Energy Commission
GETFUND	Ghana Educational Trust Fund
GMet	Ghana Meteorological Agency
GSA	Ghana Standards Authority
GSCL	Ghana Supply Company Limited
GSGDA	Ghana Shared Growth Development Agenda
IAEA	International Atomic Energy Agency
ICT	Information and Communication Technology
IFS	International Foundation for Science
IGF	Internally Generated Funds
IIR	Institute of Industrial Research
ISO	International Standards Organization
KNUST	Kwame Nkrumah University of Science and Technology
LDP	Livestock Development Project
LIPREC	Livestock and Poultry Research Centre, University of Ghana
MDA	Ministries Departments and Agencies
MESTI	Ministry of Environment, Science, Technology and Innovation
MOFA	Ministry of Food and Agriculture
MOTI	Ministry of Trade and Industry
NEPAD	New Economic Partnership for Africa's Development
NLSP	National Livestock Services Project
NMIMR	Noguchi Memorial Institute for Medical Research
OPRI	Oil Palm Research Institute
PGRRI	Plant Genetic Resources Research Institute
PPA	Public Procurement Authority
RPI	Radiation Protection Institute
S&T	Science and Technology
SARI	Savanna Agriculture Research Institute
SRI	Soil Research Institute
STEPRI	Science and Technology Policy Research Institute
STI	Science, Technology and Innovation
WSL	Swiss Federal Institute for Forest, Snow and Landscape Research
TCPD	Town and Country Planning Department
UCC	University of Cape Coast
UDS	University for Development Studies
UG	University of Ghana
UNDP	United Nations Development Programme
WAAPP	West African Agricultural Productivity Programme
WRI	Water Research Institute

1. Background

The scientific endeavor in Africa and the developing world is saddled with challenges of which one of the most critical is infrastructure. A major concern within infrastructure is equipment. It is important to recognize that the equipment challenge is intimately associated with deficiency of policies and frameworks that facilitate and enable procurement, commissioning and decommissioning of science equipment, and management systems for maintenance, including the availability of trained manpower. The urgency of the task facing today's scientists in Africa and across the developing world will require continuous support to enable them to contribute to securing affordable food, water and energy for the increasing population. Scientists need to have an enabling environment that will enable them to deliver on their mandates. All of this is dependent on the hardware conditions they work with. It is against this background that the International Foundation for Science (IFS) and African Academy of Sciences (AAS) initiated the project "Developing an enabling scientific equipment policy in Africa" to help develop effective policy to overcome the challenges in the sector.

Although Ghana does not have a National Science Equipment Policy, it has a National Science, Technology and Innovation (STI) Policy, adopted at cabinet ministerial level to provide the framework for STI development in the country. The specific objectives of the Ministry of Environment, Science, Technology and Innovation (MESTI) include the development of the sector's delivery capacities in human resources management, infrastructure and plant/equipment through appropriate policies and legislation. The goal of the STI policy is to harness the nation's total science and technology capacity to achieve national objectives for poverty reduction, competitiveness of enterprises, sustainable environmental management and industrial growth (MESTI, 2010).

The institutions working under MESTI are Town and Country Planning Department (TCPD), Council for Scientific and Industrial Research (CSIR), Environmental Protection Agency (EPA) and Ghana Atomic Energy Commission (GAEC). Other relevant institutions that work in collaboration with MESTI are the Ministry of Education and the Ministry of Trade and Industry (MOTI). Information obtained from the foregoing institutions was used in the preparation of this Scientific Equipment Policy Study of Ghana.

The aspirations for basing the foundations for the development of Ghana through science and technology (S&T) were enunciated soon after independence in 1957. Since then, we note that these ambitions are still not fully realized, especially in relation to the application of S&T. Although some progress has been made in agriculture and micro and small-scale industry, there is yet to be a seriously transformative use of science, technology and innovation (STI) to drive socio-economic activities. The S&T policy of Ghana was developed and adopted as a national document in 2000. This policy defines the objectives and priorities for investment in STI. The policy was however not implemented for several years. This is due to, among others, the absence of political structure at the highest level of government to advise and champion the crusade for implementation of the strategic plan (Frempong, 2006). Notwithstanding this deficiency, some national development plans in recent years have been thinly laced with statements of utilising S&T to propel development. For instance, the Ghana Vision 2020 contained a statement on using S&T as a pedestal to enhance the socio-economic development of the country (Ghana Government, 1996). The Ghana Poverty Reduction Strategy (GPRS) I (2003-2005) emphasized the need for robust development of S&T to boost industrial production, employment, and natural resource production, food

security, sustainability, self-sufficiency and environmental health (Ghana Government, 2003). However, in the case of GPRS II (2006-2009), no mention is succinctly made of S&T as tools to achieve the development targets in the document. Generally, the synergy between S&T and the political system had been weak in Ghana and other African countries (Frempong, 2006).

Advancements in S&T with wide applications, such as innovations in ICT and Internet applications, as well as emerging trends in biotechnology and nanotechnology, made it imperative for Ghana to review the S&T Policy. A review was undertaken leading in 2010 to the National Science, Technology and Innovation Policy (MESTI, 2010). One notes the introduction of the concept of innovation into the new framework of actions, policies and programmes to apply S&T to achieve social and economic objectives. There are sector-specific policies in Agriculture, Health, Education, Environment, Energy, Trade, Industry, Natural Resources, Human Settlements and Communications which shall be driven by sector-specific S&T programmes. An implementation plan has been formulated to facilitate implementation of the STI Policy.

The Ghana STI situation and the lack of coherent and well-articulated policies on scientific equipment is a frequently encountered feature of the African S&T experience. These observations motivated the IFS and AAS to initiate the scientific equipment policy study in Africa to help overcome the challenges in the sector. This study is a follow-up to the Scientific Equipment Project Inception Workshop held at AAS in Nairobi from 6-7 November 2013. The rationale for the study is to understand the prevailing situation of scientific equipment in Africa generally. Three countries have been identified for pilot studies, namely Ethiopia, Ghana and Kenya. In Ghana, the study aimed at presenting the scientific equipment situation and formulating recommendations for amelioration.

2. Objectives

The overall purpose of the study is to assess how science equipment policy can facilitate scientific endeavour across Africa. The specific objectives of the study include:

- Reviewing the effectiveness of science equipment policies (if available) of key organisations in Ghana in relation to organisational structures and systems.
- Mapping the national research and policy landscape, i.e., identifying the key scientific institutions, and the national and institutional policies of relevance to scientific equipment.

3. Methodology

The data collection was based on the work plan agreed between IFS and STEPRI in February 2014. It began with desk research to gather relevant information from institutional offices and libraries and on the Internet. An interview guide (Appendix 1) was designed based on the work plan and administered to a total of 25 institutions or organisations (Appendix 2). Two interview guides were developed; one was administered at key oversight organisations including the Ministry of Finance, Ministry of Education, and MESTI. The other interview guide was administered to institutions that use scientific equipment in their activities. The interview guide had three sections on procurement of scientific equipment, case studies of

institutions, and input of science, which was made up of human resources, tangible assets and organizational skills.

