National Commission for Science and Technology

State of Science and Technology in Malawi 2010-2011

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Contents

List of Tables

List of Figures

Foreword

Professor Sosten S. Chiotha
Chairperson, National Commission for Science and Technology

Malawi has a long term vision of becoming a middle income country with a technology driven economy by 2020. The Malawi Growth and Development Strategy confirms that education, science and technology are some of the major catalysts for socio-economic development. Further developments in virtually all sectors of the economy will require highly skilled and educated workforce and the application of science and technologies. A robust science, technology and innovation environment can be a key catalyst of sustained economic growth rates when properly harnessed and nurtured. According to the World Bank Policy Research Working Paper (Number 3026, April 2003), the world is experiencing unprecedented rapid pace of advancement of scientific knowledge which is not only creating new opportunities but also threats to development. The research paper argues that most developing countries are largely unprepared to deal with the changes that Science and Technology (S&T) advancement will bring. For example, in Malawi, the transition to digital photography threatens business for classical traditional photographic studios but at the same time the digital technology has created many more new business opportunities of increased access, efficiency and range of products to choose from. Similarly, the introduction of improved maize seed varieties in Malawi provided greater promise for food security because of the high yielding potential however; adoption was slow at the beginning because of the vulnerability to insect pests and poor processing qualities of the improved maize varieties. It was therefore, pleasing to learn that scientists at Chitedze Agricultural Research Station, in Lilongwe, had responded to the community needs and challenges with a new improved maize seed popularly known at the time as 'Chokonoka.' The results guided scientists involved in seed breeding programs to take into consideration the preferences of the farmers, and through research link science and technology in finding better solutions.

It is, therefore, clear that the demand for development that is built on sound science and driven by affordable and accessible technology needs to transcend the major traditional economic sectors of the economy, namely, agriculture, natural resources (Forestry, Fisheries, Mining) and others. However since, Malawi has a large rural population that directly depends on natural resources for livelihoods, the declining natural resource base as reported in the 2010 Malawi State of Environment and Outlook Report is a cause for concern.

To achieve sustained economic growth, the country needs to support the traditional economic sectors cited above with science and technology and to stimulate new enterprise opportunities through the private sector. The fact that Malawi has a youthful population is an opportunity for the country to embrace the culture of science and technology to greater heights as long as the population at large and the youth in particular are given adequate and lifelong opportunities for education and training through formal, non-formal and informal avenues. The right policy framework mix and an enabling investment climate that integrate science and technology to drive development will pay dividends in addressing not only poverty but also in improving well-being.

It is, therefore, my pleasure and honour to introduce the first State of Science and Technology Report not only to provide information but also, more importantly, to promote solution oriented approaches. Malawi needs to take advantage of many positive outcomes from advances in science and technology and to minimise any negative impacts. The positive outcomes include allocation of the largest share (over 20%) of the national budget to education and the fact that Government has carried out a number of reforms aimed at improving research and development and the application of science technology. Such notable reforms include the establishment of the National Commission for Science and Technology as an apex body in all matters of research, science and technology; the review of the National Science, Technology and Innovation Policy; and development of the National Intellectual Property Policy. However, there is also need for the public and private sector to move towards greater financial support for local Research and Development for home grown solutions to local development needs while supporting high value export oriented enterprises.

I would like to conclude by emphasizing the commitment of the National Commission for Science and Technology to use the State of Science and Technology Report as a tool for continuously tracking Science, Technology and Innovation (STI) performance in all the key developmental sectors and measuring its contribution to the national economy. The National Commission for Science and Technology will endeavour to identify and develop new indicators and to produce the State of Science and Technology Report every two years. This being the first report of its kind in this country, I wish, on behalf of the National Commission for Science and Technology Board, to thank the staff and professionals from various sectors whose contributions have made it possible for this report to be produced. The Commission welcomes feedback on gaps and any areas requiring improvement in subsequent reports.

Preface

Dr. Daniel Jamu
Chairperson of the Scientific and Awards Committee,
National Commission for Science and Technology

The State of Science and Technology Report is produced biennially by the National Commission for Science and Technology (NCST), the 2010-2011 report being the first one. The report gives the status of science and technology (S&T) indicators in various sectors of the economy. The main purpose of the Report is to ensure that the political establishment is aware of the role of science and technology in socio-economic development with the view of enhancing government commitment to, and provision of adequate resources for the development and application of science and technology. This is premised on the realisation that in order to make informed decisions, governments need reliable and precise data on S&T. The Report is also intended to serve as reference material on S&T by policy makers, government officials, especially those in the ministries of Finance and Economic Planning, Members of Parliament, researchers, technologists, academicians, multilateral organisations, cooperating partners and members of the general public.

To produce the report both primary and secondary data sources were used. Primary data was collected through a questionnaire survey. Secondary data was collected using tailor-made data collection forms from official records maintained by institutions and through desk reviews, literature and internet searches. The report comes in two volumes. Volume one is a companion report to the main report. It brings out major issues that either propel or retard the development and application of science and technology in the country. It also analyses how S&T is intertwined with other sectors within a national system of innovation. Volume two is the main report with thirteen chapters. Chapter 1 gives an introduction to the development of S&T in the country from the time it attained political independence in 1964 to 2011. The chapter also highlights national economic and demographic attributes and describes in detail how science and technology is governed in the country. It also indicates the aims and objectives of the report and ends by describing the methodology used in collecting data and approach used in preparing the report. Chapters 2 to 12 discuss the role or contribution of S&T in a particular sector, programs being implemented, and status of S&T indicators, challenges and interventions in the sector.

Writing of the report was quite an experience and a challenge at the same time, being the first of its kind to be prepared in Malawi. From data collection to printing it took almost a year. The major challenge was data collection. Most often respondents either took too long to return filled questionnaires/data collection forms or provided incomplete data sets. The actual writing of the chapters was quite swift. It took between a week and two months for authors to submit chapters. Review took two weeks and editing took another two weeks.

The problems encountered during data collection are a reflection of the prevailing institutional weaknesses in monitoring and evaluation, data management, and management information systems in general. Deliberate effort needs to be made both at national and institutional levels to build capacity in the aforementioned areas for the ease of tracking indicators to generate accurate information critical for informing policy decision-making and programme formulation. Although it took long to produce the report, it is pleasing that the report still came out – they say, "Better late than never". I have no doubt that, from the lessons learnt, the next report will be produced in half or less than half the time it took to produce the first report.

Acknowledgements

Mr Anthony Muyepa

Director General, National Commission for Science and Technology

The 2010/2011 State of Science and Technology Report was produced through a highly consultative process involving workshops, field trips, on-line reviews and one-to-one meetings. Representatives of all key science and technology institutions in the country participated in the data collection and report writing exercise. This was done under the leadership of the former Director General, Dr Henderson Chimoyo.

I, on behalf of the National Commission for Science and Technology, wish to recognize efforts by Ms Angela Msosa and Mr C. Mtengula of the National Statistical Office (NSO) for technical advice in designing data collection tools. Above all, I am deeply grateful to those who found time to fill and return the data collection forms for without their cooperation the entire exercise would have been futile.

The Commission is also indebted to all those who contributed to the drafting of the chapters and Independent Expert Reviewers, namely Mrs Margaret Ngwira, Dr. Christopher Guta, Prof. John Saka, Dr. Damson Kathyola and Dr. Ibrahim Phiri. The Reviewers greatly enriched the report and improved its quality. Prof. John Saka and Dr. Chistopher Guta deserve extra commendation for going an extra mile in editing the Consolidated State of Science and Technology Report and transforming it into a publishable manuscript.

The efforts of a good number of NCST staff members who participated in the compilation, review and production of the report are recognized. The oversight role of the NCST Board and Scientific and Awards Committee also deserves special mention.

Last but not least, I greatly appreciate efforts of the core team that was charged with coordination of the entire process comprising **Messrs** Alick Manda, Kondwani Gondwe and Frade Nyondo of the Planning Directorate of the National Commission for Science and Technology (NCST).

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Abbreviations and Acronyms

AIDS	Acquired Immune Deficiency Syndrome
AMIS	Agriculture Marketing Information System
APES	Agriculture Production Estimates Surveys
ARDEP	Agricultural Research and Development Programme
ARET	Agricultural Research and Extension Trust
ARIPO	African Regional Industrial Property Organisation
ART	Anti Retroviral Therapy
ATCC	Agricultural Technology Clearing Committee
AU	African Union
BARREM	Barrier Removal to Renewable Energy in Malawi
BERL	Bio Energy Resources Limited
BGR	Federal Institute of Geosciences of Germany
BOT	Build, Operate and Transfer
Bt	Bacillus thuringiensis
CARP	Community Action Research Project
CASTAFRICA	Conference of Cabinet Ministers responsible for the Application of Science and Technology to Development in Africa
CGIAR	Consultative Group on International Agricultural Research
CHAM	Christian Health Association of Malawi
CIAT	International Centre for Tropical Agriculture
CIFOR	Centre for International Forestry Research
CODL	Centre for Open and Distance Learning
COM	College of Medicine
COMESA	Common Market for Eastern and Southern Africa
COMREC	College of Medicine Research and Ethics Committee
COSOMA	Copyright Society of Malawi
CSI	Child Status Index
CUNUMA	Catholic University of Malawi
CVL	Central Veterinary Laboratory
DALYS	Disability adjusted life years
DARS	Department of Agricultural Research Services
DFID	Department for International Development
DHIS	District Health Information Software
DHS	Demographic and Health Survey
DoCC&MS	Department of Climate Change and Meteorological Services
DST	Department of Science and Technology
EEPG	Environmental Energy for pro-Poor Growth
EEST	Estate Extension Service Trust
EHIS	Electronic Health Information Systems
EIA	Environmental Impact Assessment
EID	Early Infant Diagnosis
EMIS	Education Management Information System
EMRS	Electronic Medical Records System
ENM	Enrolled Nurse Midwife
EORs	Environment Outlook Reports

ESCOM	Electricity Supply Corporation of Malawi
EU	European Union
FAAC	Finance, Audit and Administration Committee
GDP	Gross Domestic Product
GIS	Geographic Information System
GM	Genetically Modified
GNI	Gross National Income
GOM	Government of Malawi
GPS	Global Positioning System
GSD	Geological Survey Department
HIV	Human Immuno-deficiency Virus
HMIS	Health Management Information System
HSSP	Health Sector Strategic Plan
HSAs	Health Surveillance Assistants
HTSS	Health Technical Support Service
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICT	Information and Communication Technologies
IFPRI	International Food Policy Research Institute
IITA	International Institute for Tropical Agriculture
IP	Intellectual Property
IPRs	Intellectual Property Rights
IRLARD	Irrigation, Rural Livelihoods and Agricultural Development
IT	Information Technology
ITU	International Telecommunication Union
JICA	Japan International Cooperation Agency
JOGMEC	Japan Oil, Gas and Metals National Corporation
KCN	Kamuzu College of Nursing
KPI	Key Performance Indicators
LDCs	Least Developed Countries
LUANAR	Lilongwe University of Agriculture and Natural Resources
MACRA	Malawi Communication Regulatory Authority
MALICO	Malawi Library and Information Consortium
MAREN	Malawi National Research and Education Network
MCM	Medical Council of Malawi
MDGs	Millennium Development Goals
MEET	Malawi Environmental Endowment Trust
MEPD	Ministry of Economic Planning and Development
MGDSII	Malawi Growth and Development Strategy II
MIPO	Malawi Intellectual Property Office
MIRTDC	Malawi Industrial Research and Technology Development Centre
MISPA	Malawi Internet Service Providers Association
MoAFS	Ministry of Agriculture and Food Security
MoEST	Ministry of Education, Science and Technology
mHealth	Mobile Health
MoH	Ministry of Health
MoIT	Ministry of Industry and Trade

MTL	Malawi Telecommunication Limited
MuREA	Mulanje Renewable Energy Agency
MUST	Malawi University of Science and Technology
MZUNI	Mzuzu University
NAPA	National Adaptation Programmes of Action
NASFAM	National Smallholder Farmer's Association of Malawi
NCIC	National Construction Industry Council
NCST	National Commission for Science and Technology
NEPAD	New Partnership for Africa's Development
NESP	National Education Sector Plan
NGO	Non Governmental Organisation
NHBGM	National Herbarium and Botanic Gardens of Malawi
NHSRC	National Health Sciences Research Committee
NICTWG	National ICT Working Group
NMCM	Nurses and Midwives Council of Malawi
NMT	Nurse Midwife Technician
NPO	Not for Profit Organisation
NRCM	National Research Council of Malawi
NSO	National Statistical Office
NSTIIF	National Science, Technology and Innovation Indicators Framework
ODL	Open and Distance Learning
OECD	Organisation for Economic Co-operation and Development
OPC	Office of President and Cabinet
PAESP	Promotion of Alternative Energy Sources Project
PEI	Poverty and Environmental Initiative
PGMs	Platinum Group Metals
PIAD	Presidential Initiative on Aquaculture Development
PPP	Public Private Partnership
PVHO	Plant Vehicle Hire Organisation
QECH	Queen Elizabeth Central Hospital
R&D	Research and Experimental Development
RA	Roads Authority
RCIPMW	Regional Connectivity Infrastructure Project - Malawi
REE	Rare Earth Elements
S&T	Science and Technology
SAC	Scientific and Awards Committee
SADC	Southern Africa Development Community
SEBAP	Strengthening Evidence Based Agriculture Policy Project
SMS	Short Message Service
STI	Science, Technology and Innovation
SUCOMA	Sugar Company of Malawi
SWAp	Sector Wide Approach
TAMA	Tobacco Association of Malawi
TEAM	Tobacco Exporters Association of Malawi
TLC	Total Land Care
TNM	Telecom Networks Malawi

TRFCA	Tea Research Foundation of Central Africa
TRIM	Tobacco Research Institute of Malawi
TRIPS	Trade Related Aspects of Intellectual Property Rights
UNDP	United Nations Development Program
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations Children's Emergency Fund
UNILIA	University of Livingstonia
UNIMA	University of Malawi
USA	United States of America
USAID	United States Agency for International Development
VSAT	Very Small Aperture Terminal
WASH	Water, Sanitation and Hygiene
WCT	WIPO Cooperation Treaty
WETHAB	Water, Energy, Transport, Health, Agriculture and Biodiversity
WIPO	World Intellectual Property Organisation
WTIM	World Telecommunication/ICT Indicators Meeting
WMO	World Meteorological Organisation
WPPT	WIPO Performances and Phonograms Treaty

Executive Summary

The National Commission for Science and Technology (NCST) has a legal obligation to produce the State of Science and Technology Report every 2 years for presentation in the National Assembly. The 2010 – 2011 Report is the first since NCST started operating in 2010. This Report is therefore a baseline against which progress in the science and technology sector will be measured or compared in future. The Report has 12 chapters highlighted below:

Chapter 1 gives an introduction to and background of the Report. It highlights the role of science, technology and innovation (STI) for national development; country characteristics including location, demography and economic profile. It also indicates the governance policy instruments and structure. The key government policy documents that have embraced STI in Malawi include Vision 2020, Malawi Growth and Development Strategy (2011-2016), National Science and Technology Policy (2002), and Science and Technology Act (2003). The Chapter also highlights the roles and responsibilities of the various elements of the STI organisational structure including Cabinet Committee on Science and Technology; Parliamentary Committee on Education, Science and Human Resources; National Commission for Science and Technology and sectoral committees. The chapter concludes by giving objectives of the Report and methodology for data collection, analysis and compilation of the Report. Multiple approaches were used to collect data for the Report. These include literature search, internet searches, and questionnaire survey. Data was analysed through descriptive statistics using Excel and Statistical Package for Social Scientists (SPSS).

Chapter 2 dwells on Education and Training. The country has made progress in construction of new universities. As of 2011, there were 4 public universities from 2 in the previous years. The additional universities were Malawi University of Science and Technology and Lilongwe University of Agriculture and Natural Resources. Although legal instruments on their establishment were in place, they had not started operating during the reporting period. There were 6 private universities from 4 in the previous years. The Chapter also reports on the number of graduates from both public and private universities which show an increase from 2010 to 2011.

Chapter 3 discusses intellectual property issues. One major revelation is that very few local patents were filed between 2010 and 2011 although there was an increase in both local and international filings in 2011. This is partly due to lack of awareness of intellectual property matters and as well as lack of supporting government policy. There is however, more local registration of trademarks (27%) and registered designs (93%).

The Information Communication Technology (ICT) sector is a beacon for S&T developments in Malawi. As reflected in **Chapter 4**, there has been improvement in most ICT indicators in the country. For instance, though still low by glob al standards, tele-

density increased to 18.32% in 2010/11 from 8.15% in 2007/08. Internet subscribers increased from 2.26% in 2009/10 to 3.33% in 2010/11 whereas mobile density also increased from 16.9% in 2010 to 17.13% in 2011. Lack of national ICT policy was singled out as one of the main constraints affecting the sector.

Malawi is one of the few countries in Africa that have embraced modern biotechnology. **Chapter 5** reveals that the country has made progress in terms formulation of policy and regulatory instruments notable among which are Biosafety Act of 2002, Biosafety Regulations of 2007 and National Biotechnology and Biosafety Policy of 2008. With the foregoing, complemented by a comprehensive capacity building programme, the country was by 2011 ready to conduct confined field trials of genetically modified crops.

Chapter 6 highlights progress made in the Agriculture and Food Security sector. In general there was increase in the number research projects implemented and number of technologies developed from 2010 to 2011. However, the number of scientists did not increase between 2010 and 2011. The areas of cereals, horticulture, legumes, tobacco and tea research registered notable success in terms of number of research projects implemented and number of technologies developed.

Regarding the Water and irrigation sector **(Chapter 7)**, there has been significant increase in the area under smallholder irrigation. The total irrigated area was 42,986 hectares in 2010/11. Over half of the area is under gravity fed irrigation (21,987 ha) this is followed by the area under treadle pumps (12,757 ha). The area under motorised pumps is only about 3,000 ha. Statistics on use of sophisticated technologies such as sprinkler and drip irrigation is not available.

Chapter 8 gives performance of the health sector. The sector registered a number of achievements including reduction in infant and under-five mortality rates from 76 per 1,000 in 2004 to 66 per 1,000 in 2010; 133 per 1,000 in 2004 to 112 per 1,000 in 2010 respectively and reduction in maternal mortality rate from 984 per 100,000 in 2004 to 675 per 100,000 in 2010. Malawi also reduced malaria in-patient case fatality rate from 7% in 2004 to 3.2% in 2010 and increase in proportion of births attended by skilled health personnel from 38% in 2004 to 75% in 2009. There were a number of innovations that were implemented to improve nutrition which included school health and nutrition programmes; vitamin A supplementations; and nutrition support programmes. These interventions have resulted in improvement of nutrition indicators. For instance, the percentage of underweight children decreased from 22% in 2004 to 13% in 2010 (DHS, 2010).

As time goes by, the sector of Energy and Mining is becoming more prominent, a matter captured in **Chapter 9**. It is a fact that the energy sector affects all the other sectors. The mining sector has the potential to significantly increase the country's gross domestic product (GDP) within a short period of time. For a long time coal mining was the only significant mining activity in the country. The opening of the Kayelekera uranium mine is

seen as a turning point in the mining sector. There are now prospects of opening other large mining operations in Mzimba and Mulanje. In 2010 and 2011 the Ministry of Mines finalised negotiations with the World Bank and EU on the Mining Governance and Growth Support Project which will among other things facilitate the carrying out of country wide airborne geophysical survey and establishment of Geo-data Management Centre for Geological Survey Department (GSD) and cadastre system for Department of Mines.

Forestry, fisheries and wildlife have been broadly categorised as genetic resources in **Chapter 10**. In 2010 and 2011 Malawi had 114 endemic plant species, 16 endemic animal species and 807 fish species. The data also revealed that there were 154 threatened plant species, 27 threatened animal species and 11 threatened fish species. On the other hand, 5 plant species became extinct in 2010/11. It is also indicated in the chapter that 70 plant species were introduced in 2010 and 193,000 plant specimens were kept in herbaria. One disturbing reality highlighted in the Chapter is that production of Chambo fish declined from 23,000 tons in 1984 to 7,000 tons in 2001 and that per capita consumption of fish also declined from 14 kg per person per year in 1984 to 4 kg today.

Chapter 11 highlights technologies available for measuring climate parameters and efforts the country is making to adapt to and mitigate climate variability and change. The chapter gives count data for technologies that measure temperature and rainfall. It is indicated that automatic weather stations increased from 11 in 2010 to 21 in 2011. There was also high increase in rainfall logging systems from 15 in 2010 to 43 in 2011. However, automatic rain gauges declined from 12 in 2010 to 10 in 2011. The report also reveals that climate variability and change is one of the greatest constraints facing the country, especially in the field of agriculture. The National Adaptation Programmes of Action (NAPA) is the main policy document that contains strategies on how to adapt to climate variability and change.