The ministries responded to the policy aspect of the survey, whilst the research institutions, the universities and the polytechnics responded on the scientific equipment sections. The sampling of the institutions/organisations was purposively drawn and focused on key scientific institutions in Ghana, including:

- The research institutes of the Council for Scientific and Industrial Research (CSIR), namely Savanna Agriculture Research Institute (SARI), Crop Research Institute (CRI), Oil Palm Research Institute (OPRI), Soil Research Institute (SRI), Water Research Institute (WRI), Food Research Institute (FRI), Animal Research Institute (ARI), Building and Roads Research Institute (BRRI), Forest Research Institute of Ghana (FORIG), Institute of Industrial Research (IIR), Plant Genetic Resources Research Institute (PGRRI), and Noguchi Memorial Institute for Medical Research (NMIMR)
- Public universities such as University of Ghana, Kwame Nkrumah University of Science and Technology (KNUST), University of Cape Coast, and University for Development Studies (UDS)
- Accra Polytechnic
- Ghana Atomic Energy Commission (GAEC) and its Radiation Protection Institute (RPI)

4. Results

This section provides information on the results of the survey under the following broad headings: (i) Procurement of Scientific Equipment, and (ii) Case Studies of Institutions at National and Regional Levels. Details on policies and frameworks in science equipment, and the roles of institutions and organisations, as well as institutional input of science are included.

4.1 Procurement of Scientific Equipment

Procurement processes and procedures in Ghana have gone through a number of changes, with the main objective of minimizing the level of corruption, realizing value for money, and promoting efficiency in the procurement process. A major event was the passing of the Procurement Act, Act 663, in 2003. The stated overall objective of Act 663 is to "provide for public procurement, establish the Public Procurement Board, make administrative and institutional arrangements for public procurement, stipulate tendering procedures and provide for purposes connected with these" (Act of Parliament, 2003). The procurement law has streamlined procurement processes in the country, as well as establishing a high level of rationality in the procurement environment (PPA, 2010).

4.1.1 Role of Organizations and Institutions

The establishment of the ministries in Ghana is primarily meant to facilitate policy formulation and implementation, monitoring and evaluation in definitive sectors of the economy. Ministries exercise oversight responsibilities over public agencies whose functions

fall within the purview of the respective ministerial responsibilities. In the case of scientific equipment, the study identified three main ministries, namely:

- Ministry of Environment, Science, Technology and Innovation (MESTI)
- Ministry of Education
- Ministry of Finance

These three ministries and their agencies play roles in the acquisition, use and maintenance of scientific equipment. The National Development Planning Commission, being the constitutional body established for planning for the country, also have a role to play in guiding scientific institutions on their equipment policies.

The role of the Ministry of Finance at the national level is to ensure that funds are allocated to finance the supply of science equipment for Ministries, Departments and Agencies (MDA) in accordance with the ministries' strategic plans and budget requests for the year. The budget for science equipment, however, cannot be found as a single expenditure item, as it is budgeted for under the various MDAs where the use of scientific equipment is pronounced. For example, the Ministry of Education has an estimated budget for science equipment, so also has the Ministry of Trade and Industries and its agencies, and MESTI and its affiliates. This information can be located in the budget volumes of the respective Ministries.

4.1.2 Procurement of Science Equipment

In the research institutions, procurement of science equipment is in accordance with the procurement law. There can be competitive bidding or sole-sourcing. The process involves identification, specification and communicating with known suppliers/dealers to submit quotations. The quotations are analysed and the results submitted with recommendations to the procurement committee for action. In some instances scientific equipment are procured through partners in research programmes or projects, but in compliance with the procurement law. There can also be donations as shown in Table 1. Usually the equipment is not donated in isolation, for example, where pieces of equipment are included as prerequisites for executing research proposals which are occasionally submitted to funding agencies. Once the proposals are approved, the donor funds are used to purchase the equipment.

During this study it was realized that some scientific institutions have developed specific procedures and partnerships for acquiring equipment. For example, in GAEC, equipment is purchased through partnership with the International Atomic Energy Agency (IAEA). In ARI, proposals are also submitted to funding agencies that have shown positive response and also direct requests are made to establishments which use their services for support. A case study of ARI shows that it benefited from donation of equipment from a World Bank-sponsored National Livestock Services Project (NLSP), and implemented by the Ministry of Food and Agriculture (Animal Production Directorate). Under this project, the National Animal Feed Quality Control Laboratory was set up for the Animal Research Institute (ARI) in 1996. Equipment and reagents worth US$ 525,810 were provided to the laboratory.

Table 1: Organisations/projects/donor agencies that provided scientific equipment to scientific institutions

Organisation/Project/Donor Agency	Institution that benefited
WAAPP-World Bank, DANIDA, CORAF/WECARD-Mexico, GCP-Japan	CRI
European Union, Millennium Development Authority (Millennium Challenge Account), Danish International Development Agency (DANIDA)	WRI
JIRCAS-Japan, JICA-Japan	NMIMR, SRI, Accra Polytechnic- School of Applied Science and Arts, and School of Engineering
GETFUND-Ghana	Accra Polytechnic- School of Applied Science and Arts, and School of Engineering
Spanish Grants	Accra Polytechnic- School of Applied Science and Arts, and School of Engineering
World Bank, AfDB, Ghana Poultry Farmers Association	ARI
AGRA	SRI
IAEA	GAEC
Forestry Commission, Ghana	SRI
Kirkhouse Trust, UK	SARI
ITTO, EU, DFID-UK, DANIDA – Denmark, ICRAF, WAPP, GoG, Switzerland	FORIG
GRATITUDE PROJECT- UK	FRI
West African Gas Pipe	Department of Chemistry, University of Ghana

The African Development Bank funded the Livestock Development Project (LDP) which was implemented by the Animal Production Directorate of MoFA. Under this project the Feed Quality Laboratory was physically moved from the old office of the Animal Research Institute at Achimota to its present location at Fafraha in 2010. The ARI also benefited from the Ghana Poultry Farmers Association. Clearly the role of stakeholders in supplying scientific equipment to scientific institutions is significant. According to the ARI, for instance, the state used to provide support to the institute but for over fifteen years, the state has not provided equipment, leaving stakeholders to fill the gap. The support from the poultry farmers is a significant indication of private sector support for R&D, particularly in the provision of scientific equipment.

Sole-sourcing is encouraged for procurement of small quantities of science equipment and also for situations where it is only one dealer which can supply particular equipment. This is permissible in the procurement law. For major state projects like WAAPP, the beneficiary institutions in the CSIR are normally requested to submit their equipment needs. The Head Office of the CSIR then takes over the procurement process. For smaller projects or individual requests by scientists, selection is also done from a company's or supplier's catalogues. The order is made and payment is done from the project accounts. Clearance of the equipment is done by the scientist or the Head Office's clearing agent.

The study realized that those contacted in the private sector undertake their procurement directly from the suppliers without going through any tendering process. Private sector entities are not obliged to go by the provisions of the procurement law. The equipment is bought through direct purchase and there are rarely any donations of scientific equipment.

Examples of private sector institutions contacted were the G-2 Medical Laboratories and the MedLab Ghana Limited in Accra.

However, even for public institutions, equipment may be procured directly from manufacturers when it is difficult to find local dealers. An example of an institution that procures directly from manufacturers is Ghana Meteorological Agency (GMet). Permission for direct procurement is obtained from the Public Procurement Authority (PPA). In academia, such as at the University of Ghana's Department of Chemistry, Department of Animal Biology and Conservation Science, and Department of Nutrition and Food Science, procurement is done through open tender by the procurement office. The departments give the list of scientific equipment and their quotations to the procurement unit of the university to do the purchases. In some cases, procurement is done from project funds and the order made directly from international companies or agents in Ghana.

In the School of Applied Science and Arts of Accra Polytechnic, the department does its needs assessment and includes them in the department's annual budget. When the need arises a formal request is made to the Rector. If the amount is less than GH¢ 5,000 (approx. USD 1,667), procurement is done by the procurement office using the specifications provided. If the amount is greater than GH¢ 5,000, it goes through the normal procurement process (tender). In the School of Engineering, the main process for acquiring scientific equipment is through tender unless the equipment being procured is urgent and costs less than GH¢ 5,000. Table 2 gives a further illustration.

Generally with most of the institutions (73.7%), there were no processes that simplify the acquisition and clearance of equipment and efforts are made to adhere to the procurement law. Equipment is usually bought through direct purchase. This creates problems when equipment has to be imported and the payment of duties and taxes becomes exorbitant. Information gathered from FORIG shows that they usually seek exemption through the sector Ministry (MESTI) but sometimes the delays are such that they end up going through the normal processes and paying the required duty as everybody else. Sometimes collaborating scientists abroad are asked to purchase and bring them along when they are visiting. This only works if the equipment is portable and convenient to carry in luggage.

In Accra Polytechnic, the only process that simplifies acquisition of scientific equipment is for that which falls within the GH¢ 5,000 price limit. Also the clearance is simplified since there is an educational waiver that helps reduce stress in clearing educational equipment and this also reduces equipment cost. Application for such a waiver is submitted to the Ministry of Education, which processes it for granting. The universities and polytechnics have been taking advantage of this. The Ghana Atomic Energy Commission (GAEC) also benefits from duty exemptions through the local UNDP. United Nations agencies such as the UNDP are exempt from payment of duty. UNDP clears equipment for GAEC, which thereby benefits from that exemption. Thus exemptions or waivers are important means of facilitating scientific equipment acquisition for scientific institutions.

Table 2: Process for procuring scientific equipment by institutions

Institution	Procurement process
OPRI	Identification and specification Contacting known suppliers/dealers to submit quotations Submission of quotations with recommendations by a procurement committee
GMet	Direct from manufacturers outside the country Permission through PPA
ARI	Obtained through projects and donations
SRI	For most foreign research equipment, scientific equipment catalogues or the Internet is used For locally available field equipment, market surveys / collection of pro forma invoices from local equipment dealers
IIR	Competitive bidding Sole-sourcing Inspection
Accra Polytechnic School of Applied Science	Conduct departmental needs assessment Inclusion of needs to department's annual budget Formal request to the Rector Procurement by tender
Accra Polytechnic School of Engineering	Procurement by tender
CRI	Equipment needs assessment The Head Office takes over the procurement process Selection from supplier's catalogue book Payment made from the project's accounts
GAEC	Most of the equipment are procured through IAEA By direct purchase or through projects
G-2 Medical Lab	By purchase from suppliers
FORIG	Browse the Internet and/or search through scientific catalogues, e.g., the MRS Scientific Ltd Directory Document all specifications of preferred models of equipment for quotation Communicate with foreign companies online Contact a local company to place order for the equipment from foreign company
Faculty of Science, UG	Open tender through the Procurement Office Through project funds

4.1.3 Agencies Responsible for Supplying Scientific Equipment

From the responses, the study found that 63% of the institutions were not engaged to supply scientific equipment on a permanent basis. Most procurement by institutions goes through the normal tendering process (68.4% of the sample). However, about 37% of the institutions have agencies responsible for supplying scientific equipment. Table 3 shows some agencies that supply scientific equipment.

4.1.4 Manufacturers of Scientific Equipment

There is little or no manufacturing of equipment in Ghana. Virtually all the institutions had their scientific equipment manufactured abroad. As shown in Table 4, much of the scientific equipment being used in scientific institutions in Ghana were manufactured abroad. There is an absence of local manufacturers. This has serious implications for sustainability in the maintenance and use of the equipment. Where there is local manufacturing capacity, it also provides for maintenance of equipment and even for innovation.

Table 3: Institutions and agencies responsible for supplying scientific equipment

Institution	Agencies supplying equipment
FORIG	MES Equipment, Accra; WAGTECH International, Accra; Labchem Company Ltd, Kumasi
Department of Nutrition and Food Science, UG	MES Equipment; HANNA Local Representative; Cole Parmer; Atago; WAGTECH
Water Research Institute	MES Equipment Ltd.; WAGTECH Ltd.
Food Research Institute	Waters Incorporated
Ghana Atomic Energy Commission (GAEC)	International Atomic Energy Agency (IAEA)

Table 4: Some equipment manufacturers and countries of origin

Manufacturer of Equipment	Country of Origin
Buck Scientific	USA
Lemfield Medical	UK
Hanna Instruments	USA
MDH Service Engineers	USA
TELSTAR, S.A, TERRASSA,	Spain
Thermo Scientific	USA
Priorclave Ltd.	UK
Agilent Technologies	USA
PerkinElmer	France
Shimadzu Corporation	Japan
Scientific Industries	UK
Denver	UK
Jasco Corporation	Japan
Jenway	UK
Cole Parmer	USA
Leaver Scientific Ltd, UK	UK
Varian	Australia
Wagtech Int. Ltd	UK
Foss/Tecator	Sweden
Buchi	Switzerland
Waters Corporation	USA
Gal, Merek, Scientific Instrumentation	UK
Fisher Scientific	USA
WSL	Switzerland
Game Cameras	Canada
Applied Biosystems	UK
peQlab	UK

4.2 Case Studies of Institutions at National and Regional Levels

4.2.1 National Frameworks for Scientific Equipment Policy Development and Change

Responses from MESTI show that there are various national policy documents and plans which may provide at least minimal guidance to acquisition of scientific equipment apart from the specific procurement law. Key examples are:

- The national infrastructural plan
- National STI policy and development plan
- Ghana Shared Growth Development Agenda (GSGDA)

MESTI showed much awareness of national frameworks since they play a role by facilitating existing policies, unlike the scientific institutions that only played roles in line with their scientific mandate. According to the Ministry of Finance, the policy objectives of the GSGDA, and the strategic plan of MESTI, highlight the need to strengthen appropriate institutional frameworks to promote the development of science and technology. According to them, the responsibility of policy initiatives for the acquisition and procurement of science equipment rests with MDAs. The ministry supports the implementation of such policies through annual budgetary provisions.