Chapter 12 focuses on transport and construction. It discusses performance in the roads sub-sector, in terms of routine maintenance, periodic maintenance, rehabilitation, upgrading and new road construction. It also highlights performance in construction sub-sector in terms of number of registered construction firms, and number of construction materials manufacturers. The number of registered construction firms increased from 526 in 2002/03 financial year to 1,880 in 2011.

Chapter 1: Introduction

1.1 Science, Technology and Innovation

Science is the enterprise focused on knowledge production. Technology, by contrast occurs when the knowledge content generated through scientific exploration is put to productive use as a result of technological research. Innovation arises when knowledge, regardless of its source, is used to create new possibilities that are endowed with commercial value. It is ordinarily accepted that science and the technology it underpins are forms of public goods[1] that are not only freely available but also that no one can be denied their use/consumption. The general understanding of public goods is that they are under-produced by the normal operations of markets thus justifying Government intervention to mitigate the failure of the market to produce them. In reality, however, while members of society cannot in principle be denied the outputs and effects of science and technology, societies have different propensities to derive economic and social benefits from these public goods. It is these differences that create variety with respect to economic and social development status across nations on account of disparate scientific and technological capabilities. Countries such as Malawi are where they are on the League of Nations largely due to the extent to which their economies use science, technology and innovation to gain competitiveness of their economic activities and outputs in global markets. It is, therefore, essential for Malawi to periodically take stock of the state of science, technology and innovation in the economy. This first-ever State of Science and Technology Report (SSTR) covers the two year period, 2010-2011.

This introductory Chapter provides general information on the location, demography, economic profile and existing STI governance structure of the country. In addition, the specific objectives and the methodology utilized for the production of the Report are given.

1.2 Country Characteristics

1.2.1 Location

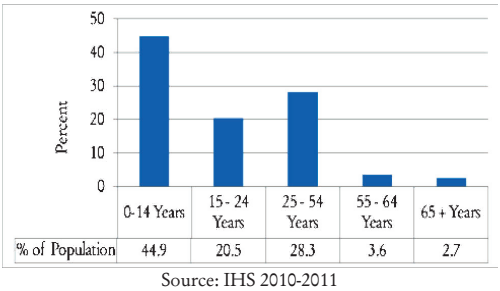
Malawi is a landlocked country in southern central Africa along the western part of the Great African Rift Valley. It covers a total area of 118,484 km² stretching 900 km north to south, and between 90 and 161 km east to west. Malawi is bordered by the United Republic of Tanzania to the north and north east, Mozambique to the east, south and south west, and Zambia to the west (see Figure 1). The country is divided into three regions: the Southern, Central, and Northern. Malawi has the third largest lake in Africa: Lake Malawi which covers 21% of its total area.

[1] A simplistic definition of public good is that they are those goods whose consumption cannot be denied from anyone demanding them. Further, public goods have the property that their consumption by anyone does not exhaust their utility to some other user.

1.2.2 Demography

The population of Malawi in 2010 and 2011 was estimated at 14,553,011 and 15,033,724 respectively based on 2008 projection. Using estimates as at 2012, however, it will be observed from Figure 2 that 65.4% of the population is at or under the age of 24 years. The country has one of the highest population densities, making diffusion of innovation easier.

Figure 1: Population Distribution by Age Groups



	0-14 Years	15 - 24 Years	25 - 54 Years	55 - 64 Years	65 + Years
% of Population	44.9	20.5	28.3	3.6	2.7

Source: IHS 2010-2011

This shows that the majority of the population is young, and hence provides the opportunity for changing mind sets regarding the country's prospects for harnessing science, technology and innovation for national social and economic development.

1.2.3 Economic Profile

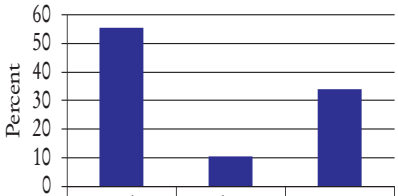
At independence in 1964, Malawi inherited an economy that was dominated by agriculture (Box 1, Figure 3) and a policy framework which favoured commercial farming. Commercial farmers readily accessed knowledge inputs (and hence innovation) from an elaborate extension service, finance and sold produce on organized markets. This trend changed in favour of small holder sector in 1970s and 1980s. Over the years, however, there has been some form of transformation such that by 2011, services contributed 50%, while Agriculture and Industry contributed 30 and 20% to GDP respectively (Box 1, Figure 4). Agriculture, however, has persistently maintained its position as the driving force of the economy. Agriculture supports industry and services, and contributes over 80% of foreign exchange earnings which have extensive multiplier effects in the economy. However, Malawi's economic performance is characterised by a large trade deficits which are exacerbated by low technological content of export products. The contribution of manufactured products in Malawi's export basket for 2010 and 2011 were 1 and 3% respectively (World Development Indicators).

Figure 2: Map of Malawi

Source: Matt Rosenburg

Box 1: Some Economic Transformation

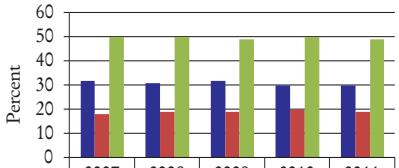
Figure 3: Composition of GDP, 1964



	Agriculture	Industry	Services
%GDP	55.5	10.6	33.9

Source: World Bank, 1966

Figure 4: Composition of GDP, 2007-2011



	2007	2008	2009	2010	2011
Agriculture	32	31	32	30	30
Industry	18	19	19	20	19
Services	50	50	49	50	49

Agriculture Industry Services

Source: World Development Indicators

1.3 STI Governance

The Malawi's STI systems have their basis in the National Vision 2020, which is supported by various Government development policy instruments. The Malawi Growth and Development Strategy provides the overarching directions regarding investments. The 2002 National Science and Technology Policy is the principle instrument guiding the organization of STI in Malawi whose implementation is supported by the Science and Technology Act (2003).

By the year 2020, Malawi as a God-fearing nation will be secure, democratically mature, environmentally sustainable, self reliant with equal opportunities for and active participation by all, having social services, vibrant cultural and religious values and being a technologically driven middle-income economy

1.3.1 Malawi's Vision 2020

Chapter 8 of the Malawi Vision 2020 expresses the country's aspiration to become a science and technology-led economy. It recognizes science and technology as important tools for economic development and calls upon the nation to ensure that the strategies recommended in the Vision document are implemented. It also calls for the existence of effective organizations for coordination of STI matters hence, the establishment of National Commission for Science and Technology in 2009.

1.3.2 Malawi Growth and Development Strategy

The Malawi Growth and Development Strategy (MGDS), which is the overarching national medium-term development framework has embraced science and technology as one of the priorities for fostering national development. It is, therefore, the intention of Government to provide leadership in integrating S&T in national development planning.

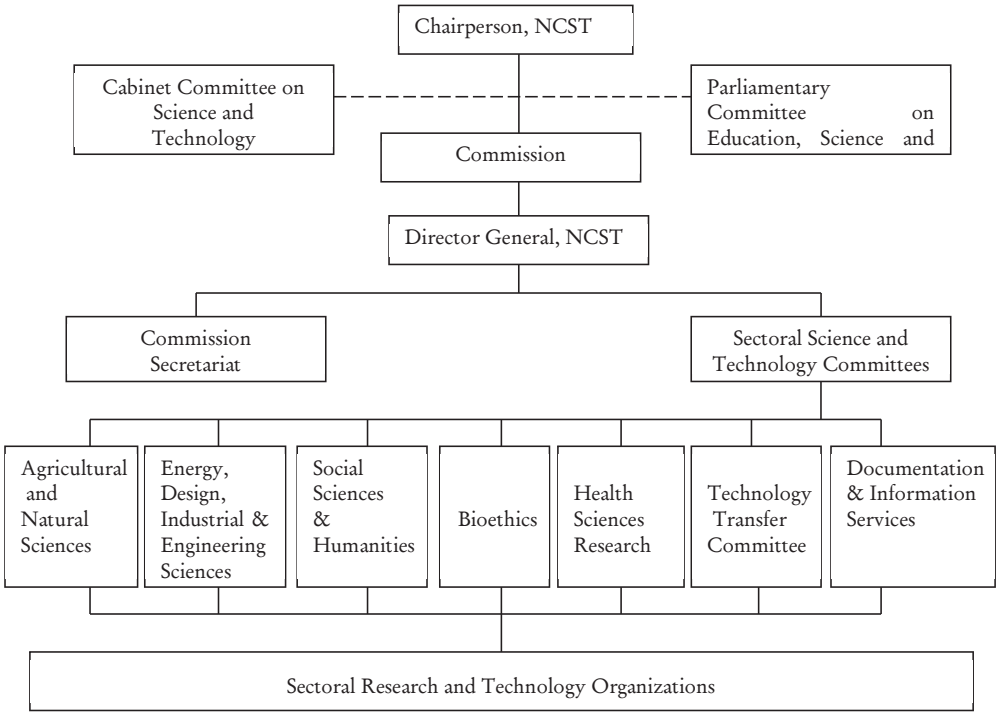
1.3.3 National Science and Technology Policy

The overall goal of the National Science and Technology Policy is to foster socio-economic development through the development and application of science and technology for improving the standard and quality of life of Malawians. The policy objectives are to:

(i) Establish and strengthen national capacity to research, evaluate, select, acquire, adapt, develop, generate, apply, and disseminate technologies;
(ii) Develop and raise the national productive capacity and improve competitiveness through the efficient application of technologies;
(iii) Promote and develop traditional, endogenous, new and innovative technologies; and
(iv) Create knowledge and S&T awareness to improve and develop the scientific and technological culture of Malawians.

In order to institutionalize STI in Malawi, the National Science and Technology Policy provides for an elaborate organizational structure (Figure 5).

Figure 5: Institutional and Organization Framework for STI in Malawi



1.3.3.1 Cabinet Committee on Science and Technology

The Committee has a critical role in formulation of science and technology related policies and bills. Prior to debate in the full Cabinet, draft policies and bills are scrutinized by the Cabinet Committee and only after the Committee gets satisfied are the documents discussed by the full Cabinet.

1.3.3.2 Parliamentary Committee on Education, Science and Human Resources

The Committee provides oversight over science and technology programmes in the country. The Committee performs advisory role to the National Assembly on science and technology matters. Often, bills related to science and technology are referred to the Committee prior to being debated in the National Assembly. The Committee has power to summon any public officer to appear before it to explain science and technology issues.

1.3.4 Science and Technology Act (2003)

The main objects of the Act are to:

(i) Provide for the advancement of science and technology;
(ii) Establish the National Commission for Science and Technology and
(iii) Provide for matters connected therewith and incidental thereto

The Act came into operation on 14th November 2008.

1.3.5 National Commission for Science and Technology

The Commission was established as a principal advisory body to Government and other stakeholders on all science and technology matters for achievement of a science and technology – led development. The vision of NCST is, "to be the lead institution in the advancement of science, technology and innovation for sustainable growth and development in Malawi". The mission of the Commission is to promote, support, coordinate and regulate the development and application of science, technology and innovation in order to create wealth and improve the quality of life of all Malawians.

The National Commission for Science and Technology reports to the Ministry of Education, Science and Technology on policy and technical issues and the Department of Statutory Corporations in the Office of the President and Cabinet on governance and other administrative matters. The Board of Commissioners has two committees namely: the Finance, Audit and Administration Committee (FAAC); and the Scientific and Awards Committee (SAC). In addition, the Commission has seven functional sectoral committees: 9

(i) Agriculture and Natural Sciences,
(ii) Energy, Design, Industrial and Engineering Sciences,
(iii) Social Sciences and Humanities,
(iv) Bioethics;
(v) Health Sciences Research,
(vi) Technology Transfer; and
(vii) Documentation and Information Services.

These functional committees review, guide and set priorities for various research programmes undertaken by research organizations and institutes.

1.4 Objectives of the State of Science and Technology Report

NCST is required to develop and synthesize science and technology indicators using internationally accepted procedures and standards; and prepare a State of Science and Technology Report every two years for presentation to National Assembly (Section 18 subsections (n) and (r) of the Science and Technology Act of 2003). Thus, the main objective of this Report is to enhance awareness and understanding of the Science, Technology and Innovation in order to foster higher and sustained national commitment. The specific objectives are:

(i) To assess contribution of each subsector to the economy and role played by Science and Technology
(ii) To determine the levels of investment in Science and Technology
(iii) To document challenges to Science and Technology and associated mitigation measures
(iv) To propose appropriate recommendations for informed policy decision-making

This Report constitutes a valuable benchmark for comparing Malawi's performance in STI against other countries in the region and beyond.

1.5 Methodology

The methodology for preparing this Report involved data collection, data analysis and report writing.

1.5.1 Data collection and Analysis

Data and information for this Report were collected through document review and administration of tailor-made questionnaires. These were completed by key R&D subsectors. The heads of institutions or their delegated representatives were the respondents. Data were analysed using Excel.

1.5.2 Report writing

A drafting session was held at Kims Koreana Garden in Lilongwe from 25th to 26th April 2013 involving representatives of all relevant sectors. The working chapters were consolidated into a single document and reviewed by 5 independent individuals at Mapiri Lodge in Dedza from 4th to 5th October 2013. An editing session was held at Mpatsa Lodge in Salima from 18th to 20th October 2013.

Chapter 2: Education and Training

2.1 Introduction

Education is a catalyst for socio-economic development, industrial growth and instrument for empowering the poor, the weak, and the voiceless (MGDS 2011-2016). Hence, countries with high levels of enrolment in basic, secondary and university experience high levels of economic growth. Quality education increases the mental capacity and labour productivity, enhances innovative capacity for the development of new ideas and facilitates diffusion of knowledge for understanding and transformation (Hanushek & Wobmann, 2007). The outcomes of quality education are evident in health outcomes, fertility choices, the education of children, the ability to develop, adoption and adaptation of new technologies to local environment, institution building, sense of nationhood (Gyimah-Brempong, 2010) and linkages between education and food security (Burchi, 2006). Tertiary education significantly contributes to income growth rate (Gyimah-Brempong, 2010). Nations therefore invest in tertiary education and research. This entails increasing percentage share of Gross National Income allocation towards education, especially, university education so that science and technology can effectively contribute to national social and economic development.

The National Education Sector Plan (NESP) is the main guiding policy document on education in Malawi. The main goal of NESP is to provide quality and relevant education to the Malawian nation. The main pillars of the plan are access and equity, quality and relevance, and governance (NESP, 2007-2016).

2.2 Status of Tertiary Education in 2010 - 2011

The country had two public universities UNIMA and MZUNI which offer various graduate and postgraduate programmes and implement research in the different disciplines including those in science and technology. The two public universities accounted for 97% of the all graduates. In addition, the Government commenced the construction of Malawi University of Science and Technology (MUST) and delinking Bunda College of Agriculture from UNIMA to be part of Lilongwe University of Agriculture and Natural Resources (LUANAR). There were eight accredited private universities and colleges which offer higher education in various programmes. These are African Bible College (ABC), University of Livingstonia (UNILIA), Catholic University of Malawi (CUNIMA), Blantyre International University, DMI-ST. John the Baptist University, Seventh Day Adventist University, Skyway University and Share World Open University. The private institutions contributed the remaining 3% of all graduates in the period 2010 - 2011.

There was some growth in the output from the university system especially in the public universities (Figure 6 and 7). The total number of graduates in 2010 and 2011 were 1840 and 2110 respectively. The proportion of female graduates in each year remained unchanged at

35%. However, the growth rates of females and males in 2010 and 2011 were 13 and 15% respectively. The two public universities are committed to a 50:50 parity. During this period postgraduates constituted only 6% of total graduates (Figure 8). This indicates low levels of research and development activities in the local universities.

Box 2: Graduate Output from Malawi Universities

Figure 6: Proportions of Outputs from Public and Private Universities, 2010 - 2011

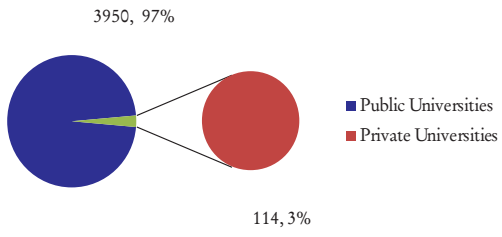
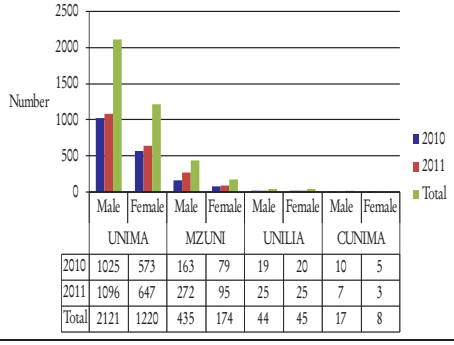
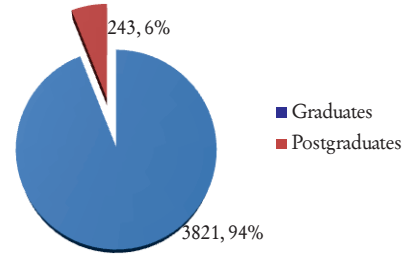


Figure 7: Total Number of Graduates from Malawi Universities, 2010 - 2011



	Male	Female	Male	Female	Male	Female	Male	Female
	UNIMA		MZUNI		UNILIA		CUNIMA	
2010	1025	573	163	79	19	20	10	5
2011	1096	647	272	95	25	25	7	3
Total	2121	1220	435	174	44	45	17	8

Figure 8: Proportions of Graduates and Postgraduates, 2010 -2011



In view of these indicators, the Government of Malawi initiated several programmes to expand enrolment and participation in higher education. Examples include:

(i) Government of Malawi with MHC project on building hostels on campus on Build Operate and Transfer (BOT) basis to increase intake;
(ii) Construction of new lecture rooms and laboratories funded by development partners;
(iii) The Universities introducing Open and Distance Learning delivery mode and established the Centre for Open and Distance Learning (CODL), and
(iv) Organizing Science career talks in secondary schools to select science subjects.

2.2.1 Challenges and recommendations

The higher education sector experiences the following challenges:

(i) Inadequate capacity of staff to deliver
(ii) Low levels of funding to the universities for research and development
(iii) Limited space for both teaching and student accommodation
(iv) Inadequate and outdated equipment

In order to address these challenges, it is recommended that Government and the higher education institutions should:

(i) Expand infrastructure for increased student enrolment;
(ii) Expand and offer programmes including use of open and distance learning approaches; and
(iii) Implement programmes which encourage enrolment of female students into science and technology fields.

2.3 Status of Secondary School Education in 2010 - 2011

The sector provides for the teaching of mathematics, physical science, biology and other applied sciences such as computer science and S&T. The relative numbers of mathematics, physical science, biology, computer science and S&T teachers in 2010 and 2011 are provided in Figure 9.. Physical science had the highest male teaching staff, about 2,250 in each year, biology was the second most capacitated; nearly 2000 in either year. The average capacity in mathematics was 1,600 staff. The female proportion was very low, accounting for 17%. Biology appears to be the most preferred science subject amongst female education students. It is not clear whether there was double counting between physical science and S&T teachers; the former are also teaching the latter subject in most secondary schools.

Figure 9: Number of Science Subjects Teachers in Secondary Schools

2.4 Challenges and Recommendations

Until now, the Education Management Information System (EMIS) unit does not collect primary school data on science teachers and subjects. This sector needs to be targeted to catalyse student interest in mathematics and science. To this end, Government should come up with a policy to increase the intake of education science students in public universities and colleges.

2.5 Conclusion

Higher education and training is critical for socio-economic development of a country. Increased investment is needed to foster increased access, quality and equity in higher education. To facilitate greater participation in R&D, it is important that higher education institutions proactively expand in postgraduate programmes which underpin knowledge generation and commercialization. Hence, the country should:

(i) Expand R&D physical infrastructure;
(ii) Provide adequate financial and human capital;
(iii) Implement programmes which encourage enrolment of female students into science and technology fields; and
(iv) Periodically undertake regular assessment of human capital development, availability and attrition.

Chapter 3: Intellectual Property Rights

3.1 Introduction

Intellectual Property (IP) has a symbiotic relationship with socio-economic development since it improves the quality of life through technological advancements and enjoyment of literary and artistic works. Intellectual Property matters in Malawi are handled by three ministries: Ministries of Justice and Constitutional Affairs, Tourism and Culture, and Industry and Trade. The Department of the Registrar General, which is under the Ministry of Justice, is responsible for the administration of industrial property (Patents, Trademarks and Registered Designs). The Copyright Society of Malawi (COSOMA), which falls under the Ministry of Tourism and Culture, administers copyright and related rights while the Ministry of Industry and Trade is concerned with trade related aspects of IP. This Ministry also handles the World Trade Organization's Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS). However, the Ministry of Industry and Trade (MoIT) is the policy holder of the industrial property laws. Malawi cannot, therefore, effectively implement its development agenda in the absence of a comprehensive and clear policy direction on how the IP system can play this vital role.