4.2.2 Regional Scientific Equipment Policy

With regards to regional equipment policy, MESTI's response was that there was no specific regional science equipment policy but there were a few documents which one may consider relevant only in terms of their emphasis on scientific research. Examples are:

- ECOWAS STI policy
- AU plan of action 2007-2008 which stated that at least 1% of GDP of member countries should be set aside for research and development

Some key OAU/AU African science initiatives dates as far back as 1980 when the Lagos Plan of Action (LPA) was adopted with much attention given by African leaders to use of science and technology as tools for economic transformation. Other protocols such as the Abuja Treaty also came into effect with emphasis on science for development (AU-ARC, 2011). After the birth of the AU, the quest for technological invention and innovation deepened with a number of packages including the inauguration of a prize for inventions and innovations. This ambition also enabled the adoption of days set aside for both African Science Renaissance, and Commemoration of African Technology and Intellectual Property Rights. These attempts for development of science and technology led to the creation of the Department of Human Resources, Science and Technology of the AU and have since been the point of coordination of NEPAD's STI activities. Some additional significant steps of AU in recent years to propel science and technology include an annual conference of African Ministers of Science and Technology (AMCOST), the 2007 Addis Ababa declaration on R&D expenditure (1% of GDP of member countries), the Pan-African university and centres of excellence initiative, and a pan-African research competition programme (AU-ARC 2011).

A follow up to the AU Plan of Action is the ECOWAS STI Policy which was adopted in 2012 at the second conference of ECOWAS Ministers responsible for science and technology

in Cote d'Ivoire (ECOWAS, 2012). The policy titled "ECOWAS Policy on Science and Technology (ECOPOST)" after the adoption made some recommendations and action plans. These include creation of a Directorate for Science, Technology and Innovation because of the key role of these sectors for the socio-economic development of the region. It was as well recommended that the Commission creates a "one-stop for science and technology" in its Solidarity Fund to finance research and development in science and technology and to facilitate the provision of external funding for research. Further, commitment was made to develop national policies for STI, and above all to devote one percent of their GDP to finance STI, in accordance with the Addis Ababa Declaration.

4.2.3 Policies on Lifting or Minimizing Duty on Research Equipment

Data gathered from the Ministry of Finance show that according to the laws of Ghana, educational scientific equipment and research laboratory equipment are admitted under the exempt regimes. To control the abuse of the exemption policy, however, MDAs are mandated to apply for exemptions based on institutional needs. This is considered and the appropriate exemptions granted by Parliament. The law also allows for tax exemptions on donated educational scientific equipment. The universities and other agencies operating under the Ministry of Education confirmed at the Stakeholder Workshop on Enabling Scientific Policy in Accra that they have been taking advantage of the exemption policy. However, research institutes such as Animal Research Institute, Water Research Institute and FORIG, which do not operate under the Ministry of Education, stated that they could not benefit from the exemption policy and their experiences in requesting for exemption had been negative.

According to MESTI, there are no specific policies on lifting or minimizing duty on research equipment but there are guidelines for waiving tax on scientific equipment. However, the Ghana Revenue Authority has its own policies concerning duty minimization and exemptions on some scientific equipment and how to go about it to obtain these benefits. GAEC has benefited from exemption of duty on equipment supplied through IAEA projects. The institution secures exemption of duty on its behalf through the local UNDP office, since it is a tax-exempt international organization. Most of the equipment supplied by the IAEA is by direct purchase through a project.

4.2.4 Provision for Manufacture of Science Equipment

With regards to local manufacture of science equipment especially for schools, the responses from the majority (94.7%) of the institutions were negative. The response from IIR was however positive (5.3%); the institute has a programme that promotes the production of school science equipment and glassware. Other medical labs such as Korle-bu Teaching Hospital also benefits from the equipment. Examples of the equipment manufactured are test tubes, burettes, pipettes and beakers.

The School of Applied Science and Arts also stated that they support the promotion and manufacture of equipment as one of their research areas of the Science Lab Department. An example of a published article in this area is "Design and Construction of a Portable Wooden Box Electric Dehydrator (PWBED) and Comparative Performance Assessment to an Electric Laboratory Oven", published in *International Journal of Engineering Research & Technology* (Vol. 2, Issue 5, May 2013). The School of Engineering of Accra Polytechnic also plays a role in equipment repairs.

4.2.5 Replacement and Maintenance of Science Equipment

The response from all the institutions contacted (100%) showed that scientific equipment is not usually replaced unless there is an opportunity for new equipment acquisition. In other words, there is no particular timetable for replacing equipment. They are discarded when they become unusable. In case there is any need for maintenance of equipment, experts are called for that purpose. The Institute of Industrial Research (IIR) of the CSIR also plays a role by maintaining some equipment of some sister CSIR research institutes. The expenses incurred in the maintenance are borne by the institutes concerned.

There are planned maintenance schedules for some institutions but lack of logistics sometimes prevents them from being carried out. In FRI, there is a planned maintenance schedule of six months in which equipment are maintained through contract service at the Institute's cost. GMet also does maintenance using trained technicians at their own cost. The Institute has some management systems for maintaining scientific equipment. The engineering division carries out regular maintenance of equipment used. Faults are reported to the maintenance section and the head of the division obtains approval from the Chief Executive to carry out any repairs. Maintenance and procurement of equipment are usually budgeted for but funds are rarely made available to carry out these activities. There are trained technicians for installation and maintenance of most equipment but some require specialists from outside the country. Some institutions do not have trained technicians to carry out maintenance work and as a result agencies are contracted for that purpose. Faults are reported through the Head of the Division to the Director and the appropriate agencies are contracted for maintenance. As shown in Table 5, some institutions have their own maintenance agencies and others do not.