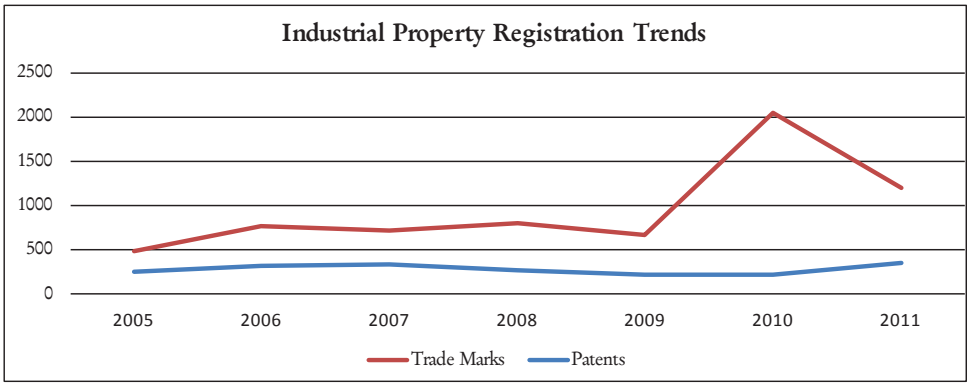
3.2 Industrial Property

Industrial Property encompasses patents, trademarks and registered designs. The Department of the Registrar General provides a secure and efficient system for the registration and protection of these industrial property rights and advises government on the appropriate policies in the area of intellectual property. This is to create an environment conducive to the increase in foreign and local investment resulting in economic growth.

3.2.1 Status of indicators in 2010 and 2011

During the period 2010 – 2011, Malawi registered very few patent applications. The Country registered fewer local and international filings in 2011 than in 2010 (Figure 10). Generally patent applications are much lower than trademark applications.

Figure 10: IP trends in Malawi since 2005



As shown in Figure 10 and Table 1, local patent registrations are very low. Most patents have been registered through ARIPO and very few have been granted by the Registrar General's Department. Reasons for low levels of patenting can be attributed to lack of awareness on intellectual property rights; absence of a strong culture of invention and innovation in the country which has been compounded by low public and private sector investment in research and development, innovation and commercialization.

Table 1: Patents Applications and Grants

Year	Applications	PCT	ARIPO	National	Grants	PCT	ARIPO	National
2005	249	1	248	0	126	0	106	0
2006	312	0	312	0	125	0	125	0
2007	343	0	342	1	79	0	78	1
2008	277	0	277	0	62	0	62	0
2009	213	0	213	0	40	0	40	0
2010	217	0	216	0	14	0	14	0
Source: Chirambo (2013)								

3.2.2 Challenges and Interventions to address the challenges

The sector faces numerous challenges. Important constraints are:

(i) The National IP office has capacity and resource constraints which hinder the effective discharge of its mandate. Its positioning in mainstream civil service cripples it with inadequate and improperly qualified staff, low budget allocations and long turn-around times for decision-making due to bureaucratic protocol;

(ii) There is little investment in research and development and, where this exists, there is a huge disconnect between research results and their commercialization into protectable IP products. In most cases, IP in research results are owned by external sponsors due to the absence of proper IP Ownership Clauses in research contracts and the lack of institutional IP policies;

(iii) The IP legal and regulatory framework is very outdated and requires overhaul in order to bring it up to modern standards and align it with national treaty obligations. Intellectual Property legislation, especially on industrial property, is incompatible with technological developments, which have occurred since their promulgation in the colonial period;

(iv) The country does not have an over-arching National Intellectual Property Policy to provide much needed policy guidance and direction. This means the country does not have an Intellectual Property Strategy to implement national objectives in this sector

(v) No centralized monitoring system exists for the implementation of the various intellectual property laws and this has historically negatively affected their effective application; and

(vi) There is very low awareness of intellectual property matters among the general population and at technical levels.

Several interventions have been undertaken to address the above challenges but they require political will at the highest levels of Government administration in order to be effectively implemented. The critical strategy is the development of the National Intellectual Property Policy which remains at draft stage to this day. IP encourages innovation, creativity and the development of new technologies which find direct application in all sectors of the national economy. In order for IP to play this role effectively, Government should put in place a suitable framework that would promote the generation, protection and commercialization of Intellectual Property Rights (IPRs). The draft policy provides that framework, which links IP and socio-economic development. The draft policy further outlines a broad road map that should enable Malawi to revitalize that link and then integrate IP into the country's development strategies. The policy provides for the establishment of the Malawi Intellectual Property Office (MIPO) to house the industrial property registers and deal with policy in the area of copyrights. This will be an autonomous institution, a parastatal under the Ministry responsible for Industry and Trade. Initial capital investment from Government is necessary to enable it to build up an asset base of infrastructure and equipment and fund its own activities. Subsequently, registration fees and levies will be used to support programme activities. This model is consistent with the best practices recommended by the World Intellectual Property Organization (WIPO) and the African Regional Intellectual Property Organization (ARIPO). Presently, an initiative is underway reviewing of intellectual property laws. Draft Patents Bill and Trademarks Bill are nearly finalised.

3.3 Copyright

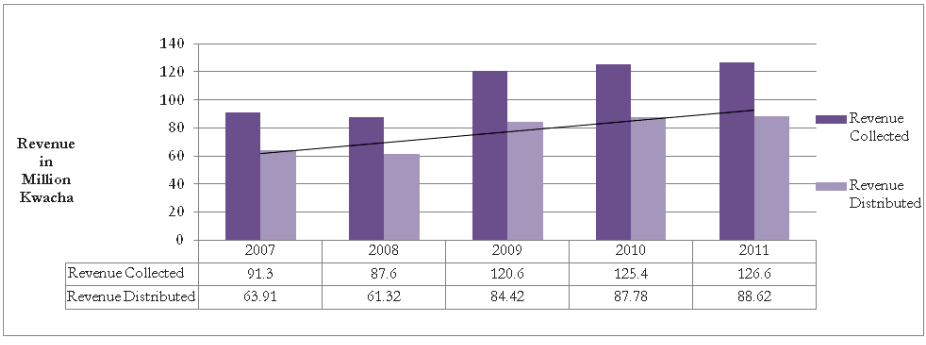
Copyright and related rights protects and promotes interests of creators in various arts disciplines, namely the book publishing, theatre, photography, writing, visual arts, poetry, folkdance music and song, film and journalism. Copyright is managed by COSOMA which has a wide and diverse membership. For example, it has 10 rights holder associations as members and the Musicians Association of Malawi has over 5,000 members. COSOMA contributes to cultural development in the country through the protection of the rights of creative people; enables rights owners to receive royalties for use of their works; and provides social welfare services to its members.

3.3.1 Status of Indicators for Copyright and Related Rights in 2010 and 2011

The Society had 415 members in 2008 and registered 8,980 works in 2009. In 2010 COSOMA increased its membership by 945 individual creators and in the following year 10,962 copyright works were registered.

COSOMA generates income through its licensing activities. The income from the revenue collections and the distribution to its members has increased over the years (Figure 11). In 2010 and 2011, COSOMA's revenue amounted to K125 and K127 million, respectively.

Figure 11: Revenue collections and distributions between 2007 and 2011



	2007	2008	2009	2010	2011
Revenue Collected	91.3	87.6	120.6	125.4	126.6
Revenue Distributed	63.91	61.32	84.42	87.78	88.62

During the period 2010-2011 COSOMA also received a grant of K37.3 million from the Royal Norwegian Embassy for the Cultural Support Scheme Project. The Project promoted the cultural expressions and copyright industries of Malawi. This is in line with the objectives of the draft National Cultural and Intellectual Property Policies. The Project plays a complementary role in achieving sustainable economic growth by enabling rights holders to gain and sharpen skills which enable them to earn a leaving through creative efforts. The Project also aimed at building the capacity of the various rights holder Associations thus contributing to cultural and economic development of the country.

3.3.2 Challenges and Interventions

The Copyright sector faces a number of challenges. These are notably the following:

(i) Increasing piracy, which is an illegal reproduction of copyright protected material, remains one of greatest threats and challenges to the development of copyright industries in Malawi. Piracy results in:

- Discouraging the would-be investors in the industries because of fearing that they will not reap the expected profits from their investment;
- Robbing creative artists of their already meagre income, since no royalties are paid to composers, arrangers, publishers, performers and other creative persons;

- Causing the exodus of many of our talented artists to other countries where they would usually make money. This drain of creative persons makes Malawi lose income, which would have been made if their works were produced locally;

- Denying Government of valuable income from taxes because pirates do not pay taxes since they do not declare the quantities produced and the revenue realized from the sale of the goods. Consequently, the value and contribution of copyright industries to our economy is not appreciated; and

- Frustrating the consumers who fail to appreciate the artistic value or beauty of a work due to sometimes poor quality of the pirated products.

(ii) The advent of digital technology has also exacerbated the development of new forms of piracy. Internet as a new and fast growing technology facilitates easy reproduction of a work. Further, the emergence of global digital networks allows the rapid, worldwide dissemination of works in digital form. The internet also provides a platform for illegal downloading of copyright protected works.

Despite the existence of the law and the establishment of COSOMA, various challenges exist in the country. These include:

- The rapid technological developments since 1989 have made the law out-dated. For example, it is generally agreed that the fines: a minimum of K1,000 to a maximum of K15,000 are too low to deter an infringer. The Act does not tackle the effect of new technologies on copyright. It leaves a lot of room for abuse of copyright works. It is not compatible with the Agreement on Trade Related Aspects of Intellectual Property (TRIPs) and the WIPO Treaties notably the WIPO Internet Treaties namely the WIPO Copyright Treaty (WCT) and the WIPO Performances and Phonograms Treaty (WPPT).

- Ineffective enforcement mechanisms due to lack of understanding of the law itself by the law enforcement agencies (Police, Customs and the Judiciary). The few that have been exposed to copyright issues are as a result of seminars, workshops or attachments organized by COSOMA. The result is that court procedures are slow, costly and complex.

- Lack of awareness of copyright and intellectual property matters by the general public and of course the artists themselves. This is because IP is not taught in our educational institutions of learning. This is compounded by the severe shortage of teachers who are specialized in the field and unavailability of appropriate materials for teaching IP.

- Low level of appreciation of the important role that copyright and intellectual property plays in national development. Intellectual property is generally perceived as a foreign concept and non-developmental. Consequently, IP receives very low profile and is not priority in the national budget as compared to health, agriculture and education. This problem is compounded by lack of statistical data to show the contribution of intellectual property to the economy of Malawi. Breakdown of revenues generated from the various categories of intellectual property, such as, music and literature are not well documented.

- Lack of Intellectual Property Policy and other related policies such as the National Arts and Cultural Policy and the National Book Policy. Due to absence of these Policies, the Copyright industry sector lacks a proper framework to implement strategies for the promotion of the arts in the country.

In order to address the challenges related to copyright issues, several programmes have been implemented. These include:

(i) Review of copyright law so that it is compliant to the WIPO Copyright Treaty (WCT) and the WIPO Phonograms and Performers Treaty (WPPT). Acceding to these Treaties will also facilitate international protection of Malawi's own national right holders, promotion of electronic commerce and encouragement of investment

(ii) Implement a study to establish the economic contribution of the copyright-based industries to the Malawi economy. The results of the Study will form a basis for adjusting policies and strategies which shall promote growth and development in the country's copyright-based sectors

(iii) Intensify public awareness and general understanding of copyright issues. COSOMA should also target law enforcement agents namely the Police, Customs and the Judiciary

3.4 Conclusion

The Intellectual Property landscape in Malawi will trigger the realization of the full benefits from the solutions contained in the draft National Intellectual Property Policy. The proposed establishment of an autonomous national IP office would solve resource and capacity challenges while, at the same time, boost the profile of IP in the country. It would also provide the required centralized monitoring system for the implementation of the various IP laws as well as guide the Government policy formulation and implementation process in various sectors. Stakeholders need to lobby for the adoption of the Draft National IP Office in order for IP matters to be given the right priority and stimulate a culture of creativity, inventiveness, innovation and commercialization. To strengthen national capacity, Malawi needs to introduce IP courses in most institutions of learning and increase awareness amongst the society.

Chapter 4: Information and Communication Technology

4.1 Introduction

The Information and Communication Technology (ICT) sector is a potential catalyst for economic transformation in any country. The ICT sector is divided into two broad industries: ICT manufacturing and ICT services; the latter being further divided into two main categories: telecommunication services and computer-related services (ITU, 2012). High-speed affordable broadband connectivity to the Internet is therefore essential to modern society, offering widely recognized economic and social benefits (ITU Broadband Commission Report, 2012).The ICT Sector in Malawi aims to (i) increase utilization of ICT; (ii) ensure universal access to ICT products and services to improve service delivery in both public and private sectors; and (iii) ensure that the population has access to timely and relevant information, and increase popular participation of citizens in development, governance and democratic processes. The telecommunications sector contributed about 4.5% of Malawi's GDP and created employment for 10% of highly skilled personnel (MACRA, 2012). Globally, society is moving beyond the concept of the connected individuals to the "Internet of Things" where people and billions of devices will be connected to high speed networks in ways that will impact on every aspect of life (Commission of the European Communities, 2009).

The highest average download speeds for consumers are currently found in Luxembourg at 49Mbit/s, while in some LDCs, such as Bangladesh, Malawi, and Sudan, the speeds of 1 Mbit/s or less obtain (Broadband commission 2012 p15). ITU (2011) reported that ICT services continue to be more affordable in high-income economies and less affordable in low-income economies. By 2010, the cost of ICT services averaged 1.5% of GNI per capita in developed countries, compared with 17% of GNI per capita in developing countries. Telecommunication plays a vital role in economic development and poverty reduction and thus contributes to achievement of the country's commitment to the MDS. MGDS II recognises that information is a vital resource that should be made available in a form that is applicable and usable, and at the right time for the citizens to make informed decisions.

4.2 Status of the ICT Sector

ITU hosts an annual World Telecommunication/ICT Indicators Meeting (WTIM) to generate discussion and provide training on ICT statistics and statistical issues (Broadband Commission 2012, p17), www.itu.int/ITU-/ict/wtim12/index.html. However, for Malawi this document is the first of the biennial volumes to be produced by Malawi. Malawi witnessed the laying of the MTL fibre infrastructure in 2009, raising the threshold of connectivity offerings to be monitored by appropriate indicators. Prior to 2009, the country utilised the expensive VSAT connectivity. However, the magnitude of the fibre related price

drop may not be very high because MTL will enjoy some monopoly over the fibre gateway for some time (Banda, 2008).

Malawi has witnessed rapid Cell Phone Subscription such that in 2010 more than 21% of the population had cell phones. The Fixed Line Subscribers consequently dropped to less than 3% of the population (figure 12). The Internet Subscribers levelled at 17% of the population.

Figure 12: Cell Phone Subscribers

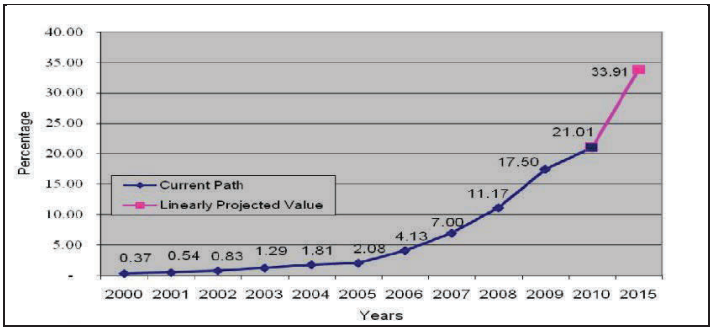


Figure 13: Fixed Line Subscribers

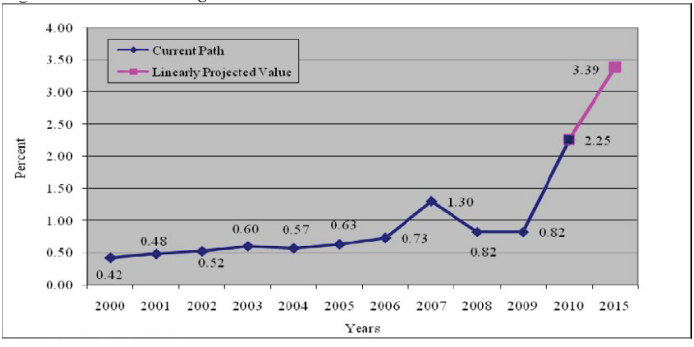


Figure 14: Internet Subscribers

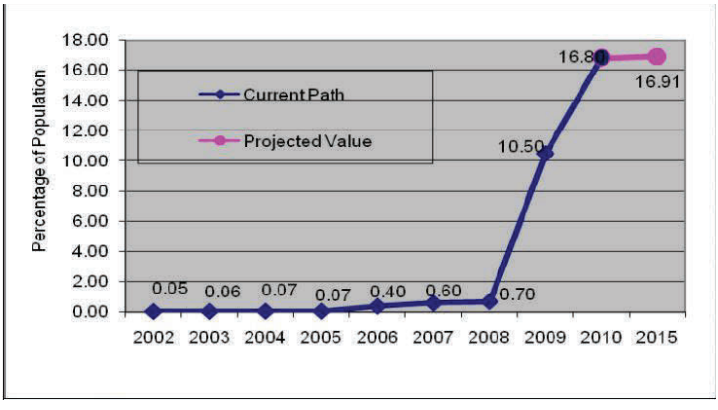


Table 2: Selected ICT indicators for 2010 and 2011

Performance Indicator	Measuring Unit	Baseline 2010	Actual 2011
Number of Computers per 1000 population		-	-
No. of Fixed Phone Subscribers per 100 population (Fixed Line Density)	Percentage	0.85 (2.3% MDG report)	1.19
No. of Mobile Phone Subscribers per 100 population (Mobile Density)	Percentage	16.9 21% (MDG report)	17.13
No. of Internet Service Providers	Number	10	12
No. of Internet users	Number	150,000	300,000
Type of Internet Connectivity			
1. Broadband Internet subscribers	Number	86,957	473,684
2. ADSL Internet Subscribers	Number	8,005	9,800
No. of Internet subscribers per 100 population	Number	2.26	3.33
Percentage of population covered by mobile cellular telephony	Percentage	-	
Mobile cellular coverage	Percentage	-	99.55
No. of fixed line telephone in rural and urban areas	Number	152,108	173,481
Mobile cellphone subscribers	Number	3,117,364	3,951,572
Radio Coverage	Percentage	75	75
TV Coverage	Percentage	40	40
No. of Telecentres	Number	18	33

Table 2 shows that (i) Fixed Line density increased from 0.85% 2010 to 1.19% in 2011 while Mobile density from 16.9% in 2010 to 17.13% in 2011. Thus, an increase in access to telephony services, (ii) The percentage of Internet subscribers rose from 2.26% in 2009/2010 to 3.33. Thus, an increase of 1.07% in the population with access to Internet was obtained. During the reporting period, both Television and Radio Coverage did not change in 2010/2011.

Malawi has exploited fully the use of ICT services in driving the economy. For example e-learning is being offered through the Republic of Malawi /Pan African e-Network Project (www.cc.unima.mw) in collaboration with several other African Countries and several

Indian institutions. The Ministry of Education, Science and Technology is building the capacity and numbers of primary teachers through open and distance learning (ODL).

In the health sector, the country is implementing the Electronic Health Information Systems (EHIS) based on the Health Management Information Systems (HMIS) Policy and Strategy of 2003. The Ministry of Health has thus developed both patient level and aggregate Electronic Medical Records Systems (EMRS); Mobile Health (mHealth) applications to support health service delivery; and District Health Information Software (DHIS 2) for collecting, analyzing and reporting aggregate level data for decision making and planning. DHIS 2, a web based system, has been deployed centrally at MoH and is available for use at district level in Malawi. Each health centre aggregates its patient and other health data monthly and forwards the report to the district where the data is then captured into the electronic system.

In the agriculture sector, the Ministry of Agriculture and Food Security (MoAFS) is using the GPS technology for measurement of garden area. The Ministry purchased 1500 GPSs for use by the extension workers in garden measurement. MoAFS in collaboration with IFPRI is piloting an electronic data transfer system for Agriculture Production Estimates Surveys (APES) and Agriculture Marketing Information System (AMIS) under the 'Strengthening Evidence Based Agriculture Policy (SEBAP) project.

In the education sector, Libraries, have embraced ICT for enhancing the delivery of information. This is achieved through the Malawi Library and Information Consortium (MALICO) and this Consortium combine their purchasing power to subscribe to vastly subsidized electronic journals, giving their members access to resources at par with European Universities www.acu.ac.uk/focus-areas/digital-resources-for-research. Further, the Malawi Research and Education Network (MAREN) is recognised by the Ministry of Education, Science and Technology and by the Department of e-Government as the Malawi National Research and Education Network (NREN). The Network is working towards aggregating bandwidth demand for its members and providing cross border links to enhance collaboration, improve quality and decrease costs. It is linked to the regional network supported by UbuntuNet Alliance and co-funded by the European Union through the Africa Connect project. Both MAREN and UbuntuNet Alliance thus enhance the capacity of the academic ICT Sector.