Table 5: Some institutions and maintenance agencies

Institution	Maintenance Agency
GSA	Uses the services of maintenance staff
CRI	IIR or a private individual
IIR	Uses the services of maintenance staff
OPRI	IIR
WRI	Scimed Instruments Ltd. F. Malawi MES Equipment Ltd.
Accra Polytechnic, School of Applied Science and Engineering	Have no maintenance agencies Uses the services of their maintenance staff
GAEC	Have no maintenance agencies Have built local capacity through international training to maintain and repair equipment
NMIMR	Have no maintenance Have built local capacity through international training to maintain and repair equipment
FORIG	MES Equipment, Accra CSIR-IIR High Tech Centre; KNUST

For example in OPRI, WRI and FORIG, there are agencies responsible for the maintenance of lab equipment. In some cases these agencies are the representatives of the manufacturing companies from where the equipment is sourced and maintenance is at the cost of the company. In FDA, the management system for maintenance is through preventive maintenance contractual agreements with agents of equipment manufacturers and this is done at the organization's cost. Usually there is no change of equipment until there is a breakdown.

In most of the institutions (84.2%), there is a component in the institutional budget (of government subvention[1]) for maintenance and procurement but the funds rarely come. Others have no budget that caters for maintenance and procurement of science equipment. In the private sector, especially medical laboratories, there is a line included in the lab's overall working budget for the maintenance of equipment. In WRI there is a management system for maintaining scientific equipment but it is currently not applicable. Part of the internally generated funds by the various divisions is used in procuring and maintaining the equipment. GAEC uses part of the institution's budget, from Internally Generated Funds (IGF), to maintain and procure necessary scientific equipment. The Institute does local maintenance with remote troubleshooting support from manufacturers and purchases faulty parts for replacement. Data gathered from FRI show that there is a budget for maintenance and procurement of scientific equipment.

4.2.6 Sharing, Standardizing and Calibration of Science Equipment

Some institutions known to carry out calibration exercises are the Ghana Standards Authority (GSA) and the Institute of Industrial Research (CSIR-IIR). The GSA is the national standards body mandated to undertake calibration, standardization, management system certification, testing services verification and inspection of weights and measures, and weighing and measuring instruments including scientific equipment. GSA is a member of both international and regional standardization bodies including International Standards Organisation (ISO) and African Organisation for Standardization, among others. Affiliation with these bodies has equipped them with capacity in standards harmonization, development and access to technical information relating to calibration and standardization (GSA, 2014).

The Metrology Section of the CSIR-IIR also offers calibration services to some institutions in the country. They also have the capability in various measurement areas such as electricity, pressure, temperature, mass and acoustics. It also facilitates interaction between the CSIR-IIR and industry, universities and other collaborators to help support Ghana's growth through cutting-edge technological development and application. To ensure maintenance of standards, IIR as well collaborates with GSA in their activities relating to metrology (CSIR-IIR, 2014). Many institutions contacted use the services of GSA in calibration and standardization. Others also use the services of IIR in calibration. Some institutions have their own technicians who calibrate and standardize some of their equipment as well as the manufacturers of the equipment also calibrate their own equipment.

[1] "Government subvention" refers to the budgetary disbursement coming from the government (Ministry of Finance) to public agencies to enable these agencies to perform their mandated tasks. The subvention generally covers salaries and wages, administrative expenses, R&D activities and capital investment. Due to the national economic constraints, subvention to most public institutions does not totally cover all the key areas of expenditure.

The Livestock and Poultry Research Centre (LIPREC) also shares equipment with the Animal Science Department and other scientists of the University of Ghana. The two departments all belong to the College of Agriculture and this makes it easier for them to share equipment. Food Research Institute and Soil Research Institute (SRI) as well share equipment with universities and other research organizations.

Calibration of equipment is also an important component of maintenance. Some institutions such as the Department of Nutrition and Food Science of University of Ghana engage the GSA to regularly calibrate its equipment. Table 6 shows other institutions which engage other agencies for calibration of equipment to ensure the effectiveness of usage. However, there are other institutions which do not have institutionalized calibration of their lab equipment. A science policy can address this lapse in some of the scientific institutions by providing guidelines for maintenance of equipment including calibration.

Table 6: Institutions with provisions for calibration and standardizing

Calibration and standardizing	Institution responsibility
GSA	GSA
IIR	IIR
School of Engineering, Accra Polytechnic	GSA
School of Applied Science and Arts, Accra Polytechnic	GSA
CRI	IIR, Chief Technicians
WRI	IIR
GAEC-Secondary Standards Dosimetry Laboratory (SSDL) for calibration of radiation and measuring instrument	GAEC
NMIMR	GSA, NMIMR
FRI	No provision
FORIG	GSA Retired Chief Technician
GMet	No provision
OPRI	IIR
WRI	IIR
GMet	No provision
G-2	Technicians and agents of manufacturers
Department of Chemistry, UG	Ecolab University of Ghana and GSA
Department of Animal Biology and Conservation Science, UG	Technical staff
Department of Nutrition and Food Science, UG	GSA

4.2.7 Mass Media and Organisations

Organizations do have linkages with the mass media especially when they have a particular interest in the subject of the scientific activity. The Ministry of Finance engages the media in its policy dissemination and education efforts. Paramount of all is the dissemination of the annual National Budget and Economic Policy of Government which is a statement of revenue mobilisation and expenditure allocations to various sectors of the economy, including that for scientific equipment. Virtually all the institutions contacted (100%) engage the mass media in one way or the other.

The mass media assist agencies such as GMet to disseminate its public weather information through TV and radio broadcasts. The Ghana News Agency also circulates seasonal

forecasts, when released, to media houses to be publicized. The Food and Drug Authority also links with the media through consumer alert publications. Some institutions, however, have partial linkages with the media. OPRI held radio discussions on coconut cultivation on farms. CRI interacted with the media for the promotion of scientific knowledge and products. The FRI has links with the mass media through the dissemination of research findings. FORIG also organizes radio talk shows, mostly to discuss forest science and environmental issues and invitations to international conferences and seminars.

CSIR-WRI regularly invites the media to their seminar presentations who in turn publish them in the newspapers. GAEC normally invites the mass media for their programmes. The Institute also advises clients on suitable equipment for use, e.g., radiation protection instruments for use in hospitals, research for industry, and X-ray machines for use in hospitals.

Medical Laboratories has links with the mass media in carrying out specific programs on radio concerning health care. LIPREC has linkages with the media through Radio Universe and the Public Affairs Directorate of the University of Ghana which make public their concerns and findings.

With regards to the potential of the mass media to influence science equipment policy change, some of the institutions were optimistic (57.9%). The mass media as a partner in development can, through its documentaries, newspaper articles and radio, express the potential benefits of science for economic and human development. This can set the tone for discussions for policy change in favour of science and the use of scientific equipment to promote production, growth and development. The mass media has the potential to popularize technology and transfer. The mass media can influence science equipment policy change if the awareness is created among media professionals for them to understand and appreciate the need to do so. Others stated that the mass media has no particular influence on science equipment policy change, unless the scientific institutions together with their sector ministry and the Ministry of Education influence science equipment policy change.