4.3 Challenges and intervention

The ICT sector faces several challenges. Important examples include:

(i) Low usage and adoption of electronic and online services;

(ii) Lack of a National ICT Policy which also fosters competition;

(iii) Inadequate Legal and regulatory frameworks including for collection and management of indicators;

(iv) Inadequate Institutional and Human Resource Capacity;

(v) Underdeveloped ICT Infrastructure, exacerbated by high cost of ICT equipment and services; and
(vi) Frequent Vandalism of equipment.

In order to address the various challenges, the following interventions are needed:

(i) Completing the World Bank-funded RCIPMW initiative to expand access and bring competition to the sector and thus bring prices down;
(ii) Establishing proactive system for monitoring performance and development of Key Performance Indicators (KPI). Malawi needs to participate in regional and global comparisons;
(iii) Enhancing the National College of Information Technology and the introduction of electronic teaching and learning facilities;
(iv) Establishing a National Data Centre that will rationalize data storage and data processing facilities;
(v) Introducing at least five electronic systems to facilitate efficiency and effectiveness in public service delivery;
(vi) Developing and implementing a web portal that will facilitate online communication between Government and the general public; and
(vii) Strengthening in various initiatives such as MAREN and an Internet Exchange Point hosted at College of Medicine through MAREN and managed by the Malawi Internet Service Providers Association (MISPA).

4.4 Conclusions and recommendations

The ICT Sector has critical potential in supporting the economy of the country. The recent developments in the infrastructure will allow Malawi to utilise the services in the health, education and agriculture sectors. Therefore, the country needs to:

(i) Continuously review ICT policies/plans and legal and regulatory frameworks in order to re-align them with the Government's development agenda and new technological developments;
(ii) Undertake national level awareness campaign among stakeholders on the Sector's action lines and the respective targets and indicators in order to enhance the collection and maintenance of data on indicators;
(iii) Ensure that the ISPs fine-tune their offerings more towards services rather than merely bandwidth to stay on the market;
(iv) Enable Reserve Bank of Malawi to facilitate electronic money transfer so that Malawi can participate in equal footing in the global tourism sector and in other aspects of international commerce;
(v) Increase the capacity of Tertiary education institutions to realign their ICT curricula to meet the changing demands of this cutting edge sector;

(vi) Exploit fully the Social media for expanding the market place, reinforcing democracy and reducing national isolation;

(vii) Expand the Use of services such as video conferencing must be encouraged. This can reduce wear and tear on individuals and vehicles, saving scarce resources and having a positive impact on the environment; and

(viii) MACRA should develop indicators for the sector with the full support of the RCIPMW project.

Chapter 5: Biotechnology

5.1 Introduction

Biotechnology is the use and modification of living organisms or parts of living organisms to make or modify a product, improve plant or animal breeds, or organisms for specific uses. Biotechnology is not new; it has been used for many centuries in agriculture and manufacturing industry to produce food, chemicals, medicines and several other products that are very useful in many areas including nutrition, human and animal health (AfricaBio, 2006).

There are two major types of biotechnologies namely: traditional and modern biotechnology. The traditional biotechnology refers to a number of ancient ways of using living organisms to make new products or modify existing ones. Important examples include the making of bread, cheese, yoghurt, organic manure, wine and beer using living organism such as yeast and bacteria. Modern biotechnology, which is due to recent advances in biotechnology, is often referred to as genetic engineering. It includes a cluster of techniques that focus on genetic improvements of crops and production of animal vaccines. This technology enables scientists to identify, isolate and move genes from one organism to another with ease and precision. Genetically modified (GM) crops have various products and are commercialized if proven to be safe to environment and humans by an authorized regulatory authority. However, this technology has associated risks. These are ethical concerns emerging from the use of the technology to manipulate and transform nature, environmental concerns such as pollution arising from use of chemicals and socio-economic risks.

5.2 Global and Local Status of Modern Biotechnology

The first genetically modified crop to be commercialized was Bt (*Bacillus thuringiensis)* Maize in 1996 in the USA and its production has been increased globally in terms of hectares put under GM cultivation. Globally, 160 million hectares were cultivated in 2011; representing an 8% growth. In 1996, 1.7 million hectares were used for growing biotech crops. Twenty nine countries in 2011 planted GM crops of which 19 were developing countries, and 10 industrialised countries. The 5 lead biotech developing countries, China, India, Brazil, Argentina and South Africa grew 44% of global biotech crops. In 2011, Africa made steady progress in planting, regulatory and research activities on biotechnology crops. Three countries (South Africa, Burkina Faso and Egypt) commercialized biotechnology crops, jointly planting 2.5 million hectares (ISAAA, 2011). Further, Kenya, Nigeria, and Uganda conducted field trials while Malawi approved an application to conduct Bt cotton confined field trial.

Malawi has a policy and legal framework for the promotion and safe use of biotechnology and its products. These documents include Biosafety Act of 2002, Biosafety Regulations of

2007; and National Biotechnology and Biosafety Policy. This Policy was approved by Malawi Government in June 2008.

5.3 Challenges and Interventions

The full realisation of benefits from biotechnology in Malawi encounters several challenges. These are:

(i) Inadequate capacity and funding to implement recommendations outlined in the National Biotechnology and Biosafety Policy;
(ii) Misconceptions derived from some media (anti-GMOs);
(iii) Not enough information available to stakeholders hence need for wide publicity;
(iv) Limited buy in by some key players stakeholders;
(v) Possible blockage of European market; and
(vi) Incoherent policies of regional organizations such as AU, SADC and COMESA.

To address these challenges, Malawi received funding from Program for Biosafety Systems (PBS) to implement a comprehensive biotechnology and biosafety program in the Country.

5.4 Conclusion

Biotechnology promises a lot of opportunities for Malawi. However, until now the country has relied on donor support. Sustainable investment in this technology is urgently required from all stakeholders including Government.

Chapter 6: Irrigation, Water and Sanitation

6.1 Contribution of Sector to the Economy

The Irrigation, Water and Sanitation sector is one of the key priority areas of infrastructure development that effectively contributes to sustainable economic growth and development in the country. The sector has direct linkages with agriculture and food security, industrial development, climate change, natural resources and environmental management, health, tourism, energy generation, fisheries and other socio-economic developments. Water is fundamental for energy, transport, health, agriculture and biodiversity. Improved water supply services have direct impact on the well being of people particularly, women and children in rural areas and on reducing the burden of water carriage (as women and children normally carry water from source to home). Time and effort saved in water collection has a huge potential for better child care and improved education.

Water, sanitation and hygiene services also make a significant contribution to public health: helping to alleviate the burden on curative health services by reducing disease transmission (diarrheal disease, intestinal worm and respiratory infections) particularly in children less than 5 years of age. A recent study (UNICEF Malawi 2006) estimated that there is a savings of about US$ 0.95 per person per year or about $1,111,500 due to avoiding or reducing diarrhoea cases arising from improved water and sanitation services. Malawi is committed to achieving the MDG target of 95% access to safe water. To this end, simple hand washings, and increased investments in water, sanitation and hygiene facilities are being utilized to improve the health and quality of life.

Improved school water, sanitation and hygiene facilities significantly contribute to the quality of education by reducing disease burden among children and staff, improving school attendance and retention particularly among girls, improved attraction and retention of teachers. Irrigation development also makes a profound contribution to the economy through irrigation agriculture. Several technologies such as use of treadle and motorized pumps, and gravity fed irrigation system have been adopted by farmers. In 2011, 25 small and medium multi-purpose dams were constructed in 24 districts across the country to make water resources readily available for multiple uses. Citizen's access to portable water supply especially in the rural areas has been increased by the construction over 7,500 boreholes and shallow wells through both government and other stakeholder initiatives in the sector. Irrigation farming contributed approximately 15% of the gross national maize production in the 2009/10 agricultural season (Ministry of Agriculture and Food Security)

6.2 Status of Indicators in 2010 and 2011

6.2.1 Irrigation Development Technologies

There were four major technologies: gravity fed systems, motorized pumps, treadle pumps and watering can which were used by farmers These technologies brought the area under smallholder irrigation to 42,986 hectares for 2010/11 (Table 3).

Table 3: Cumulative area under different irrigation technologies

Name of Technology	Number of Schemes	Total area utilized for irrigation, ha	Number of beneficiaries		
			Male	*Female*	*Total*
Gravity	2,916	21,987	43,898	37,260	86,164
Motorized pump	870	3,093	13,962	11,946	26,039
Treadle pumps	11,106	12,757	71,491	54,050	125,471
Watering can	18,810	5,149	75,769	52,401	128,170
Total	**33,702**	**42,986**	**205,120**	**155,657**	**365,844**

Watering can was the technology used by most beneficiaries. While motorized and treadle pumps offer the greatest potential for enhancing productivity, the total area under these technologies constituted 37%. Gravity irrigation, which covered the highest hectarage (51%) is not only inefficient but also causes environmental and health problems such as salination and water-borne diseases.

6.2.2 Water Abstraction Technologies

In order to provide access to clean and potable water, the sector uses Gravity Fed Water Supply Schemes and Hand Pump Technologies (Table 4)

Table 4: Piped Water Schemes (Gravity Fed Schemes & Hand Pump Technologies 2010/11)

Region	Design number of taps	Number of Operational taps	Functionality rate	Design coverage people	Actual coverage people	Lost coverage people
North	2,305	530	23%	276,600	63,618	212,982
Central	1,465	776	53%	175,800	93,174	82,626
South	10,215	4,188	41%	1,225,800	502,578	723,222
Total	13,985	5,494	39%	1,678,200	659,280	1,018,830

Evidently, the functionality of the system is very low, 39% indicating that the capacity to manage and maintain the system is lacking. This is compounded by wanton vandalism and theft of equipment and component parts and absence of enabling policy to adopt locally developed technologies. The MIRTDC has developed cost effective/ robust/ pump guard technology which can enhance the functionality rate (Figure 15).

Figure 15: Water Supply Point Protection Technology

(a) Clamped Pump Guard (b) Pump Guard Mounted, side view

6.3 Challenges and Interventions

The Sector faces several challenges. These are:

(i) vandalism of water supply systems leading to water losses apart from high repair and replacement costs;
(ii) inadequate funding to the sector for construction of new water sources to cater for the increased demand for water arising from population growth;
(iii) ageing infrastructure;
(iv) dwindling water resources; i.e. streams, dambos and rivers due to siltation;
(v) inadequate production capacity of water due to increased water demand;
(vi) lack of equipment (Plants and Machinery) for undertaking construction of dams and boreholes; and
(vii) land tenure problems affecting construction of permanent infrastructures for most irrigation schemes.

To overcome these challenges the following strategies it is important to:

(i) strengthen Water Users Association at a community level to run and manage the water facilities;
(ii) create an enabling environment for use of locally developed technologies for protection of water outlets;
(iii) ensure efficient use of funding;
(iv) enhance catchment protection and management; and
(v) develop capacity to maintain water resources.

6.4 Conclusion

Provision of safe and potable water to all people of Malawi is a priority. However, the water sector experiences challenges which require technological interventions. Thus, there is need to up-scale use of more efficient and effective technologies.

Chapter 7: Health

7.1 Introduction

The overall goal of the sector is to improve the quality of life of all the people of Malawi by reducing the risk of ill health and the occurrence of premature deaths, thereby contributing to the social and economic development of the country (HSSP, 2011-2016). Therefore, the Health Sector is meant to contribute to the attainment of the Millennium Development Goals (MDGs) and Malawi Development and Growth Strategy II (MDGS) goals. The health sector MDG targets for maternal mortality ratio (MMR), neonatal mortality rate (NMR), infant mortality rate (IMR), under-five mortality rate (U5MR) are 155 per 100,000; 12 per 1000; 45 per 1000; and 78 per 1000 respectively by 2015-16.

The key strategic health delivery mechanism in Malawi is the essential health package (EHP). This is a minimum set of interventions which are delivered for free at the point of delivery to more than 85% of the population. The 13 diseases/conditions prioritised in the EHP are: Acquired Immunodeficiency Syndrome due to Human Immunodeficiency Virus 1 (HIV/AIDS), acute respiratory infections (ARI), diarrhoeal diseases, perinatal conditions, non-communicable diseases (NCDs) including trauma, tuberculosis (TB), malnutrition disorders, cancers, vaccine preventable diseases, mental health and epilepsy, neglected tropical diseases (NTDs), eye, ear and skin infections.

The Ministry of Health with its major stakeholders formulated the Health Sector Strategic Plan (HSSP, 2011-2016) to address the burden of disease imposed by the above EHP conditions. This is achieved through various public health interventions such as health promotion, disease control, prevention and surveillance, behavioural change, and community participation. The major outcomes of the HSSP are increased coverage of high quality EHP services, strengthened performance of the health system to support the delivery of EHP services, and improved equity and efficiency in the delivery of EHP services. These services are delivered through various disease control programmes namely: National Malaria Control Programme (NMCP), National TB Control Programme (NTP), NTDs Programme, NCDs Programme, IMCI Programme, HIV/AIDS Unit, EPI Unit and facility-based curative interventions.

7.2 Status of Indicators in 2010 and 2011

7.2.1 Output – Impact Indicators

The sector registered several achievements (DHS 2010). These included reduction in:

(i) infant mortality rate from 76 per 1,000 in 2004 to 66 per 1,000 in 2010;
(ii) under-five mortality rate from 133 per 1,000 in 2004 to 112 per 1,000 in 2010;
(iii) maternal mortality rate from 984 per 100,000 in 2004 to 675 per 100,000 in 2010; and
(iv) malaria in-patient case fatality rate from 7 % in 2004 to 3.2 % in 2010

The Neonatal Mortality Rate (NMR) in 2010 was 31 per 1,000. Malawi experienced an increase in proportion of births attended by skilled health personnel from 38% in 2004 to 75% in 2009. These positive trends are projected to improve further with efficient and sustained implementation of the HSSP.

7.2.2 Input Indicators

Delivery of health services is heavily dependent on key input indicators among which are health personnel (Table 5). There is limited human capital capacity for effective delivery of health services in the country. The Ministry of Health operates with 60% (7,691) of the total staff establishment (12,672) while CHAM hospitals operate with 35% (1,836). The sector is thus beset by high vacancy rates amongst all cadres of the healthcare workforce, making the sector vulnerable. The shortage of human resources affects the quality of laboratory and imaging services. This is evident in the failure by the national reference laboratory to perform certain sophisticated tests and medical engineering to design appropriate technologies.

Table 5: Health Personnel in Malawi in 2010

Cadre	MoH			CHAM		
	Posts	Filled	Vacancy Rate (%)	Posts	Filled	Vacancy Rate (%)
Specialist Doctor	230	33	86	n/a	n/a	n/a
Medical Officer	344	168	51	116	33	71.5
Clinical Officer	756	118	84.3	649	240	63
Medical Assistant	955	683	28.5	245	199	18.5
Reproductive Health Officer	4	8	-100	n/a	n/a	n/a
Nursing Officer	1017	45	95.6	266	96	64
Nursing Sister	n/a	n/a	n/a	1248	329	73.6
Community Nurse	216	48	77.8	363	31	91.4
Enrolled Nurse/Midwife	0	71 n/e	0	1542	154	90
Nursing/Midwife Technician	9057	2473	72.7	847	754	11
Health Education Officer	93	27	71	n/a	n/a	n/a
Health Surveillance Assistant	0	4017n/e	0	n/a	n/a	n/a
Total	12672	7691		5276	1836	

Source: MoH Planning Department and CHAM Secretariat

n/a = Data not available; n/e = non established

The low levels of the health professionals have resulted into the doctor to population ratio falling from 1/46,347 in 2010 to 1/96,370 in 2011. The gains for Malawi have been witnessed with improvement of the nurse to population ratio, which increased from 1/1618 in 2010 to 1/1549 in 2011 (Table 6).

Table 6: Number of doctors and nurses in 2010 and 2011 registered with MCM and NMCM

Nurses	**2010**	**2011**
Registered Nurses	3,350	3,577
NMT[2]/ENM[3]	5,644	6,125
Total	**8,994**	**9,702**
Medical specialists		
Paediatricians	9	5
Obstetricians & Gynaecologist	3	6
Physicians	4	8
Surgeons	8	2
Oncologist	1	1
Pathologists	2	2
Radiologist	0	1
Public Health	2	1
Anaesthesiologists	4	2
Radiologists	1	1
Neurologists	1	0
Haematologists	2	1
Neurosurgeon	0	1
Orthopaedic Surgeon	0	1
Family medicine	3	0
General Practitioners	274	125
Dentists	9	11
Medical Laboratory Technologists	30	28
Clinical Psychologists	1	0
Optometrists	3	1
Psychiatric Clinical Officers	3	1

[2] NMT stands for Nurse Midwife Technician

[3] ENM stands for Enrolled Nurse Midwife

An analysis of the data indicated that the country has limited specialist capacity in key areas of medicine. For example, in 2011 Malawi had one specialist in the following areas: oncology, orthopaedic surgery, neurosurgery and radiology. Until recently, The Ministry did not have established posts for research officers in the Ministry of Health. Currently, the Research Unit has only two Professional Officers.

Thus, the Ministry has weak capacity to commission and conduct research studies. This is compounded by the absence of health research policy and regulatory mechanisms and no funding for research activities. Funding provided meets the wage bill for the Department. This has resulted into the weak disconnect between research and policy review, formulation and practice. The Ministry of Health and the NCST implemented the Health Research Capacity Strengthening Initiative (HRCSI) Programme to build the national capacity in various health related disciplines (Table 7). The country also formulated and launched the National Health Research Agenda (NHRA), which provided a framework for national research in health sciences and management.

Table 7: Cumulative HRCSI Grants in 2010 and 2011

Type of Grants	2010	2011
Research Grants	5	11
MSc training fellowships	31	31
PhD training full	6	6
Small grants	4	8
Undergraduate grants	126	222

7.3 Challenges and Interventions

The health sector continues faces major challenges. These include:

(i) High vacancy rates amongst all cadres of health care personnel;
(ii) Low capacity to conduct research, offer quality laboratory and imaging services, and monitor and evaluate programmes;
(iii) Inadequate basic diagnostic and life support medical equipment;
(iv) Non compliance with national guidelines and standards for Quality Assurance and Management(QA/QM);
(v) The health budget is largely supported by donors,
(vi) Phasing out of the Health Research Capacity Strengthening Initiative(HRCSI) Programme;
(vii) Weak mechanisms for tracking resource inflows through the sector using National Health Accounts; and
(viii) Chronic shortage of drugs and medical supplies.

In order to address these challenges, it is essential that:

(i) The Ministry of Health in conjunction with NCST consolidates the Health Research Capacity Strengthening Initiative(HRCSI) Programme which aims at enhancing institutional capacity for high quality multi-disciplinary health related research studies beyond the Phase 1 whose funding has been withdrawn;
(ii) The country expands the national capacity to conduct research, offer quality laboratory and imaging services, and monitor and evaluation programmes; and
(iii) Malawi provides inadequate basic diagnostic and life support medical equipment to inform disease diagnosis and treatment; and
(iv) The Ministry of Health establishes the National Public Health Institute, as the centre of excellence for quality public health interventions. This entails building the human capital for the health sector.

7.4 Conclusion and Recommendations

The health sector has an important role in the social and economic development of the country. The development of the human capital and provision of research funding, strengthening of laboratory and imaging services and associated basic diagnostic and life support medical equipment are critical for better and sustainable health delivery services.

Chapter 8: Agriculture

8.1 Introduction

Agriculture is the mainstay of the Malawi economy. The sector contributes about 36% of the Gross Domestic Product (GDP), 87% of the total employment, supplies more than 65% of the manufacturing sector's raw materials, provides 64% of the total income of the rural people, and contributes more than 90% of the foreign exchange earnings. It is the main livelihood of the majority of rural people, who account for more than 85% of the current estimated 12-13 million people. Smallholders are responsible for more than 80% of Malawi's agricultural production, but theirs is predominantly subsistence farming, and reliance on rain leaves them vulnerable to bad weather. Investment in productivity enhancements is minimal. To sustain growth in the sector, crop diversification and agro-processing will be critical.

The main economic products of Malawi are tobacco, tea, cotton, groundnuts, sugar and, coffee. These have been among the main cash crops for the last century, but tobacco has become increasingly predominant in the last quarter-century. Tobacco alone accounts for 43% of the agriculture gross domestic product, 60-70% of the country's foreign exchange earnings and 13% of overall GDP and 23% of total tax revenues. The impact of tobacco is significantly felt at the household-level where it provides income or employment for over one third of the country's population. Malawi is the leading exporter of burley tobacco in the world and has substantially increased its production of flue-cured tobacco in recent years.