4.2.8 Scientific Equipment Policy Precedents in Other Sectors

Ghana has a number of sectoral policies formulated to drive their development. These policies may be considered as precedents to scientific equipment policies in that they define the directions of the use of the equipment. For example:

- Agriculture: Food and Agriculture Sector Development Policy (FASDEP)
- Industry: Industrial Policy
- ICT: National ICT Policy

According to the Ministry of Finance, the Agriculture, Health and Education sectors are generally exempt sectors for the payment of duties on imported scientific equipment. Hence specific items imported for the development of these sectors are cleared under exempt regimes.

4.3 Input of Science

4.3.1 Manpower for Scientific Equipment

The study showed that all the institutions (100%) had scientists and technicians who use scientific equipment in their work. Notwithstanding, the manpower for scientific equipment in some institutions is limited. These institutions did not have the technical expertise for the maintenance and repair of their scientific equipment. Table 7 shows the institutional staff strength and the number trained on scientific skills/use of scientific equipment.

Table 7: Institutional staff strength and the number trained on scientific skills/use of scientific equipment

Institution	Total staff strength	Number trained on scientific skills and use of scientific equipment
ARI Lab	8	2
GMet	466	350
OPRI	633	20
CRI	760	40
WRI	247	148
SRI	312	45
NMIMR	400	200
IIR	120	43
GAEC	83	61
G-2 Medical Laboratories	24	18
School of Applied Science, Accra Polytechnic	26	26
School of Engineering, Accra Polytechnic	93	85
LIPREC	134	32
FORIG	281	243
FRI	40	23
Department of Chemistry, UG	45	10
Department of Nutrition and Food Science, UG	23	7
Department of Animal Biology and Conservation Science, UG	41	6
FDA Lab	45	45

4.3.2 Scientific Staff Turnover

Scientific staff turnover ranged from low to very high. The reasons are due to poor conditions of service, inadequate equipment and lack of training opportunities. Some staff turnover is a

result of compulsory retirement, inefficiency, indiscipline and appointment with foreign and local institutions. Some public institutions that have recorded low turnover were attributed to the introduction of the Single Spine Salary Pay Policy which has improved salaries in the public sector. The School of Engineering of Accra Polytechnic alluded to this fact. The turnover of some institutions is a result of further education. Whatever the cause of the turnover of scientific staff, it affects the use of scientific equipment in the institutions.

4.3.3 Outputs of Scientific Institutions

The study provided highlights of outputs from the scientific institutions, mainly in line with their mandates. For example, the Animal Research Institute is a backbone of the feed industry in Ghana. It provides formulations and know-how to the Poultry Farmers Associations, Feed Milling Companies, commercial poultry farms, private farms, the Animal Production Directorate of MoFA, and others. The Crops Research Institute also develops high yielding crop varieties resistant to pests and disease and other desirable traits as well as good agricultural practices and technologies for farmers, processors and other end-users. The Water Research Institute provides data on water resources (ground and surface water), water quality for industries, water technologies, contribution to pollution prevention, and protection and conservation of water resources in Ghana. The Soil Research Institute also focuses on the development and promotion of soil management technologies for sustainable agriculture, industry and environmental sanity in Ghana.

Apart from these primarily agricultural research institutes, there is the Ghana Atomic Energy Commission with outputs in other areas. The Commission authorizes the possession and use of radiation sources and irradiating devices within practices, conducts regulatory inspections and safety assessment for the purposes of authorization and enforcement of the requirements of the LI 1559 of 1993, and promotes human resources development in radiation protection and safety by providing training of regulatory staff and organizing courses for registrants and licensees. GAEC carries out relevant research to enhance protection of workers, patients, the public and the environment from the harmful effects of ionizing radiation sources.

FORIG develops technologies for the management of natural forests and plantations as well as policy interventions to guide the national discourse with respect to forests and forest resources management. It also provides technical training and capacity development for artisans in the wood industry, graduate and post-graduate training in natural resources management, and training in forest nursery development to support the national afforestation and reforestation programmes. FORIG carries out the rehabilitation of degraded forests and mined sites and provides solutions to forest health issues in plantations development. There is also the promotion of lesser-used timber species in the timber industry, value-addition to the timber resources, and research publications in the form of peer-reviewed journal articles, edited technical reports, conference papers, books, book chapters, monographs, fliers and policy briefs to aid sustainable forest management.

The study also highlights outputs from other institutions such as the GMet which provides weather forecasts, climactic data and information to those who need them. Accra Polytechnic also produces graduates in the technical disciplines of engineering. There are also industrial products by the Polytechnic which comprises winches, welding products, machine products (shaft and gears) and building blocks among others.

4.3.4 Current Research Priorities

The institutions underscored the importance of research (89.5%) to enable them to achieve their organizational goals. These institutions and their research priorities are below.

Ministry of Finance
- Impact assessment of economic policies including, e.g., taxation, trade policies, and poverty reduction strategies

Ghana Meteorological Agency (GMet)
- Occurrences of dry spells during the rainy season in northern Ghana
- Improving seasonal forecasting in Ghana

Oil Palm Research Institute (OPRI)
- Breeding and production of high yielding planting materials, tolerant to diseases, pests, drought and of longer exploitation life
- Development of sustainable agro-management and cultural practices to ensure optimum production of the crop
- Development of land use efficiency and intensification strategies through farming and crop systems research, involving intercropping with cash and food crops and the integration of small ruminants (sheep) in oil palm and coconut plantations
- Development of ecologically sustainable pest and disease management strategies
- Development of high value products for improved livelihood of coconut farmers
- Training of trainers and farmers to ensure increased production and enhanced income levels of farmers, towards rural poverty alleviation and an improvement in the standard of living of farmers
- Commercialization of the research results (intellectual property)

Crop Research Institute (CRI)
- Development of crop varieties for food and industrial uses
- Priority crops are roots and tubers, cereals, vegetables and fruits
- Development of improved management technologies to enhance productivity of crops on farmers' fields

Water Research Institute (WRI)
- Pollution prevention, protection and conservation of water resources in Ghana.

Soil Research Institute (SRI)
- Development of climate change adaptation technologies for sustainable soil management
- Development of integrated soil fertility management technologies
- Promotion of conservation agriculture options for soil management

Noguchi Memorial Institute into Medical Research (NMIMR)
- Researching to find a way to eradicate malaria in Ghana
- Train more research scientists in various fields of public health

Ghana Atomic Energy Commission (GAEC)
- Occupational exposure control in medical, industrial, research and teaching
- Medical exposure control in diagnostic radiology and radiotherapy

- Public exposure to radioactivity in environment and waste management
- Exposure to non-ionizing radiation from mobile phones and base stations

Forestry Research Institute of Ghana (FORIG)
The priority areas, by Research Programme and Division, are as follows.