Major food crops include maize, rice, cassava, sweet potatoes, and a host of legumes including groundnuts, beans and soya beans. Maize is by far the most important food staple in Malawi. Per capita consumption of maize is 133 kg, and it accounts for over half (54%) of the caloric intake of households in Malawi. Cassava and sweet potatoes are also important staple food crops in Malawi. Cassava contributes 7% of total caloric intake, while sweet potatoes and potatoes contribute 8%. In addition, cassava and sweet potatoes become particularly important in low-rainfall years, being more drought-resistant than maize. Rice and wheat products together contribute less than 4% of caloric intake, but they are the preferred staples among urban and high-income households. Over the last century, tea and groundnuts have increased in relative importance while cotton has decreased. In addition to crops, there is a small livestock industry centred on cattle, sheep, goats and chickens. The main industries deal with agricultural processing of tobacco, tea and sugar and timber products.

There are a number of challenges that face agricultural development in Malawi. A major concern is the low level of agricultural productivity and high costs of production. This is due to soil infertility; limitations of most farmers to use fertilizer because of prohibitive costs; a lack of forex for required inputs; a limited number of rural financial institutions; high interest rates; and the extent to which extremely small-scale farmers compose the vast

majority of growers in Malawi making it difficult for them to access markets and engage collectively for better farm-gate prices. Transport cost is another serious problem, along with the development of irrigated farming still at a nascent stage.

However, a number of opportunities also exist for agricultural development in Malawi. As a strategic development sector for the country, it is positioned for major government, private sector, and donor support. The GOM is strongly backing a policy of increasingly diversified and integrated farming. Malawi also offers low formal barriers to trade providing an enabling environment for expansion of export-led agriculture.

To contribute effectively to the economy, Government needs to address the challenges facing the agriculture sector. There is need for creativity and innovativeness in generating and disseminating agricultural technologies, while conserving the natural resource base, to meet the increasing demands for food and cash by all Malawians. It is against this background that the Ministry of Agriculture and Food Security has a vision of 'A nation with sustainable food security and increased agro-based incomes'. To realize this vision, the Ministry's mission is *'to promote and facilitate agricultural productivity so as to ensure food security, increased incomes and creation of employment opportunities through the sustainable management and utilization of natural resources, adaptive research and effective extension delivery system, promotion of value-addition and agribusiness and irrigation development'*. It is in this context that Science and Technology (S & T) fits in the overall development of the agricultural sector.

8.2 Science and Technology Institutions in Agriculture

The key science and technology institutions in the agriculture sector include the Department of Agricultural Research Services (DARS), a public institution which has a network of research stations responsible for research on cereals, legumes and livestock nutrition; the Central Veterinary Laboratory (CVL) another public sector institution responsible for research on livestock diseases; the Agricultural Research and Extension Trust (ARET), a farmer-funded institution which provides research, extension and training services for the tobacco sub-sector, and; the Tea Research Foundation (TRF), a privately funded institution dedicated to the tea industry. The Lilongwe University of Agriculture and Natural Resources (LUANAR), formerly known as Bunda College of Agriculture, conducts some commissioned and student research projects in agriculture. Currently no national institution is charged with the responsibility of research on some key crops such as sugarcane and rubber.

DARS is responsible for crop and livestock research, with the exclusion of tobacco, tea, and sugarcane. The department has three main research stations, four experiment stations and nine substations. Each of the major stations has its own mandate. Chitedze Agricultural Research Station, in the centre of the country, is the largest of the three, employing about half of DARS's researchers, and is responsible for research on field crops, livestock, farm machinery, soil fertility, plant genetic resources, and seed services; Bvumbwe Agricultural

Research Station in the southern region focuses on horticultural and plant protection research; and Lunyangwa Agricultural Research Station, located in the northern region, principally serves as a regional centre for all commodities. DARS's research activities are structured around seven multidisciplinary commodity teams, each headed by a national research coordinator. In addition to research, DARS provides services such as soil and plant analysis, seed testing and certification, training, pest and disease identification, produce inspection, plant quarantine, and plant genetic resource conservation. The DARS has evolved since the establishment of its predecessor in 1940, to become a professional institution with about 45 highly qualified and skilled indigenous scientists and an excellent research infrastructure and facilities that enable it to generate technologies that have impacted greatly on agricultural productivity in Malawi.

The Agricultural Research and Extension Trust (ARET) was established in September 1995 and has now established a network of three research stations at Kandiya in Lilongwe, Mwimba in Kasungu and Kabwafu in Mzimba; 24 field offices throughout the country, and; a training college at Mwimba in Kasungu to assist it fulfil its mandates of research, extension and training for the tobacco sub-sector. The Trust also has a network of laboratories (analytical, plant protection and seed) at its Kandiya Research Station. Its staff compliment comprises of 20 professional staff and 150 technical and support staff. ARET is a unique organisation not only in Malawi but internationally as its organisational setup and funding mechanisms set it apart from others. it is a true reflection of a Public-Private-Partnership as it has the involvement of Government and farmers as its Trustees. It is also unique in that all its funding comes from farmers, who are the beneficiaries of the technologies. The Trust has over the years generated many technologies that have made Malawi very competitive in tobacco production.

The Tea Research Foundation of Central Africa (TRFCA) is a grower funded institution which was founded in 1966. It now has two research stations in Mulanje and Thyolo and until recently had extensive operations in Zimbabwe. The TRFCA has some laboratory facilities including a mini tea factory, climate change growth facility and analytical lab. It has 4 scientists and 22 technical and support staff.

Aside from the three centres, there are other institutions that conduct research in agriculture. For instance, the Central Veterinary Laboratory (CVL), which also falls under the responsibility of Ministry of Agriculture, is a national referral veterinary laboratory, which is supported by two regional and nine district laboratories. CVL's mandate includes veterinary research, diagnostic, public health, and animal quarantine services. It has 8 professional staff. The Sugar Company of Malawi (SUCOMA) has a small R&D unit, employing three researchers who focus on sugar-related agronomic research and herbicide use.

The various agricultural research agencies in Malawi collaborate with each other as well as with regional and international organizations. For instance, four centers of the Consultative Group on International Agricultural Research (CGIAR)—the International Center for

Tropical Agriculture (CIAT), the International Crops Research Institute for the Semi- Arid Tropics (ICRISAT), the International Institute for Tropical Agriculture (IITA), and the World Agroforestry Centre have established offices at Chitedze Research Station, which has strengthened collaboration in the areas of germplasm exchange, capacity building through postgraduate and internal short training activities. Some of these activities are part of regional Southern African Development Community (SADC) projects.

8.3 Funding of Science and Technology (S&T) in Agriculture

Overall, Malawi has achieved the Maputo Declaration of 2003 in which AU states committed to the "allocation of at least 10% of national budgetary resources to agriculture and rural development policy implementation within five years". Since 2005, Malawi has maintained a budgetary provision of higher than 10% to agriculture. However, there has been no undertaking of how much of that allocation needs to be for S and T. As it is, public agricultural research in Malawi has been largely funded by the government, loans from the World Bank, and contributions from foreign donors. In the 1990s, DARS received most of its funding from the national government and the World Bank. In addition to World Bank–supported projects, major contributors included the U.K.'s Department for International Development (Dfid), Japan International Cooperation Agency (JICA), the European Union, USAID, and the Center for International Forestry Research (CIFOR). These funding sources have since diminished their contributions. The other two institutions, ARET and TRFCA, depend on a levy received on tobacco and tea sales respectively. Their budgetary level is, therefore, heavily dependent on production of the commodities each year. This model has been highly successful and needs to be emulated for research on commodities that have a consolidated production and marketing structure.

8.3.1 Status of Indicators

(i) Numbers of Scientific Staff

This indicator gives details of the available scientific human resources in the various research institutions. In this context, a BSc has been taken as a basic qualification for a scientist. The category also includes those with Masters and Doctorates. As shown in Table 8, the total number of scientists in DARS, ARET, TRFCA and CVL marginally increased from 79 to 80 between 2010 and 2011. DARS continues to dominate the human capital base with about 60% of the total number of scientists. The major changes have been one additional scientist each in the areas of soils, plant genetic resources, tissue culture and plant protection. However, there has been an overall reduction in the number of scientists in the critical area of technology dissemination, rendering relevant the question of how technologies will reach intended beneficiaries unless more innovative methods are used. In future, it might be important to disaggregate this data on the basis of gender, levels of qualifications, age and areas of specialisation. It might also make more sense to separate administrative staff from those in technical areas.

Table 8: Number of Agricultural Scientists

Field/Type	2010	2011
Crop Breeding	16	16
Agronomy	13	13
Animal Sciences and Nutrition	9	9
Soil Fertility Improvement	4	5
Farm Mechanization	2	2
Irrigation and Drainage	1	1
Plant Genetic Resources and Conservation	1	2
Technology Promotion and Dissemination	14	12
Tissue Culture	0	1
Plant Protection (Field Diseases and Field Pests)	5	6
Seed Technology	4	3
Plant Quarantine	1	1
Agricultural Economics	7	7
Agricultural Statistics	1	1
Crop Storage	1	1
Total	**79**	**80**

Research Programmes and Activities

The number of research programmes and activities is often a good indicator of research focus. Data in Table 9 shows that, over the two years, there has not been a significant movement in the total number of experiments and trials from 261 in 2010 to 267 in 2011. However, a close examination of the data shows increased focus on legumes and horticultural crops. This is probably as a result of the increased status of these crops in the National Export Strategy as well as their envisaged role in the entire diversification debate. Overall, tobacco has the most number of trials as a single commodity, perhaps a reflection of its economic importance as well as improved access to funding. This is followed closely by programmes on legumes and horticultural crops.

Table 9: Number of Research Projects Implemented by Field

Field/Thematic Area/Subject	2010	2011
Cereals Research (Maize, rice, sorghum and millet)	39	40
Horticulture (Root and Tubers, fruits/vegetable, tree nuts	47	49
Legumes, Fibres and oil seed crops(Pulses, ground nuts, cotton, and sunflower)	43	48
Livestock and pastures	12	12
Soils, Irrigation and agricultural engineering	20	21
Plant Protection (Field diseases and field pests	21	19
Technical Services (Seed Quality Control, Genebank, Economics, Statistics, Library)	16	14
Tobacco (Breeding, agronomy, plant protection)	54	52
Tea (Breeding, agronomy, plant protection)	9	12
Total	**261**	**267**

(ii) Technologies Released

The number of technologies released is a very good indicator for science and technology as it implies an output of any programme and the likely impact that programme might have. The approval of new agricultural technologies is done through the Agricultural Technology Clearing Committee (ATCC) of the Ministry of Agriculture. The ATCC has set up procedures for this process. Over the two years, a total of 68 technologies have been approved by the ATCC, and the bulk of these have been on tobacco, beans and sweet potato (Table 10).

Most of the released technologies were new varieties that are more productive and new chemicals that have been evaluated and found to be effective in controlling major diseases and pests. This is a major achievement as most of the research programmes are undertaken over a long period of time, up to 10 years for variety development. What is lacking, however, is the patenting of the technologies; hence most of them remain unprotected. In the long run patenting could be used as an indicator for science and technology and scientists and their institutions need to be encouraged to patent their technologies.

Table 10: Number of Technologies Approved for Public Use

Field	2010	2011
Maize	3	3
Rice	2	2
Bean	7	7
Potato		6
Sweet potato	3	7
Cassava	3	
Cowpea	1	
Pigeon pea	1	
Soybean	1	1
Banana	2	
Potato (aeroponics)	1	
Crop storage	2	
Tobacco	10	6
Total	36	32

(iii) Investments in Scientific Infrastructure

This indicator aims at showing whether investment in research infrastructure (buildings, equipment and facilities) has been undertaken during the years under review. During the year 2011, the tea and tobacco research institutions invested about USD0.7 million in the procurement of laboratory equipment for the tobacco analytical laboratory and installation of an 'Automatic Rain Shelter', a facility that simulates climate change and drought for tea research. These facilities will enhance the undertaking of various research programmes.

(iv) Total/Gross National Agricultural Production

Production estimates, among other things, reflect technology uptake and therefore are a good indicator for science and technology in agriculture. The situation in Malawi has an even greater bearing as the Farm Input Subsidy Programme (FISP) promotes improved crop varieties and fertiliser inputs. Similarly, the newly introduced tobacco Integrated Production System (IPS), enables farmers to access seed of recommended varieties, chemicals and fertilisers, thus promoting technology use. In both cases, technologies have become a key driver to the overall production system.

An analysis of the national production estimates (Table 11) shows that the productivity of most crop commodities increased across the two years. For instance, in maize, groundnuts, tobacco, cotton, pulses, cassava and potatoes the increase in tonnage is much higher that the increase in hectares of land showing increased productivity per unit area. This can be attributed to use of improved production technologies such as improved seed varieties, fertilisers and agronomic practices in addition to favourable weather.

Table 11: Crop production estimates for 2010 and 2011

CROP	AREA Hectares)	PRODUCTION (Tonnes)	AREA Hectares)	PRODUCTION (Tonnes)	% INCREASE	
	2010	2010	2011	2011	Hectares	Tonnes
MAIZE	**1,696,270**	**3,419,409**	**1,732,371**	**3,895,181**	**2**	**14**
Local	518,568	477,788	482,601	467,126	-7	-2
Composite	534,316	1,061,240	540,717	1,167,681	1	10
Hybrid	643,326	1,880,182	709,053	2,260,374	10	20
OPV Seed	60	199				
RICE	**59,098**	**110,106**	**61,559**	**117,733**	**4**	**7**
Local	30,088	36,624	17,956	42,805	-40	17
Faya	11,126	24,490	10,336	23,068	-7	-6
Pussa	3,640	11,184	3,865	12,052	6	8
TCG 10	2,050	8,440	2,117	8,349	3	-1
IET4094(SENGA)	268	478	320	668	19	40
Kilombero	11,569	27,723	12,340	29,839	7	8
Mtupatupa	357	1,167	281	952	-21	-18
GROUNDNUTS	**295,236**	**297,487**	**308,094**	**325,215**	**4**	**9**
Chalimbana	150,823	126,654	151,701	130,313	1	3
Manipinter	136	151	98	111	-28	-26
Malimba	9,764	6,602	9,407	6,882	-4	4
CG 7	126,078	154,198	137,754	176,467	9	14
JL 24 & Nsinjiro	8,435	9,882	9,134	11,442	8	16
TOBACCO	**165,557**	**172,972,943**	**162,714**	**174,927,709**	**-2**	**1**
NDDF	4,656	3,310,912	5,957	4,622,921	28	40
Flue Cured	5,414	7,185,351	7,429	9,797,330	37	36
SDDF	32	16,084	188	139,186	488	765
Oriental	306	179,140	0	0		
Burley	155,149	162,281,456	149,140	160,368,272	-4	-1
COTTON	**47,209**	**29,165**	**59,626**	**52,456**	**26**	**80**
WHEAT	1,548	2,341	1,216	1,850	**-21**	**-21**
SORGHUM	**88,468**	**53,932**	**89,602**	**73,330**	**1**	**36**
MILLET	47,892	24,495	**46,351**	**32,911**	**-3**	**34**
Finger			45,359	32,476		
Pearl			992	435		
PULSES	**658,003**	**470,489**	**678,232**	**531,967**	**3**	**13**
Beans	288,566	152,398	297,627	176,760	3	16
Pigeon peas	190,437	193,005	196,552	220,017	3	14
Cow peas	66,776	26,183	70,599	31,928	6	22
Field peas	4,125	2,623	4,247	2,619	3	0
Grams	1,593	864	1,812	1,174	14	36
Soya beans	75,186	73,356	75,839	75,665	1	3
Dolichus beans	5,205	2,762	5,417	3,157	4	14

Velvet beans	10,465	8,641	10,592	9,514	1	10
Ground beans	13,371	9,413	13,224	9,492	-1	1
Chick peas	2,086	1,244	2,157	1,641	3	32
CASHEW NUTS	84,389	456	95,689	479	**13**	**5**
MACADAMIA	**69,136**	**1,582**	**78,844**	**2,150**	**14**	**36**
SESAME	2,184	544	2,155	798	**-1**	**47**
SUNFLOWER	**10,873**	**9,175**	**12,437**	**10,621**	**14**	**16**
PAPRIKA	**3,926**	**395,556**	**2,956**	**1,397**	**-25**	**-100**
CHILLIES	3,107	1,780	3,100	1,966	0	10
CASSAVA	**195,828**	**4,000,986**	**200,139**	**4,316,373**	**2**	**8**
S.POTATOES	179,933	2,897,888	188,705	3,223,263	**5**	**11**
POTATOES	**48,805**	**775,650**	**52,689**	**928,941**	**8**	**20**

Source: Ministry of Agriculture (2010, 2011). National Crop Estimates

Similarly, there has also been a general increase in the numbers of livestock (Table 12) and quantities of meat (Table 13) and dairy products over the two years. The largest increases have been registered in the number of chickens as well as quantities of chicken meat. However, the volumes of dairy milk have diminished.

Table 12: Numbers of livestock and volumes of livestock products for 2010 and 2011

Type of Livestock	2010	2011
1. Chickens		
(i) Indigenous Chickens	21,683,889	24,796,788
(ii) Broilers	16,627,188	27,405,810
(iii) Layers	5,635,298	5,685,626
(iv) Black Australorp/Mikolongwe Chickens	725,711	802,717
Total All Chickens	44,672,086	58,690,941
2. Cattle		
(i) Beef Cattle	1,060,221	1,106,787
(ii) Pure Dairy Cattle	11,136	12,247
(iii) Dairy Crosses	39,203	45,454
Total All Cattle	1,110,560	1,164,488
3. Pigs		
(i) Indigenous Pigs	1,924,773	2,117,069
(ii) Small Scale Exotic	222,553	296,571
(iii) Commercial Exotic	13,344	19,532
Total All Pigs	2,160,670	2,433,172
4. Goats	4,442,907	4,929,808
5. Sheep	228,649	240,269
6. Rabbits	1,022,864	1,229,193
7. Guinea fowls	1,350,585	1,568,371
8. Turkeys	145,486	177,394
9. Doves/Pigeons	2,560,964	2,932,538
10. Ducks	1,014,869	1,212,103
11. Guinea Pigs	170,721	216,565

Table 13: Livestock Products

Meat and Dairy Products		
Category	Amount	
	2010	2011
1. Meat		
(i) Beef (Cattle Meat)	34,055,000	35,072,000
(ii) Goat Meat	27,796,000	29,779,000
(iii) Mutton (Sheep Meat)	1,065,000	1,123,000
(iv) Pig Meat	67,217,000	207,742,000
(v) Chicken Meat*	54,746,000	74,356,000
(vi) Rabbit Meat	4,886,000	5,871,000
(vii) G/Fowls Meat	1,711,000	1,987,000
(viii) Turkeys Meat	186,000	225,000
(ix) Doves/Pigeon Meat	3,245,000	3,716,000
(x) Ducks Meat	1,284,000	1,534,000
Total Meat Production	196,191,000	361,405,000
**All chickens(indigenous chickens, Broilers, Layers and Black Australorp)*		
2. Milk	101,411,000	58,568,000
3. Eggs		
(i) Eggs from Chickens**	3,556,000	4,170,000
(ii) Eggs from G/fowls	179,000	208,000
(iii) Eggs from Turkeys	17,000	23,000
(iv) Eggs from Pigeons	188,000	212,000
(v) Eggs from Ducks	118,000	145,000
Total Egg Production	4,058,000	4,758,000
***All chickens(indigenous chickens, Broilers, Layers and Black Australorp)*		
4. Hides	308,636	323,045
5. Skins		
(i) Skins from Goats	2,850,214	3,165,057
(ii) Skins from Sheep	99,148	103,174
Total Skins	2,949,362	3,268,231

Table 14: Sales of Chickens

Breed (DAHI sales)	2010	2011
Black Australorp (Mikolongwe Chickens)	**276,322**	**359,908**

8.3.2 Challenges and Interventions

The Key Challenges to Science and Technology in Agriculture include:

(a) **Low and Unpredictable public funding** – public funding for science and technology has often been low rendering the implementation of a comprehensive

research programme almost impossible. In addition, since funding for public research is through Government budgetary provisions and sometimes donor funding, it is subject not only to Government priorities but also availability of resources. Hence funding for science and technology in agriculture is often unpredictable and has in the past led to lack of continuity of research programmes.

(b) **Inadequate scientific capacity** – the data presented on human resources shows that scientific capacity has remained static. This is indeed a key challenge as successful research programmes will require constant development of scientific capacity. There appears to be no concerted efforts to uplift the national scientific capacity. It is important that this resource base is enhanced through recruitment and training of staff to attain various skills. It is only through well trained human resources that innovations will be enhanced. There is a need to have a consolidated human resource capacity building plan for the agriculture sector so that scientific capacity is brought to a level that enhances innovation.

(c) **Poor infrastructure and equipment** – investments in new facilities and infrastructure are quite low. Research centres lack basic facilities for meaningful research. In addition, the various institutions independently build capacity at their own level, leading to duplication of effort. A concerted and deliberate effort is necessary to build infrastructure and procure equipment for Science and Technology. Again, there is need to have a consolidated plan of action for building national capacity in terms of scientific infrastructure, equipment and facilities.

8.3.3 Conclusions and Recommendations

The contribution of science and technology to the growth of the agriculture sector is enormous. However, it does not appear to be matched with resource allocation. It is therefore, important that Government determines a predictable minimum level of funding as a percentage of the total agriculture budget along the lines of the Maputo Declaration for S & T in agriculture. Similarly, it is critical that a consolidated capacity building programme be undertaken to build scientific capacity as well as infrastructure for a successful science and technology programme.

There is growth in the various indicators presented here. However, it is important that there is a deliberate effort at clarifying and quantifying the various indicators that would be used to determine efforts and impacts of Science and Technology on the sector. Over a period of time, this could result on a reliable databank that can be used to show impact and point at areas of weakness and strength.

Chapter 9: Energy and Mining

9.1 Energy Sector

9.1.1 Introduction

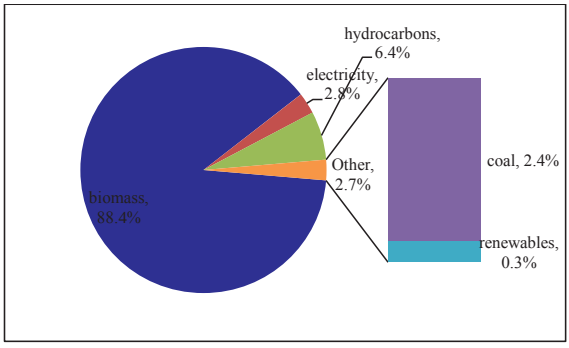
Energy drives economic growth and development. Indeed energy is an essential part of most if not all human activity since it enables heating and lighting as well as providing motive power needed at both household and industrial levels. By way of examples, energy underpins the provision of clean water by our water utility companies and pumping of riverine and ground-water for irrigating sugarcane fields at Nchalo and Dwangwa and tea plantations in the Shire Highlands. It facilitates provision of health services by enabling preservation of vaccines, sterilization of medical equipment and use of x-ray machines in our hospitals. It also powers the communication networks provided by Malawi's service providers such as TNM and Airtel and its abundant availability is a pre-condition for the much needed investment in the mining sector which is becoming a new source of economic growth in Malawi. Clearly, therefore, energy is a critical input into Malawi's economic development and its consumption, measured in terms of energy use per capita, is an important indicator of development. Thus, a well-developed and efficient energy system that maintains and improves productivity, facilitates new investments; and generally supports high economic activity is essential for Malawi's development. Hence, measures taken at all levels of Malawi society to expand supply and use of energy are vital for sustaining economic gains. Science, technology and innovation as they obtain in Malawi's knowledge networks in the academia, public and private research organizations and, indeed, private enterprises provide bases for stimulating programmes and activities aimed at expanding supply and use of energy in the economy.

9.1.2 Characterizing the Energy Sector: State of Indicators

From an energy-mix perspective, Malawi has, historically, been highly dependent on biomass. As Figure 16 shows, biomass accounted for 88.4% of the energy consumed in 2008 (Taulo et al., 2013)[4]. Hydrocarbon (petroleum) products contributed 6.4% while the contribution of electricity and coal stood at 2.8% and 2.4% respectively (ibid).

[4] We report the 2008 indicators because they are the most recent for which reliable data is available (Taulo et al., 2013).

Figure 16: Total Primary Energy Supply in Malawi (2008)



Source: Taulo et al., 2013

It will be observed, by way of comparison with projections of Malawi's energy-mix made in the National Energy Policy 2003 presented in Table 15, that while the country has made some progress towards reducing dependence on energy from biomass by enabling both rural and urban populations access electricity as a form of modern energy, the ratio of electricity in the consumption mix, then at 2.8%, was still a long way from the projected level of 10% by 2010.

Table 15: Energy-mix Projections: 2000 - 2050 Percentages

Type of energy	2000	2010	2020	2050
Biomass	93	75	50	30
Liquid fuels	3.5	5.5	7	10
Electricity	2.3	10	30	40
Coal	1.0	4.0	6	6
Renewables[5]	0.2	5.5	7	10
Nuclear	0.0	0	0	4
Total	100	100	100	100

Source: Malawi Government (National Energy Policy, 2003)

On the positive side, consumption of liquid fuels at 6.4% had, by 2008, already surpassed the projected proportion of 5.5% that was to be attained by 2010. This is most likely due to increasing numbers of vehicles on the roads of Malawi and the need for businesses to augment their energy needs by installing standby generators to mitigate the frequent loss of electricity supply from the national grid. Nonetheless, the nation is vulnerable to international trends and geopolitical conditions given the indicators on importation of petroleum products included in Table 16.

[5] Renewables include solar, wind, biogas

Table 16: Quantity of fossil fuels imported by type

Type	Unit of Measurement	Number	
		2010	2011
Petrol	Litres	110,517,996	96,623,768
Diesel	Litres	207,342,707	166,062,232
Paraffin	Litres	11,517,996	8,526,457
Coal	Tonnes	6.2	17.2

Source: MERA

It will be noted from Table 16 that despite increasing population of vehicles and people, Malawi imported less hydrocarbon based liquid fuels in 2011 relative to 2010 with diesel registering the highest rate of decline of nearly 20%. Diesel is a major source of energy for powering the distribution sector which contributes significantly to national income.

The National Energy Policy 2003 projected that by 2010 renewable energy technologies would constitute 5.5% of the energy-mix. However, it will be noted from Figure 16 that by 2008 contribution of renewable energy sources to the energy-mix stood at 0.3%. It is unlikely that this level of achievement had changed significantly by 2011 given that there was scaling down of public sector interventions aimed at promoting use of solar technologies. Nonetheless, these public sector interventions undertaken in the early 2000s led to the establishment of a number of private sector enterprises that continue to trade in solar technologies in Malawi. In addition, despite a moderately high potential[6], national action to promote biogas use for domestic cooking especially has not been vigorously pursued. From a technical perspective, there is inadequate knowledge and expertise in local institutions to implement a national biogas technology development programme (Department of Energy). This is exacerbated, from a social perspective, by reluctance by the populace to accept innovations entailed in the use of biogas which may require users to handle animal and human waste let alone use gas from these resources for domestic cooking. From a systemic approach to innovation, this suggests the need for the science, technology and innovation system in Malawi to build capacity regarding both technical and social aspects of biogas technologies. Finally, the indicator regarding use of coal shows that while progress was made towards the target of 4.0% by 2010, more needed to be done given that by 2008 the contribution of coal to the energy mix stood at 2.4%.

These characteristics of the Malawi energy sector underpinned a low per capita energy consumption indicator such that as at 2008, total energy consumption stood at about 300 kg of oil equivalent per capita (BEST, 2009; Taulo et al., 2013)[7]. The global average is 1851 kg of oil equivalent per capita (World Bank, 2013). This places Malawi among the countries with very low energy consumption: a feature consistent with the country's low ranking on the UN Human Development Index.

[6] According to Kraemar(1996) and Wasser (1997) the potential for biogas in Malawi based on 1995 animal population data was around 317 573 cubic metres of gas per day or 2724 TJ per year.
[7] Lack of data makes it impossible to provide the current energy use intensity.

9.1.3 Challenges and Interventions: Programmes in the Energy Sector

In order to enhance supply and use of energy in the economy, a range of programmes and activities were undertaken during the period 2010-2011 and actors in Malawi's science, technology and innovation systems[8] made specific contributions. The highlights of these programmes, organized along the main components of the country's energy mix, are presented below.

9.1.3.1 Biomass and Bio-fuels

Unsustainable use of biomass energy is a major challenge in the energy sector because the high dependence on fuel-wood and/or charcoal not only for domestic cooking but also for industrial activities such as curing tobacco and tea processing leads to deforestation. Thus, actions leading to development and promotion of energy efficiency cookstoves especially are essential. During the period 2010-2011, both public and private sector actors took various actions to promote clean and efficient cook stoves, conduct research and development on affordable biomass and bio-fuels; and promotion of use of bio-fuels in transport.

9.1.3.1.1 Promoting Clean and Efficient Cook Stoves

A number of projects were implemented during the period under review to promote use of clean and efficient cook stoves in the country. With funding from UNDP, under the Poverty and Environmental Initiative (PEI) Program, the Department of Energy Affairs promoted use of clean and efficient cook stoves in Dedza, Ntcheu, Balaka and Machinga districts. Under yet another UNDP-funded Project called Environment and Energy for pro-Poor Growth Project (EEPG), the Department promoted the stoves in the cities of Blantyre, Zomba, Lilongwe and Mzuzu. EEPG completed a Government-funded Promotion of Alternative Energy Sources Project (PAESP) which also concentrated on promotion of these stoves in the said cities. About five (50) groups comprised of men and women were formed in each of these sites, and each group having about forty (40) people. The groups were trained in production, use and marketing of the stoves.

Several non –governmental organizations (NGOs) also took part in promoting clean and efficient cook stoves, notably Mulanje Renewable Energy Agency (MuREA), Concern Universal, and Total Land Care (TLC). MuREA concentrated on promotion of these stoves in Mulanje and Phalombe districts, while Concern Universal concentrated in Balaka District and TLC worked across the country.

9.1.3.1.2 Promoting use of Bio-fuels in Transport

The major activity in this area was the research and development work supported by the Government of Malawi to develop technology for the ethanol-driven vehicle. During the period under review, the National Commission for Science and Technology with the

[8] The system referred to comprises actors from the private and public sectors; and the academia.

support of Lilongwe Technical College completed the related research work which started in 2006. The research work showed that use of ethanol for powering motor vehicles was a viable alternative in Malawi (figure 17). Thus, the output of the research has been an important basis for recommendations that were to eventually be submitted to Cabinet for approval.

Figure 17: One of the Nissan Tiidas successfully tested on Ethanol Blends displayed at Comesa Hall in Blantyre

Source: NCST

From a private sector perspective, BERL Limited continued to be active in taking actions to promote the planting of jatropha with the intention of using it in the production of bio-diesel in Malawi.

9.1.3.2 Petroleum

Malawi's high dependence on imported liquid fuels is yet another challenge in the sector. Indeed, triggered by economic factors related to prevailing geo-political conditions, Malawi experienced severe problems regarding supply of petroleum fuels during the period 2010-2011. This exposed, in the process, the country's capacity limitations on storage of reserve petroleum products. Consequently a major programme conceived by Government with the support of private sector players was the construction of fuel reserve storage tanks with the aim of increasing national fuel security.

9.1.3.3 Renewable Energy Technologies

Since the coming to an end of the Barrier Removal to Renewable Energy in Malawi (BARREM) Programme in 2007, public action to directly promote solar technologies has been sparse. Among other intentions, the BARREM programme aimed at leveraging the cost to end users of renewable energy technologies which is a major challenge. Nonetheless, Mzuzu University and UNIMA (Polytechnic), whose capacities in solar energy technology was enhanced during the BARREM programme continued to offer training in solar technologies thereby addressing the challenge of shortage of technical renewable energy experts at both certificate and graduates levels. This supported private sector actors in the solar energy sub-sector some of whom (e.g. Global Solar - Malawi) are becoming known market players in the region. Although small, and with partial funding from the IRLARD Project, action was taken by the Malawi Industrial Research and Technology Development Centre (MIRTDC) towards the development of windmill technology for irrigation at Nkhate Irrigation Scheme in Chikhwawa district.

Figure 18: Windmill technology under development at Nkhate Irrigation Scheme in Chikhwawa

Source: MIRTDC

9.1.3.4 Electricity

Regarding electricity, two initiatives that were active in the period 2010-2011 are noteworthy. First, Malawi undertook preparatory actions leading to the coming into effect of the Millennium Challenge Corporation where Malawi was expecting to receive support from the US government towards rehabilitation of existing capacity to generate and distribute electrical energy. The second action was the preparatory actions by Government and ESCOM regarding completion of phase 2 of Kapichira hydropower station. Regarding micro and mini-hydro electricity generation, benefiting from funding from the Malawi Environmental Endowment Trust (MEET), MIRTDC took initial steps towards

rehabilitation of the Matandani mini-hydro scheme in Neno district. These actions were expected to make some contribution towards mitigating the challenge of high demand for electricity in a context where installed supply capacity has been constant.

9.1.3.5 Coal

From a technology development perspective, the Malawi Industrial Research and Technology Development Centre embarked on research aimed at developing, using locally available materials, a more efficient, affordable and safe coal-burning stove whose use would result in low consumption rates of fuel as well as reduce indoor air pollution.

9.2 The Mining Sector

9.2.1 Introduction

The importance of the mining sector to Malawi's development cannot be over-emphasized if lessons from other countries such are taken into account. Botswana has become a middle income country thanks to diamond mining. Mining contributes billions of dollars to Australia's economy and employs over 750,000 people (http://www.thisisourstory.com.au/). In Malawi, by contrast, the mining sector has, historically, not been prioritised with the consequence that in 2009 its contribution to GDP stood at 1.2%. This changed during the period 2006-2011 when, under MGDS I, the mineral sector was singled out by Malawi Government as one of the sectors with enormous potential to significantly boost the economy of Malawi other than agriculture. Following this action, the sector, constituted by the Ministry of Mines as the apex body providing policy leadership and strategic direction and a host of private sectors actors such as firms and specialized associations/cooperatives, was vigorously promoted and marketed both locally and internationally with a view to attracting investor interest. Consequently, there have been increased numbers of prospective investors engaged in geological exploration and/or mining of petroleum, coal, uranium, niobium, heavy mineral sands, etc; implementing, in the process, considerable and sound staff recruitment and training strategies. There has also been an increased number of small scale miners trained and assisted with value adding machinery. Above all there has been an increase in government revenue collection arising from economic activities in the sector. The key achievements are presented below with focus on the role of science, technology and innovation systems.

9.2.2 Characterizing the Mining Sector: State of Indicators

Malawi is endowed with significant quantities of a wide range of mineral resources. Prior to and after independence in 1964, geo-scientists at the Geological Surveys Department (GSD) conducted field research that has formed the basis for production of detailed geological and mineral occurrence maps of Malawi showing the location and quantities of what are now known mineral deposits (Table 17). Laboratory analysis done in Malawi and elsewhere has also enabled determination of the quality of the deposits thereby facilitating assignment of their grades.

Table 17: Known Mineral Deposits, Reserves and Grades

DEPOSIT	LOCATION	DELIANATION RESERVES
		(Million tonnes/ grade)
Bauxite	Mulanje	28.8/43.9% Al2O3
Uranium	Kayelekera	12,5/0.15% Ur3O8
Monazite/Strontianite	Kangankhunde	
	Karonga/Chitipa	
Corundum	Chimwadzulu-Ntcheu	11.0/8% Sr and 2% REO
Graphic	Katengeza - Dowa	8.0/75.6gm per m3
Limestone	Malowa Hill - Bwanje	15/48% CaO, 1.2%
Chenkumbi - Balaka		MgO
Titanium Heavy		
Mineral	Nkhotakota - Salima	700/6.0% HMS
Sands	Chipoka	
	Mangochi	680/6.0% HMS
	Halala (Lake Chirwa)	15/6.0% HMS
Vermiculite	Feremu - Mwanza	2.5/4.9% (Med+Fine)
Coal	Mwabvi - Nsanje	4.7/30% ash
	Ngana - Karonga	15/21.2% ash
Phosphate	Tundulu - Phalombe	2.017% P2O5
Pyrite	Chisepo - Dowa	34/8%S
	Malingunde - Lilongwe	10/12%S
Glass Sands	Mchinji Dambos	1.6/97% SiO2
Dimension Stone	Chitipa, Mzimba	Blue, Black, Pink, Green
	Mangochi, Mchinji, Chitipa	Granite
Gemstones	Mzimba, Nsanje, Chitipa Chikhwawa, Rumphi, Ntcheu	Numerous pegmatites and volcanics

Source: Geological Surveys Bulletins and Private Companies Mineral Exploration Reports

During the period 2010 – 2011 a number of scientific works were undertaken by actors in the sector a synopsis of which follows.

9.2.2.1 Remapping the geology of Malawi

An agreement with the French Government to support the remapping of the Geology of Malawi was reached. In addition, the Ministry finalized negotiations with the World Bank and EU on the Mining Governance and Growth Support Project which was to, among other effects; facilitate the carrying out of a countrywide airborne geophysical survey and establishment of Geo-data Management Centre for GSD and cadastre system for Department of Mines. In preparation for establishment of Geo-data Centre, the GSD started computerizing the geo-data that hitherto was in analogue format. The IT capacity of GSD

was enhanced with desktop and laptop computers and appropriate software (ArcGIS) to support this development.

9.2.2.2 GIS, Remote Sensing and Mineral Research

In the public sector a major research activity was the undertaking of field cross checks (ground truthing) on possible rare earth elements (REE) mineralization in areas initially identified by remote sensing technology in Mangochi, Liwonde, Balaka, Mwanza, Ntcheu, Thyolo, Mulanje and Chiradzulu Districts. This activity was conducted in conjunction with the Japan Oil, Gas and Metals National Economic Corporation (JOGMEC). The Southern region of Malawi has potential for these minerals.

In the private sector, following issuance of related licences, a range of studies and technological research work activities were undertaken including those summarized in Table 18.

Table 18: Private sector Technology Development Efforts

Research Activity	Implementing Firm
Niobium, Zirconium and Uranium separation to come up with a final process flow sheet for the Kanyika Niobium deposit.	Globe Metals
Separation process for rare earth minerals at Songwe deposit in Phalombe	Mkango Rare Earth
Concentration trials for the Tundulu phosphate deposit	Optichem Limited
Exploration and Process development for the Makanjira heavy mineral sands	ZTE
Uranium exploration over Livingstonia, Hara and Mwankenja coalfields	Globe Mining Company and Paladin Africa
Gold exploration over Misuku and Dwangwa areas	SEAM Limited
Trial processing of Lulwe limestone for cement production	Rift Valley Minerals
Re-evaluation of the Golomoti limestone deposit and re-analysis of results	Bwanje Cement Company
Limestone Exploration in Mangochi at Chiripa	Zagaf Cement Sales
EIA Study in readiness for oil exploration in blocks 2 and 3 over Lake Malawi	Surestream Oil Company
Re-evaluation of Tengani Minerals Project (Zirconium, Rutile, Titanium, Illmenite)	SGS South Africa

Source: Department of Mines

Thus, in the period 2010-2011, Malawi experienced a boom in mining exploration activities with a number of companies both local and foreign being issued with licences (see Table 5) to actively pursue intensive exploration for minerals in different parts of the country. In addition, in order to respond to social change as an aspect of the innovation system, some firms notably Globe Metals and Mining embarked on intensive public consultations with

different stakeholders and the local community around the project area in Mzimba to update them on the progress of the project.

9.2.2.3 Seismic Monitoring and Geo-environmental mapping and assessment

Malawi lies within the EARS and remains seismically active. In response to its responsibility with respect to monitoring geo-hazards such as earthquakes and landslides, GSD installed modern equipment at 10 seismic stations across the country expanding in the process coverage beyond the three old stations at Zomba, Lilongwe and Mzuzu which depended on outdated seismic technology. Further, collaborative research between GSD and the Federal Institute of Geosciences (BGR) of Germany focused on environmental geology covering such areas as geo-hazards assessment of Zomba; and identification and mapping of geo-hazards prone areas in Mzuzu City and part of Mzuzu- Nkhata Bay Road. This supported, for example, the identification and technical design of a new site for a waste management facility in Mzuzu.

Table 19: New Mining and Prospecting Licences issued in 2010

Type of Licence	*Number Issued*	*Mineral(s)*
Small Scale Operators		
Non-Exclusive Prospecting Licence	62	Gemstones, Ornamental stones
Mining Claim Licence	41	Gemstones, Ornamental stones
Reserved Minerals Licence	41	Gemstones, Ornamental stones
Large Medium Scale Operators		
Exclusive Prospecting Licence	36	Uranium, Heavy Mineral Sands, Base Metals, and Platinum Group Metals, Limestone, Gypsum, Iron Ore, Glass Sands
Mining Licence	5	Quarry aggregate, heavy mineral sands,limestone, Rear Earth Mineral
Reconnaissance Licence	0	

Source : Department of Mines

9.2.2.4 Laboratory Services and Mineral Inspection

The capacity of the Mines Environmental Laboratory in the Department of Mines (DoM) was developed through the acquisition of necessary equipment such as Gamma and Beta scintillators, portable dust monitoring apparatus and methane and other gas monitoring equipment. This enabled the Mines Department to commence quarterly monitoring of water quality in all catchments engaged in coal production operations. In the case of the GSD, although its analytical and industrial minerals laboratories in Zomba and Linthipe and coal analysis laboratory in Lilongwe continued to conduct tests and analyses of its own geological samples and samples from individuals as well as those from some private companies, most of private companies continued to send samples outside the county for analysis on account of inadequate technologies and capacity locally. Nonetheless, GSD enhanced its capabilities by, among other actions, procurement of a portable XRF machine for field sample testing. These capabilities were used to; for example, identify rare earth deposit for Gold Canyon Exploration in Mulanje. The Department also used its capabilities to inspect about 25,000 tonnes of rock, mineral and soil samples and gemstones for export with an estimated value of over MK20 billion.