- Forestry and Wildlife Programme

Forest and Wildlife Management Division (FWMD)
- Resource assessment and harvesting
- Utilization, conservation and wildlife management

- Forests, Livelihood and Governance Division (FLGD)
  - Rural livelihoods, benefit sharing, poverty reduction
  - Policy and institutional framework for natural resources management
  - Pluralism and governance of natural resources
  - Agroforestry
- Forest Products and Trade Programme

Forest Industry Development Division (FIDD)
- Efficient processing and utilization of timber
- Forest sector investment

- Forest Products, Trade and Marketing Division (FPTMD)
  - Sustainable trade in forest resources
  - Development and marketing of NTFPs
  - Bio-energy
- Environment, Biodiversity and Land-Use

Ecosystem Services and Climate Change Division (ESCCD)
- Stream flow and soil productivity
- Ecosystems health and vitality
- Mechanisms for harnessing environmental services
- Mitigation and adaptation of climate change

Biodiversity and Land-Use Division (BLUD)
- Biodiversity conservation and management
- Landscape restoration and rehabilitation of degraded lands

Livestock and Poultry Research Centre (LIPREC)
- Conservation of indigenous Ghanaian animal genetic resources
- Availability, feeding value and utilization of browse forages and crop residues by small ruminants
- Monitoring and evaluation of range resources using geomatics
- Dry season feeding of ruminants
- Agribusiness and systems innovation

School of Engineering, Accra Polytechnic
- Working together with MPTECH in the construction of solar panel and other construction activities

School of Applied Science, Accra Polytechnic
- Promotion and manufacture of equipment, e.g., design and construction of a Portable Wooden Box Electric Dehydrator (PWBED)

Institute of Industrial Research (CSIR-IIR)
- Use of agriculture waste to generate biogas
- Substainable energy (e.g., solar, wind)
- Extraction of active ingredients in herbal plants for export
- Energy efficiency of electrical equipment and cook stoves

Department of Chemistry, University of Ghana
- Projects in medicinal chemistry, natural products
- Solid state and molecular structures, structure and function correlation of bioactive compounds

4.3.5 Inventory of Available/Unavailable Science Equipment

The following are examples of the equipment available and that which is urgently needed in selected institutions:

Ghana Meteorological Agency
Equipment available includes:
- 50 automatic weather stations (AWS)
- 1 automatic weather observing system (AWOS)
- 1 weather radar

Equipment urgently needed:
- 250 fully automated weather stations
- 4 automatic weather observing system (AWOS)
- 2 weather radar
- 1 radiosonde equipment
- 10 lightning detectors
- 5 wind profilers
- Communication infrastructure to store, transmit and receive weather data and information

Water Research Institute
Equipment available includes:
- Atomic Absorption Spectrophotometer (AAS)
- Gas Chromatograph-Mass Spectrometer (GC-MS)
- UV Spectrophotometer
- Ion Chromatograph (IC)

Equipment urgently needed:
- Inductively-Coupled Plasma Mass Spectrometer (ICP-MS)
- High Performance Liquid Chromatography (HPLC)

Department of Chemistry, University of Ghana
Equipment available is:
- X-ray diffractometer for single crystal
- NMR (yet to be installed)
- Rotary evaporators
- Soxhlets

Equipment needed but unavailable:

- Double beam UV spectrophotometer
- Atomic Absorption Spectrophotometer
- Flame photometer
- PH meters (with space electrodes) combined electrode
- Conductivity meters
- Abbe refractometers
- Infrared Spectrophotometer (FTIR)
- Mass spectrophotometer
- HPLC (High Performance Liquid Chromatography)
- Gas Chromatography (GC)
- Ion Chromatography

Food and Drugs Authority
Equipment available is:
- HPLC, UV/VIS spectrophotometer, AAS, FTIR spectrophotometer, GC, GC-MS

4.4 Challenges

The study shows that Ghana's scientific institutions are grappling with several challenges. Highlights include:

- Inadequate funds to budget for scientific equipment
- Bureaucracy and delays in provision of tax exemption on duty of research equipment, resulting in some institutions paying for duty even though they qualify
- Inadequate logistics
- Obsolete scientific equipment which do not provide reliable results
- Inadequate training of scientific staff on use of scientific equipment, and high rates of staff turnover
- Almost no or little local content in scientific equipment because there are no local manufacturers of scientific equipment, especially for schools
- Public procurement through tendering is not good for precision equipment
- Bureaucracy in signing preventive maintenance contractual agreement because of sole-sourcing issues
- Delay in paying contract sum when budgeting for maintenance

The study realized that inadequate funds to budget for science equipment were one of the major challenges. In the state institutions, for instance, the budget for equipment is usually delayed and sometimes is not provided for years. This also has a ripple effect on the replacement and maintenance regimes of equipment with some equipment more likely to be out of use. When equipment is out of order or obsolete, it certainly may not provide reliable results. The panacea to these predicaments was the submission of proposals and working through partnership projects with donor agencies for support in the provision of equipment. This was confirmed by some of the institutions. They got opportunities for new equipment through projects and stakeholder support. Inadequate funds also posed logistical challenges which negatively affects planned maintenance schedules.

Another challenge was bureaucracy in clearing of equipment for state institutions which applied for tax exemption through the ministries. In Ghana, state institutions have to apply for tax exemption from the ministries before they can clear equipment from the ports. To

avoid paying tax, a permit is obtained from the ministries and attached to the bill of laden for submission to the Ghana Supply Company Limited (GSCL) to clear the equipment on behalf of the institution without paying tax. Delay, therefore, demands that the institution wait which negatively affects their work, especially on time-bound projects. The bureaucratic processes and delays therefore compel some institutions to pay the required duty as everybody else.

In terms of manpower for scientific equipment, there are scientists who are trained on the operation and maintenance of scientific equipment, however they were limited. Some installation and maintenance of equipment required expertise outside the country. The limited manpower in the institutions was due to poor conditions of service, appointment with foreign and local institutions, and inadequate training opportunities for scientists to handle equipment among others.

Among all the institutions contacted only one of them manufactures equipment for schools and some medical labs locally. Local content in the manufacture of scientific equipment is therefore not encouraging. This has implications for sustainability in the maintenance and use of equipment. Local manufacturing capacity also provides opportunities for maintenance of equipment and even for innovation.

It was claimed that public procurement through tendering is not good for procuring precision scientific equipment. The explanation was that in public procurement, brand quotation is not allowed but only specifications of the type of equipment are allowed. For example, when procuring for analytical balance, one cannot request for Mettler Toledo Analytical Balance (a brand). It is the specifications that are needed. For instance, a technical specification for a balance could be a capacity up to 320-g and readability of 0.01-mg/0.1-mg without the brand name given at procurement. Generally going by technical specification is not so much of a problem once the decision is made primarily on the technical superiority of the equipment. However, sometimes technical quality is sacrificed for price. Many times the decision on purchase is made on the basis of the tenders with the lowest quotations. Moreover, the businessman is a non-technical person who might not know much about science equipment. According to the study, this challenge could be solved when procurement is done through sole-sourcing. It was however labelled to be bureaucratic in the country. The bureaucracy involves justification and seeking approval from Public Procurement Authority (PPA). It is then sent to the Presidency for approval again. If the sole-sourcing quotation is in US dollars, an approval has to be obtained from the Ministry of Finance to transfer foreign currency. As a result of this bureaucracy and delays, one is forced to go by public tendering since it is contractual and time-bound for delivery though the services might not be satisfactory.

The bureaucracy that is associated with sole-sourcing is the same when it comes to signing preventive maintenance contractual agreements. Maintenance is also a service which has to go through the normal tendering. However, because of sole-sourcing issues, it has to go through justification and seeking approval from PPA and the Presidency. Finally, delay in paying contract sum when budgeting for maintenance was as well considered a challenge. Sometimes, the institutions do not have the money to pay especially when they have to pay from their own internally generated funds.

5. Conclusions and Recommendations

Ghana has built a fairly solid science and technology system to facilitate national development. In particular, the institutional framework for research and development has been structured over the years. Appropriate technical scientific institutions have been established such as the CSIR and GAEC. These institutions have scientific equipment in their laboratories to undertake their required activities. However, there are several cases where additional equipment is required. The challenges surrounding the acquisition and use of scientific equipment make it difficult for the realization of the dream of facilitating national development through STI application. This must be a national priority.

To be able to achieve the goals and objectives of the National STI Policy and realize socioeconomic development through science in Ghana, it is recommended, among other things, to:

- Provide adequate funding for science research equipment acquisition and maintenance. Funding will enable institutions to replace and maintain equipment so as to provide reliable results and improve efficiency. This together with equipment support from partnership projects will help improve the working conditions of scientists in the country and enable them to deliver on their mandates. When the issue of funding is solved, it will help reduce the effects posed by inadequate logistics on planned maintenance schedules.

- Ensure the effective implementation of the exemption policy regarding taxes and duties on scientific equipment; there must be curtailing of bureaucracies and delays in the clearance of scientific equipment from the ports. This could be achieved by ensuring effective coordination between the Ministries, Departments and Agencies with regards to equipment procured from outside the country for the public sector.

- Train scientific staff in scientific skills and use of scientific equipment, and incentivise staff retention. Building capacity in this direction will ensure that experts required for equipment installation, operation, qualification and maintenance are obtained within the country. This will in the long run reduce the high foreign capital needed to train scientists outside the country. Inadequate training opportunities were part of the reasons for scientific staff turnover. Provision of training opportunities will therefore help in scientific staff retention.

- Encourage local production of quality laboratory research equipment especially for schools. The study realized that only one institution manufactures scientific equipment for schools and some medical laboratories. This is insufficient especially relating it to the national drive for socio-economic development through STI. Encouraging local production of equipment will also provide an opportunity for maintenance of equipment and even for innovation.

- Curtailing the bureaucracies associated with sole-sourcing will encourage its greater and more effective use. According to the study, there are some advantages associated with sole-sourcing. The institution after procuring the equipment benefits from installation, qualification and training from the manufacturer or their agents. Also, if the institution is a regular customer of the manufacturer the

institution could get a discount and sign maintenance agreements with them. However, with the normal tendering, after the businessman has delivered the equipment, the institution has to contract the services of an expert somewhere to do the installation. Meanwhile, the expert might not have the expertise in the same field of equipment to work on. The resulting effect might be a trial and error on the equipment which could be damaging. It is therefore important that known credible technical agencies be engaged to supply or maintain scientific equipment within the framework of the law.

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Appendix 1 Scientific Equipment Policy Study – Interview Guide

1. Interview Guide for Scientific Institutions

A. General information

Name of institution
Location
Name of respondent
Contact Number/email address

B. Procurement of scientific equipment

1. How do you procure scientific research equipment? What process do you go through to obtain them?
2. Any agency responsible for supplying scientific equipment?
3. Who are the manufacturers of your equipment? (Companies, Country of Origin)
4. Is there any process that simplifies the acquisition and clearance of equipment?
5. Does your organization buy the equipment outright or they are provided by the state or donated?
6. If the equipment is donated, who are the donors? (Donor agencies, Country of Origin)
7. How often do you change and maintain your equipment?
8. Any agency responsible for maintaining your equipment? At what/who's cost?
9. Do you have any provisions for sharing, standardizing and calibrating equipment?
10. Do you have any provision that promotes the manufacture and production of equipment especially for schools locally?

C. Case studies of institutions at national and regional levels

11. What is the management system for maintaining scientific equipment in your institution/organization?
12. Is there any component in the institutional budget for maintaining and procuring scientific equipment?
13. Is there manpower for scientific equipment? (e.g. technicians)
14. What is the role of your organization to ensure supply of science equipment in the country/sub region/region?
15. Does your organisation have any linkage with the mass media and in what form?
16. Do the mass media have any potential to influence science equipment policy change?

D. Input of science (human resources, tangible assets and organizational skills)

17. What is your total staff strength?
18. How many are trained on scientific skills and use of scientific equipment?
19. What is the frequency of the scientific staff turnover in your organization? Any reason(s)?
20. Kindly provide an inventory of equipment available and those not available but urgently needed in your operations.
21. What are the resultant outputs of your institution from the tangible assets and the human resources?
22. Do you know of any existing national frameworks for scientific equipment policy development and change? What are these national frameworks?
23. Do you have any current research priorities? What are these priorities?

2. Interview Guide for Ministries

A. General information
Name of institution
Name of respondent
Contact Number/email address

B. Case studies of institutions at national and regional levels

1. Is there any component in the national/institutional budget for maintaining and procuring scientific equipment?
2. What is the role of your organization to ensure supply of science equipment in the country/sub region/region? (Question to sector ministry e.g. MESTI, Education, Finance and AU Commission).
3. Are there policies that enable the acquisition, procurement of science equipment in your organization/national/regional? What are these policies?
4. What is the status of current national policies, guidelines and legislation concerning scientific equipment?
5. Do you know of any existing national frameworks for scientific equipment policy development and change? What are these national frameworks?
6. Does your organisation have any linkage with the mass media and in what form?
7. Do the mass media have any potential to influence science equipment policy change?
8. Are you aware of any regional science equipment policy? (e.g., African Union Commission, ECOWAS)
9. Are there policies on lifting or minimizing duty on research equipment especially donated items?
10. Are there scientific equipment policy precedents in other sectors? (e.g. agriculture, industry).
11. Do you have any current research priorities? What are these priorities?

Appendix 2 Contact Persons and Organisations/Institutions

Name	Organisation/Institution	Contact
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