9.2.3 Sectoral Performance

Arising from there developments, there was general increase in mineral production and sales (Table 20). For example, relative to 2009, coal production volumes grew by 34% and 40% in 2010 and 2011 respectively. Increased level of activities in infrastructure development contributed to growth in the volume of rock aggregates. Growth was also realized with respect to production of agricultural lime, cement, uranium concentrate, dimension stone and rock aggregates. Coal production also increased slightly due to higher demand for industrial use especially in the tobacco processing companies, cement and brewery companies both within and outside the country. Mineral exports included coal, uranium concentrate, stone aggregate, granulated clay and gemstone. However, gemstone production decreased although the sales value increased as indicators show (Table 20). It is likely that the improved organization of the sector fostered by training in gemstone prospecting and identification techniques of local small scale gemstone miners in the country led to a reduction in smuggling and availability of reliable and legitimate buyers. About 21,000 people were involved in the extraction of these minerals. In 2009 the mining sector contributed 1.2% to the GDP while in 2011 its contribution increased to 10%.

Table 20: Mineral Production Volumes and Values

Mineral	2009		2010		2011	
	Quantity (tonnes)	Value (K'million)	Quantity (tonnes)	Value (K'million)	Quantity (tonnes)	Value (K'million)
Coal	59 201	364	79 186.34	627.293	83,145.67	658
Cement Limestone	47 150	30.7	57 296	38.840	60,160.8	40.7
Agriculture Lime	25 900	16.84	31 790	123.459	33,379.5	129.63
Other						
Uranium Concentrates	58.582	1,287	772.622	18, 394.43	951.38	20,046.18
Granulated Clay	8,050	39.54	1,020	5.355	None	None
Dimension Stones	240.6	5.6	435.9	13.861	457.69	14.55
Rock aggregate	970 550	1 941	989 750	2 050	1,039,237	2 ,152.5
Gemstones	306.7	253.61	206.98	606.001	217.33	636.3
Terrazzo	12 355	12.7	4,434	19.1	6,651	28.65

Source: Department of Mines

In order to support these developments, the public sector invested in human capacity development through short and longer-term training (Table 21). Public officers attended short-term training in such areas as remote sensing and GIS, seismic data analysis, geological mineral databases management, computer-based mineral exploration techniques, earthquake monitoring and warning systems as well as medium term training leading to Masters Degrees in Geology. Nonetheless, there are still gaps in human capabilities especially that in some of the areas of competence the number of incumbents can be a low as 1. Thus, capabilities can be lost easily through normal attrition which is, in Malawi as elsewhere, exacerbated by the HIV/AIDS pandemic.

Table 21: Courses and Number of Officers Trained, 2010 – 2011

Course Title	Number of Officers trained	Year	Country of study	Funding agency
Remote sensing and GIS	5	2010	Botswana	JOGMEC, GoM
Remote sensing and GIS	5	2011	Botswana	JICA
Geothermal Surface exploration	2	2010	Kenya	UNU-GTP, KenGen, GDC, GoM
Geothermal Surface exploration	1	2011	Kenya	UNU-GTP, KenGen, GDC, GoM
Seismic data analysis	2	2010	South Africa	GoM, African Array
Geological, Mineral Databases management	2	2010	Namibia	GoM
GIS & Remote Sensing	1		Japan	JICA, GoM
Computer based mineral exploration techniques	1	2011	France	French Embassy
Earthquake Monitoring and Warning Systems	3	2010	China	GoM
Master of Science degree in Geology	2	2010-2011	University of Fort Hare, RSA	GoM
Master of Science degree in Geology	1	2011	James Cook University, Australia	Australia Gov
Sustainable Mining Operations	3	2010	Kosaka Institute of Mining	Japan
Uranium Mining Monitoring Techniques	6	2010	Tunisia, Uganda, Gabon and Madagascar	IEAE organised courses
Mineral Processing Techniques	3	2010	Egypt	Arabian Development/South South Dev organisation
Negotiating Mining Agreements and Policy	2	2010	Senegal	IDEP

Geo-data and GIS Management	2	2010	Curtin University – Australia	Australia Government
Extractive Industry Management	1	2010	University of Sydney – Australia	Australian Government through AUSAID
Mining and the Environment	1	2010	Portugal	Australian Govt
Uranium Mining Study Tour	10	2009-2010	Namibia	Commonwealth Secretariat
MSc Geology	1	2009-2010	Fort Hare University	South Africa

Source: Departments of Mines and Geological Survey 2010-2011 annual reports

9.3 Conclusion and Recommendations

Malawi's science, technology and innovation (STI) systems contributed to the performance of the energy and mining sectors during the reporting period. In the energy sector, engineers and scientists in the public and private sectors undertook actions aimed at improving access to energy by both domestic and industrial users. They did this by undertaking maintenance of existing supply capacity of the various forms of energy in the country's energy-mix as well as developing new capacity and enhancing energy use efficiency. However, all these efforts have not significantly improved energy intensity in terms of consumption per capita. A multiplicity of factors account for this but at base is Malawi's low level of human development. One that is relevant to the theme of this report is the shortage of capabilities in most if not all of the energy source areas in the country – a matter that the Department of Energy notes with respect to biogas especially.

While all actions undertaken are commendable, the progress made by the National Commission for Science and Technology in conjunction with Lilongwe Technical College to complete the research phase of the ethanol-driven vehicle is praiseworthy. Equally, actions by relevant players in the STI systems towards diversification of the energy-mix through development and application of renewable energy sources are noteworthy. Despite the miniscule contribution renewable sources make to energy consumption in Malawi, they represent developments at the global technology frontier and developing national capabilities in the related technologies should be a matter of national priority. While actions to maintain current levels of operations by actors in the energy sector are required, investing in new capacities and capabilities is even more important. Of relevance are actions to expand further modern energy supply capacity as much as making it affordable by all users, especially those in rural areas. A prime mover for this is development of human capabilities in STI through education and training plans which are informed by a baseline inventory of sectoral capabilities that enables gap to be identified and filled.

With respect to mining, the period 2010-2011 saw the initiation of a range of development that continued to prime the sector for higher contribution to economic growth and development. Here too scientists and engineers played crucial roles in leveraging and realizing actions and intentions. For example, discounting time value of money considerations, the fact that training to small-scale gemstone miners led to higher income from sales despite low volume of production points to productivity gains. Thus, the role played by the Government (through GSD and DoM in the Ministry of Mines) stands out. It is observed, however, that in the mining sector especially, foreign investors have an upper hand regarding access to business opportunities. Encouraging more domestic investment is, therefore, indicated. As in the energy sector, there is need to invest more in both human and physical capacity and capabilities in the public sector especially. Prioritizing expenditure for undertaking public sector STI programmes in the mining sector is recommended.

Chapter 10: Genetic Resources

10.1 Contribution of Genetic Resources to the economy

Genetic resources are crucial in supporting livelihoods, infrastructure development and energy in Malawi. Further to providing wood and non-wood products, the sector is important for soil and water conservation for agriculture and household use, provision of animal habitat, beautification of the countryside, enhancement of ecotourism and biodiversity, and regulation of climate change through carbon sequestration (Government of Malawi, 2011). The economic contributions of various sub-sectors of the genetic resources to the national GDP is very significant but not adequately captured in official statistics (Table 22)

Table 22: Estimated Contribution of Genetic Resources to GDP

Genetic resource	Share of GDP by official statistics	Additional contribution identified	Total share of GDP	Source of new evidence
Forestry	1.8%	4.3%	6.1%	BEST 2009 – Charcoal and firewood
Fisheries	4.0%	-	4.0%	
Wildlife	-	2.7%	2.7%	WTTC 2009 –Nature based tourism
Total	5.8%	7.0%	12.8%	

Source: Economic Valuation of Sustainable of Natural Resources Use in Malawi, 2011

Until now, the large contribution of charcoal and firewood as well as non-timber forest products such as medicinal plants, game meat, caterpillars, thatch grass, art and craft materials, wild edible fruits and vegetables, and mushroom is also omitted in official statistics.

10.2 Status of Genetic Resources Indicators in 2010 and 2011

Malawi has very varied physiographic features such that soils vary extensively due to topography and interaction with climate and geology (Kamwendo, 2004). These variations in relief, steep habitat gradients in a heterogeneous environment are reflected in the diverse flora (indigenous plants) and fauna (wild animals) of the country (Msekandiana & Mlangeni, 2002).

The country has more species of flora and fauna than other countries in the sub-Saharan Africa (Kamwendo & Dudley, 2005).

Box 3: Some of the unique flora and fauna that occur in the country (Figures 19-22)

Figure 19. Zebras at Nyika National Park

Figure 20. Waterbirds caught for food and sale at L. Chilwa

Figure 21. Aloe christianii

Figure 22 One of the threatened plant species (Pterocarpus angolensis). All photos by J. Kamwendo

Malawi is very rich in flora and fauna, which if properly managed and utilized could significantly contribute to the economic growth and creating of wealth and employment in the country. Malawi has over 6,000 described species of plants (Kamwendo, 2005) of which 114 species are endemic and 248 are threatened and listed in the National Red Data List (Msekandiana and Mlangeni). There are also nearly 190 species of mammals of which 8 are threatened (Chitaukali, 2002); 659 described species of birds of which 4 species are endemic and 7 threatened (Kaliba, 2005); 83 species of amphibians of which 6 species are endemic and 12 threatened; 145 species of reptiles of which 9 are threatened (Mazibuko, 2005); over 1,000 species of fish of which 95% species are endemic and 11 threatened (Banda, 2005);over 118,000 species of insects/invertebrates of which only 1 is threatened (Dudley, 2005) and

33,000 species of both edible and non-edible fungi (Meke and Boa, 2005). Most of these species are of socio-economic importance to the country since they are sources of livelihoods, infrastructure development and energy (Government of Malawi, 2011). However, the future survival of these valuable species in nature is threatened due to over-exploitation, loss of habits due to agricultural expansion, conversion of protected areas into plantations, introduction of invasive alien species and climate change. As a result, some of species are becoming endangered and/or extinct (Kamwendo & Dudley, 2005).

The national systems have put in measures to preserve the threatened genetic pool of these species in museums, herbaria, botanic gardens and gene banks. (Tables 23 - 24). The Museum of Malawi increased the number of species of birds, mammals, insects and Herpetofauna in 2011.

Table 23: Number of rare, endemic, endangered and economic species in Malawi

Type/Use	Number of species					
	2010			2011		
	Animals	Plants	Fish	Animals	Plants	Fish
Rare	DD	DD	DD	DD	DD	DD
Endemic	16	114	807	16	114	807
Economic	DD	DD	1,000	DD	DD	1,000
Medicinal	DD	DD	DD	DD	DD	DD
Threatened	27	154	11	27	154	11
Extinct	DD	5	DD	DD	5	DD

Source: Msekandiana & Mlangeni (2002) DD= Data Deficient

Table 24: Number of specimens in museums, herbaria and genebanks

Museums	2010	2011
Birds	2,645	2,699
Mammals	2,046	2,071
Insects	1,293	1,669
Herpetofauna (Amphibians and Reptiles)	876	889

Source: Museums of Malawi Database (2013)

The total plant specimens increased from 165,000 in 2010 to 193,000 in 2011. There was a 16.7% increase in threatened live plants conserved at the Gene Banks (Table 25). The Country has over 70 new as well as invasive plants (Table 26).

Table 25: Plant Specimen in the Herbaria, Gene Banks

Herbaria	2010	2011
Number of plant specimens preserved	165,000	193,000

Genebanks		
Number of threatened live plant species conserved in botanic gardens	18	21
Number of seed specimens preserved in gene banks	3,978	3,995

Source: Malawi Plant Genetic Resources Centre and Herbarium of Malawi Database (2013)

Table 26: Number of new plants, fish and animals including invasive species introduced

Plant	2010	2011
New plants	70	70+
Invasive plants	70	70+

Malawi implemented four projects in 2010 in conservation biology and taxonomic/plant systematic studies. There was a 50% reduction in 2011.

Table 27: Number of Research Projects implemented by field

Field/Thematic Area/ Subject	2010	2011
Taxonomic/Plant systematic	2	1
Conservation biology	2	0
Total	**4**	**1**

The fisheries sector plays a significant role for Malawi's population as a source of food, income and employment opportunity to nearly 300,000 people involved in the industry. The current beach value of fish is about 15 - 20 million USD per annum. The contribution of fish as a source of protein declined from 70% in 2009 to 40% in 2010. In 2011, its contribution was less than 30% of the total animal protein supply. The production of commercially important tilapia (Chambo) declined from 23,000 tons in 1984 to 7000 tons in 2001. Consequently, per capita consumption of fish declined from 14 kg per person per year to less than 4 kg today. The dramatic decline in national fish supply has resulted into a supply deficit of 16,000 tons. In order to bridge this gap and to achieve steady supply of fish to the nation, aquaculture is now being promoted aggressively and at commercial levels. Aquaculture contributes 3000 tons to total annual fish production and currently fetches an

average price of MK1600 per kilogram on the market. The MALDECO Aquaculture Company was established to contribute to increased fish production for the nation as well as for the export market.

10.3 Challenges and interventions

Malawi experienced several challenges in the management of the genetic resource sector. These include:

(i) Inadequate funding, leading to limited research activities and laboratory and other field equipment.
(ii) Lack of appropriate office space and inadequate storage facilities for collections. This led to preservation problems of the collected genetic materials which are vital for research and education activities.
(iii) High rates of human resource attrition as a result of the HIV and AIDS pandemic compounded by officers leaving for greener pastures in other countries (brain drain). The lost human resource is not replenished as quickly as required.

The aquaculture subsector experienced a number of challenges. These are:

(i) Slow growth of cultured tilapia species
(ii) Lack of quality fingerlings for both catfish and tilapia species
(iii) Lack of specific feed for cultured species and scarcity of feed ingredients
(iv) Inability to access credit and institutional support
(v) Limited resources of the Department of Fisheries to support aquaculture services

10.4 Programmes and interventions put in place to address the challenges

The local institutions in Malawi pool resources together with international organisations to implement programmes to mitigate the limited human resource capital. They also undertake various programmes to enhance the human capacity building and infrastructure development. Some of the programmes and interventions that genetic resources institutions are taking include:

(i) The Millennium Seed Bank Project (website): This project aims at collecting and conserving rare, economic, endemic and endangered plant species in the country and in some countries in the world. This is a collaborative project between Royal Botanic Gardens in the U.K and National Plant Genetic Resource Centre in the country.
(ii) Lake Chilwa Basin Climate Change Adaption Programme: This programme aims at developing and implementing Basin-wide climate change adaptations that will enhance the capacity of communities to be resilient to the adverse impacts of climate change and adopt sustainable livelihood and natural resource management practices in Zomba, Machinga and Phalombe districts.
(iii) Nyika-Vwaza Transfrontier Biodiversity Conservation Programme which aims management of wildlife and other natural resources in parts of Malawi and Zambia.

(iv) Improved Forest Management for Sustainable Livelihoods Programme: This programme aims at building capacity of local communities surrounding forest reserves to sustainably manage forest resources to improve their livelihoods. This programme is implemented in twelve districts of the country.

(v) The Shire River Basin Management Programme: This programme aims at promoting management of natural resources in and around the Shire River.

(vi) Mulanje Mountain Biodiversity Conservation Project: The main aim of the project is to promote biodiversity conservation, research and monitoring; environmental education; forest co-management and sustainable livelihoods.

10.5 Conclusion

Malawi is endowed with various genetic resources which play a very significant role in influencing social and economic development at both the household and national levels. About 80% of the population in the country depends on genetic resources for their subsistence and household income. The genetic resources also contribute about 12.8% of the national GDP. However, the resources are continuously being degraded due to human activities and to some extent by the impacts of climate change. Therefore, all stakeholders must work to address the challenges being faced by the genetic resources sector. Adequate funding for research and home-based development technologies is vital for conservation of the country's unique genetic resources. Fish farming can play an important complementary role to improve income generation and food security and the commercial aquaculture sector can contribute towards economic growth and creation of wealth.

Chapter 11: Climate Change and Meteorological Services

11.1 Introduction

Climate variability in Malawi affects weather patterns including rainfall which affects crop production. The Country experiences severe climatic hazards including dry spells, droughts, intense rainfall, floods and flash floods among others. The occurrence of extreme weather events such as droughts and floods, leads to food insecurity and serious environment and human health problems. Climate variability and change are Malawi's greatest challenge. Management of climate change is thus critical; using the most reliable technologies for collecting and managing data is thus paramount. The provision of reliable, responsive and high quality weather, climate and climate change services to meet national, regional and international obligations is necessary. This entails timely dissemination of accurate and up-to-date data and information for socio-economic development. The Department of Climate Change and Meteorological Services (DoCC&MS) is charged to monitor, predict and provide information on weather, climate and climate change, which would contribute towards the socio-economic development of the country.

11.2 Status of indicators in 2010 and 2011

Malawi has technologies for measuring various climate parameters (Table 28). The Country built the capacity of automatic weather stations; nearly 100% increase was achieved in 2011. A significant increase in the logging systems was also obtained in 2011; the number increased from 15 in 2010 to 43 in 2011. In contrast, there was a decrease in the automatic rain gauges. This may be due to limited human capacity and inability to repair such technologies. No increase in manual weather stations was thus observed. A 10% increase in manual rain gauges was noted in 2011.

Table 28: Total number of technologies for measuring climate parameters

Climate Parameters	Technologies	2010	2011
Temperature, Rainfall	Automatic Weather Stations	11	21
	Manual Weather Stations	22	22
Rainfall	Manual Rain gauges	80	88
	Rainfall Logging Systems	**15**	**43**
	Automatic Rain gauges	**12**	**10**

11.3 Challenges and interventions

Malawi encountered various challenges in monitoring climate variability and change. These are:

(i) Limited funding to procure pieces of equipment, replace the non-working and obsolete data collection instruments and facilities for monitoring climate and climate change;

(ii) Closure of several meteorological stations in the country due staff turn-over mainly due to death, retirement, transfers and promotions;

(iii) Weak implementation of the National Adaptation Programmes of Action (NAPA), and

(iv) Absence of organized baseline information on climatic conditions and since there are no diagnostic assessments to guide decision incorporating climate change issues into policies, investment frameworks and project activities.

In order to mitigate these challenges, it is recommended that:

(i) The DoCC & MS be fully supported to procure and modernise automatic weather stations for use at all Weather Stations;

(ii) Developing a national climate change and adaptation policy and strategy and

(iii) The national human capital be expanded and strengthened to maintain the weather stations and equipment. Offering of scholarship to Malawians to train at MUST in atmospheric sciences is thus necessary, and

11.4 Conclusion

Management of climate change is critical in Malawi to inform planning and prediction of weather so that the Country, which is based on rain-fed agriculture achieves sustained food security. Therefore, managing current climate risk and adapting to climate change are priority concerns in Malawi. This means, the Country should establish automatic weather stations at all weather stations. This would facilitate timely and accurate data collection which will support Early Warning Systems, which are crucial in addressing climate change challenges in Malawi. Developing a national climate change and adaptation policy and strategy is thus critical.

Chapter 12: Transport and Construction

12.1 Introduction

While transport is a service, its components form key aspect of Malawi's physical infrastructure. This infrastructure depends on the services provided by the construction sector. Thus, this chapter focuses on the transport and construction sectors within the context of infrastructure as a key component of national institutions. Generally, infrastructure is critical for all production activities and where there is infrastructural failure, there is bound to be strong impact on transaction costs because of the likelihood of high cost of production of goods and services. In the specific case of transport infrastructure, its availability in good condition influences, among other factors, access to markets. In addition, poor transport infrastructure has the potential to depress demand[9] of goods and services which, in turn, negatively impacts on the demand for science, technology and innovation as inputs into existing and improved production processes.

12.2 Characterizing the Transport Sector: State of Indicators

Malawi is served by four transport modes namely road, rail, lake and air transport with each mode being governed by specific regulatory frameworks. The transport system currently comprises about 24,929 km of public road network, 810 km of rail track which links Mchinji on the Zambian border with Nsanje on the country's southern border with Mozambique through Lilongwe. Regarding water-based transport, there are four major lake harbours. With respect to air transport, although data elsewhere indicates existence of 25 airports (CIA World Factbook), air transport is mainly accessed through two international airports in Lilongwe and Blantyre. There are, in addition, three other commercial airports located at Mzuzu, Karonga and Mangochi.

12.2.1 The Roads Sub-Sector

Among the four modes of transport that exists in the country the road transport system has the biggest network covering major parts of Malawi. Hence it is the most accessible and affordable mode for the transportation of people as well as goods and services. Of the total road network of 24,929 km only 4,073km (representing about 16%) is paved (Table 29). In functional terms the main, secondary, and tertiary roads effectively make up the country's primary road network. The most recent assessment of the primary road network indicated that 79% of the paved roads have an international roughness index (IRI) of less than 4 while 19% of the score 4-6 on the IRI. Only 2% of the primary road network, with a score greater than 6 on the IRI, are considered to be in poor conditions (Millennium Challenge Corporation). The district roads, which are normally of earth standard, have continued to be improved during the period 2010-2011 so as to provide access at local level. This

[9] *Households located too far away from markets (mainly urban centres or cities) are highly affected by the poor condition of existing transport infrastructure a feature that decreases effective crop market demand and the input – output linkage in Malawi (Munthali, Lall and Wang, 2008)*

notwithstanding, the state of Malawi's road network is still characterized as inadequate with respect to providing access to ports thereby underpinning inadequate road freight capacity. It thus contributes to high costs of transportation in Malawi.

Table 29: Malawi Road Network (June 2010)

Road Class	Paved		Unpaved		Total	
	Km	Share	Km	Share	Km	Share
Main	2,809	70%	548	3%	3,357	13%
Secondary	442	10%	2,683	13%	3,125	13%
Tertiary	44	1%	4,077	20%	4,121	17%
District	8	0%	3,492	14	3,500	14%
Urban	770	19%	578	3%	1,348	5%
TOTAL	4,073	100%	11,378	55%	15,451	62%
Un Designated Community Roads		0%	9,478	45%	9,478	38%
Total Road Network	4,073		20,856		24,929	

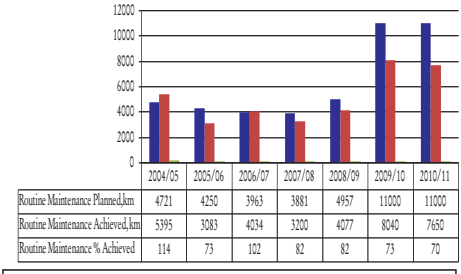
Source: RA Road Data Management System

From a science, technology and innovation perspective, scientists, engineers and technicians at the Roads Authority (RA) provide knowledge services needed for the Authority to fulfil its responsibility of constructing, rehabilitating and maintaining the public road network under a regulatory framework provided for in the Public Roads Act (1962), the Local Government Act (1998) and the Urban (Public and Private Streets) Act (1956). Equally, scientific and technological knowledge embedded in private sector road construction firms is vital for the realization of the Authority's responsibility. Indeed, while the RA developed Annual National Roads Programmes and Budgets related to routine maintenance, periodic maintenance, and rehabilitation and upgrading as well as construction of roads; successful implementation and completion of these programmes depended on private sector construction capabilities.

Additional indicators in relation to programmes in the road sector are presented as Figures 22 and clustered in Box 3. It will be observed that the period 2010-2011 saw escalation in the road routine maintenance programme relative to the previous years. Regarding periodic road maintenance, there was also pick-up in efforts during the period following a relative slump in the period 2007-2008. There was, however, low level of performance with respect to the road rehabilitation programme during the period as indicated by the percentages of achieved performance relative to the planned levels. Finally, although in terms of performance 2011 was better than 2010 with respect to the upgrading and construction programme, there was more activity in 2010 when consideration is given to distances covered.

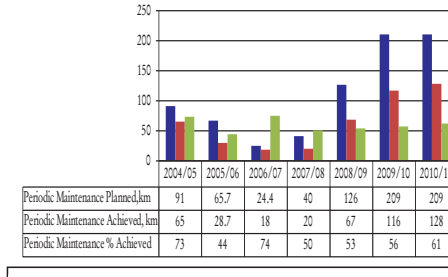
Although the road sub-sector delivered the programmes outlined above, it was beset by a number of constraints. From a STI perspective, the critical constraints related to inadequacy of technological capacity in the construction industry manifested by the quality and quantity of construction equipment and machinery. Small to medium construction firms were, in addition, constrained by inability to raise working capital indicating the need for innovation in Malawi's financial system. Market conditions also impacted negatively on the programmes. Beyond unfavourable macro-economic conditions that led to price escalations on account of inflation as well as unavailability of imported inputs on account of shortage of foreign exchange, there were constraints arising from poor complementary services especially with regard to utilities.

Box 4: Programme Performance in the Roads Sub-sector



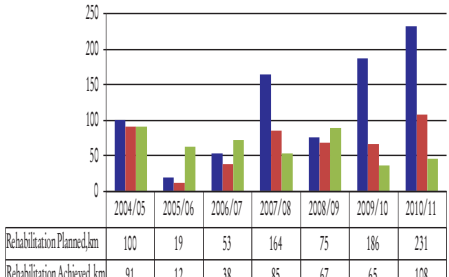
	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11
Routine Maintenance Planned,km	4721	4250	3963	3881	4957	11000	11000
Routine Maintenance Achieved,km	5395	3083	4034	3200	4077	8040	7650
Routine Maintenance % Achieved	114	73	102	82	82	73	70

Physical Performance for Road Maintenance 2005 - 2011



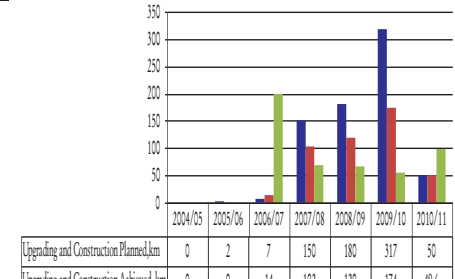
	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11
Periodic Maintenance Planned,km	91	65.7	24.4	40	126	209	209
Periodic Maintenance Achieved, km	65	28.7	18	20	67	116	128
Periodic Maintenance % Achieved	73	44	74	50	53	56	61

Physical Performance for Periodic Maintenance 2005 - 2011



	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11
Rehabilitation Planned,km	100	19	53	164	75	186	231
Rehabilitation Achieved, km	91	12	38	85	67	65	108
Rehabilitation % Achieved	91	62	72	52	89	35	46

Physical performance for Rehabilitation 2005 - 2011



	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11
Upgrading and Construction Planned,km	0	2	7	150	180	317	50
Upgrading and Construction Achieved, km	0	0	14	102	120	174	49.6
Upgrading and Construction % Achieved	0	0	200	68	67	55	99

Physical performance for Upgrading and Construction 2005 - 2011

Figure 23 Roads Sub-sector Programme Performance
Source: Roads Authority Annual Reports

Research has shown that there is a dearth of complementary services in the economy which makes firms accord preference to internalization of functions as opposed to acquiring them from markets (Guta, 2011). Fundamentally, there was inadequate availability of qualified engineers and technicians for design, construction, supervision and implementation of road infrastructure projects indicating the need for greater efforts in building human capabilities.

12.3 Construction Sector

12.3.1 Introduction

The construction industry underpins the development of the country's physical infrastructure. The ratios of its contribution to GDP in 2010 and 2011 were 3.2% and 3.4% respectively indicating that it is yet to become a significant sector relative to agriculture and retail and wholesale which dominate the economy. The sector grew 16.5% in 2010 (up from 7.4% in 2009). It however, declined by 2.4% in 2011 despite a projected growth of 9% largely on account of the adverse economic conditions in Malawi that began in 2010. The NCIC is mandated by the 1996 Construction Industry Act to regulate, promote and develop a sustainable and efficient construction industry. It represents the interests of Malawians in ensuring that the *constructed* infrastructure facilitates national development in line with the medium and long term national development agenda such as the MGDS and the Vision 2020.

12.3.2 Status of indicators in 2010 and 2011

This report tracks three indicators related to the construction industry namely, (a) Number of construction technologies by type and origin, (b) Number of people trained in the use of construction technologies and, (c) Number of registered construction firms in each year. The data on number of construction technologies is not available. The number of people trained in all short courses declined from 391 in 2010 to 246 in 2011 (Table 30).

Table 30: Total Number of people trained in Building and Construction Related Courses

Type of Training	2010	2011
Short Courses (5 day duration)	314	202
Foremanship Course Level 1 (12 Weeks)	42	26
Foremanship Course Level 2 (12 Weeks)	35	18
Total	391	246

As presented in Table 31, the number of registered construction firms[10] has increased from 1,081 in 2009/10 to 1,372 in 2010/11. Proportion of local firms has not changed significantly since they constituted 94% in 2010 and 95% in 2011. As regards construction material manufacturers, the number has increased from two in 2009/10 to six in 2010/11. The increasing trend has just picked again after dropping from 11 in 2007/08 FY to two in 2009/10.

[10] Includes all categories in Building, Electrical, Civil and Miscellaneous Contractors but excludes registered material manufacturers and suppliers.

Table 31: Total number of registered construction firms[11]

Sub-Sector	2009/10	2010/11
Building	302	472
Electrical	102	118
Civil	671	764
Renewable Energy	6	18
Total	1,081	1,372

12.3.3 Challenges

The industry sees less technology transfer from foreign firms whose services are either imported directly from some bilateral aid projects or through privately executed projects whose clients bring foreign based professionals. This arises from the practice that sees grant construction projects coming with pre-identified construction firms or privately executed projects importing services and having minimal participation of the local human resource.

It is estimated that in terms of value 77 percent of the construction works is taken by the few foreign firms because there are few Malawian registered professionals.

The local construction industry has recently been massively hit in the 2011/12 FY after poor macroeconomic environment which saw the supply of fuel, one of the biggest inputs in construction, in acute short supply.

12.3.4 Programmes and Interventions to address the challenges

The NCIC has recently finalised the National Construction Policy which is aimed at guiding the industry in enhancing the capacity and performance of the industry and protecting local firms' market share by building their capacity and from unfair competitions.

The Malawi Government has recently gazetted the National Construction Industry (also called Project Registration) regulations which is aimed at facilitating the registration of all construction activities and hence improved monitoring. In addition, the Government has proposed Joint Venture regulations that which is expected to facilitate technology transfer of partnering foreign and local construction firms when in force.

12.4 Conclusion

The Malawi Construction Industry continues to register growth and development in science and technology. However, there are still challenges that the Government is working on such as the production of the National Construction Policy, the new National Construction Industry and Joint Venture regulations which will facilitate technology transfer of between Malawi and the rest of the world.

[11] The data is aggregated for all categories in both local and foreign owned firms

References

AfricaBio. (2006). *Agricultural biotechnology, facts for decision makers*.

Africa Connect. (2012). AfricaConnect Video. Retrieved from www.youtube.com/watch?v=sS1EZMi-7ck

ARET. (2010). *Technologies proposed for release to the Agricultural Technology Clearing Committee (ATCC)*, Lilongwe.

ARET. (2011). *Technologies proposed for release to the Agricultural Technology Clearing Committee (ATCC)*, Lilongwe.

AU. (2006). *10 Percent National Budget Allocation to Agriculture Development*, African Union Pamphlet, Addis Ababa.

Australian mining: this is our story. (n.d.) Retrieved from http://www.thisisourstory.com.au/

Banda, M. (2005). Fish. In C.O. Dudley (Ed.), *Biological Diversity of Malawi* (pp. 31-35). Limbe: Wildlife and Environmental Society of Malawi.

Banda, T. M. (Compiler). (2013). *Malawi Telecoms and Internet Market Profiles*. (Internal document).

Baobab Health. (n.d.) Retrieved from http://baobabhealth.org/about/

Beintema, N., Mwenda, A.R.E., & Mtukuso, A.P. (2004). *Agricultural Science and Technology Indicators – Malawi*. IFPRI-ASTI Country Brief No. 22, Washington D.C.

Beintema, N., Mwenda, A.R.E., & Mtukuso, A.P. (2004). *Agriculture Development*. African Union Pamphlet, Addis Ababa.

BEST. (2009). *Biomass energy strategy* www.euei-pdf.org/country-studies/biomass-energy-strategy-best-malawi.

Broadband Commission. (2012). *State of broadband 2012 – achieving digital inclusion for all*. Annual report (p.44). Retrieved from http://www.broadbandcommission.org/documents/bb-annualreport2012.pdf

Burchi, F. (2006). *Identifying the Role of Education Socio Economic Development*, paper for International Conference on Human and Economic Resources, IZMIR.

CAADP. (2008). *The 10 Percent that Could Change Africa*. CAADP Pamphlet. Johannesburg.

Chitaukali, W.N. (2005). Mammals, In: C.O. Dudley (Ed.), *Biological Diversity of Malawi* (p.19). Limbe: The Wildlife and Environmental Society of Malawi,

Commission of the European Communities. (2009). *Internet of Things — An action plan for Europe* (PDF). Retrieved from http://ec.europa.eu/digital-agenda/

Dudley, C.O. (2005). Invertebrates. In: C.O.Dudley (ed.) *Biological Diversity of Malawi* (pp. 37-41). Limbe: The Wildlife and Environmental Society of Malawi.

FEWS. (2011). 2010/2011 *Third round national agricultural production estimates*. Lilongwe.

FEWS. (2012). 2011/2012 *Third round national agricultural production estimates*. Lilongwe.

Guta, C.W. (2011). *Effects of learning and innovation on development*: *the case of Malawi.* (unpublished doctoral dissertation). University of Manchester, UK.

Gyimah-Brempong, K. (2010). *Education and economic development in Africa.* Paper prepared for the 4th African Economic Conference, October 27-29, 2010. Tunis.

Hanushek, E.R. & Wobmann, L. (2007). *The role of education quality in economic growth*. World Bank Policy Working Paper No. 4122
http://www.macra.org.mw/downloads/pppcMonitoringevaluation.pdf

ITU. (2010). *Partnership on measuring ICT for development: Core ICT indicators 2010.* Geneva*:* ITU. Retrieved from http://www.itu.int/dms_pub/itu-d/opb/ind/D-IND-ICT_CORE-2010-PDF-E.pdf

ITU. (2011). *ICT facts and figures.* Geneva: ITU Retrieved from http://www.itu.int/en/ITU-D/Statistics/Documents/facts/ICTFactsFigures2011.pdf

ITU. (2012). *Country profile Malawi profile.* ITU ICT-Eye: Retrieved from http://www.itu.int/icteye

ITU. (2012). *Measuring the information society*. Geneva: ITU

James, Clive. (2011). *Global status of commercialized biotech/GM crops: 2011.* ISAAA Brief No. 43. NY: ISAAA - Ithaca.

Kaliba, P. (2005). Birds. In: C.O. Dudley (Ed.) *Biological diversity of Malawi* (pp. 21-29). Limbe: The Wildlife and Environmental Society of Malawi.

Kamwendo, J.S. & Dudley, C.O. (2005). General Introduction. In: C.O. Dudley (Ed.) *Biological Diversity of Malawi* (pp.5-7). Limbe: The Wildlife and Environmental Society of Malawi

Kamwendo, J.S. (2005). Flora and vegetation. In: C.O. Dudley (Ed.) *Biological diversity of Malawi* (pp. 9-13). Limbe: The Wildlife and Environmental Society of Malawi.

Klaus Droppelmann, K., Mapila, M.A.T.J., Mazunda, J., Thangata, P., & Yauney, J. (2013). *Who talks to whom in African agricultural research information networks? - The Malawi case.* IFPRI Discussion Paper 01264. Washington D.C.

Kraemar. (1996) & Wasser. (1997). *Technical report on elaboration of a coordinated biogas programme in Malawi,* UNIDO/UNDP, April 1997.

MACRA. (2012). *Measuring universal ICT access*. Blantyre: MACRA.

Malawi Government. (1998). *Vision 2020: National long-term development perspective for Malawi.* Retrieved from www.sdnp.org.mw/malawi/vision-2020.

Malawi Government. (2002). *National science and technology policy*. Lilongwe: National Research Council of Malawi.

Malawi Government. (2003). *National energy policy*. Lilongwe: Department of Energy Affairs.

Malawi Government. (2003). *Science and technology Act no. 16 of 2003*. Zomba: The Government Printer.

Malawi Government. (2008). *National education sector plan* 2008-2017*: A Statement*. Lilongwe: Ministry of Education and Science and Technology.

Malawi Government. (2010). *Demographic and health survey*. Zomba: National Statistical Office.

Malawi Government. (2010). *Draft national intellectual property policy*. Lilongwe: Ministry of Industry and Trade.

Malawi Government. (2010). *Malawi millenium development goals report* (p.55). Lilongwe: Ministry of Development Planning and Cooperation.

Malawi Government. (2011). *Crop production estimates for the 2010/11 season*. Lilongwe: Ministry of Agriculture.

Malawi Government. (2011). *Economic evaluation of sustainable environment and natural resource use in Malawi.* Lilongwe: Ministry of Finance and Development Planning.

Malawi Government. (2011). *Malawi growth and development strategy II 2011 – 2016. Lilongwe:* Ministry of Development Planning and Cooperation.

Malawi Government. (2011). *Malawi health sector strategic plan* 2011-2016. Lilongwe: Ministry of Health.

Malawi Government. (2011). *Public service management reforms and capacity development programme document 2012 – 2016.* Lilongwe: Office of the President and Cabinet.

Malawi Government. (2012). *Crop production estimates for the 2011/12 season.* Ministry of Agriculture, Lilongwe.

Malawi Government. (2012). *Profile of department of agricultural research services (DARS)* 2012. Lilongwe: Ministry of Agriculture and Food Security.

Mapila, M.A.T.J., Yauney, J., Droppelmann, K., & Thanhgata, P. (2012). *Research capacity for operationalisation of the Malawi agricultural sector wide approach (ASWAp).* IFPRI Policy Note 12. Washington D.C. USA.

Mazibuko, L.C.J. (2005). Reptiles and amphibians. In: C.O. Dudley (ed.) *Biological diversity of Malawi* (pp.25-29). Limbe: The Wildlife and Environmental Society of Malawi.

Meke, G. & Boa, E. (2005). Mushrooms. In: C.O. Dudley (ed.) *Biological Diversity of Malawi* (pp. 43-48). Limbe: The Wildlife and Environmental Society of Malawi.

Msekandiana, C.G. & Mlangeni, E. (2002). Malawi. In: Golding (Ed.). *Southern African plant red data lists (*pp. 42–49). SABONET Report Series No. 14, Pretoria.

Museums of Malawi. (2013). *Museums of Malawi Database*. Blantyre.

Mviha, P.J.Z., Mtukuso, A.P., Banda, M.H.P., & Chisama. B.F., (2011). *A catalogue of agricultural technologies released by the Ministry of Agriculture and Food Security: 2004-2011*. Lilongwe: Department of Agricultural Research Services.

National Commission for Science and Technology. (2011). *Livestock and dairy products questionnaire*. Lilongwe.

National Herbarium and Botanic Gardens of Malawi. (2013). *Herbarium of Malawi Database.* Zomba.

Nyirenda, H.E. & Mphangwe, N.I.K. (1998). *Use of plucking shoots for propagating tea*. In: Tea Planters Handbook, 2012.

Nyirenda, P. (2012). *Malawi ICT sector indicators on infrastructure and access.* Report no 1. Retrieved from http://stats.uis.unesco.org/unesco/ReportFolders.aspx

Roads Authority. (2011). *Annual reports 2004/05 to 2010/11*. Lilongwe: Roads Authority.

Roseboom, J. and Pardey, P.G. (1993). *Statistical brief on the national agricultural research system of Malawi*. ISNAR Statistical Brief No. 3. The Hague

Rosenburg, M. (2005) Education – Geography: Retrieved from http://geography.about.com/library/cia/blcmalawi.htm

Taulo, J.L., Salima, G. Sabitosi, A.B. and Gondwe, K. (2013). *The state of energy supply in Malawi: challenges and opportunities*. Energy Journal *(Publication pending).*

UNESCO Institute of Statistics (UIS). (2010). *Measuring R&D: Challenges faced by developing countries,* Montreal.

UNESCO Institute of Statistics. (2010). *UIS S&T Statistics Database*, Montreal.

University of Malawi. *e-learning.* Chancellor College. Retrieved from www.cc.unima.mw/elearning

World Bank. (2012). *Information and communication for development report 2012: Maximizing Mobile*. Retrieved from www.worldbank.org/ict/IC4D2012

World Bank. (1966). *The Economy of Malawi*. Report No. AF-51a. Washington DC.

World Bank. (2009). *Africa Development Indicators Database* 2008-09.

World Bank. (2011). *Handbook on infrastructure statistics*, African Infrastructure Knowledge Programme. Retrieved from http://www.afdb.org/en/knowledge/publications/handbook-on-infrastructure-statistics/

World Bank. (2013). *The Little Data Book 2013*. Washington, DC: World Bank. doi: 10.1596/978-0-8213-9812-8. License: Creative Commons Attribution CC BY 3.0.

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