THE REPUBLIC OF MALAWI

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Introduction

This report looks at the science, technology and innovation system of Malawi and is structured in three main parts. Section 1 briefly deals with the national political environment. Section 2 presents the key country characteristics, specifically indicators pertaining to the country's economic, health, education, and information & communication technology (ICT) infrastructure. Section 3, which forms the main part of the report, gives an overview and analysis of the science and technology (S&T) system. This section is subdivided into seven thematic subsections covering the governance of S&T, the S&T landscape, S&T human resources, funding, research outputs, technological innovation and lastly international co-operation and networks activities.

Section 1: The political environment

The British protectorate of Nyasaland was established in 1891, which became the independent nation of Malawi in 1964. After three decades of one-party rule under President Hastings Kamuzu Banda, Malawi held its first multi-party elections in 1994, under a provisional constitution that came into full effect the following year. Current President Bingu wa Mutharika, elected in May 2004 after a failed attempt by the previous president to amend the constitution to permit another term, struggled to assert his authority against his predecessor, culminating in Mutharika quitting the political party on whose ticket he was elected into office. Mutharika subsequently started his own party, the Democratic Progressive Party (DPP), and has continued with a halting anti-corruption campaign against abuses carried out under the previous regime. Increasing corruption, population growth, increasing pressure on agricultural lands, and the spread of HIV/AIDS pose major problems for the country (www.cia.gov/cia/publications/factbook/geos/mi.html).

Section 2: Country characteristics

2.1 Basic economic outlook

Malawi is a landlocked, densely populated country that ranks among the world's least developed countries. Its economy is heavily dependent on agriculture – agriculture represents 38.6% of the GDP, accounts for over 80% of the labour force, and represents about 80% of all exports. Nearly 90% of the population engages in subsistence farming.

Smallholder farmers produce a variety of crops, including maize (corn), beans, rice, cassava, tobacco, and groundnuts (peanuts). Its three most important export crops are tobacco, tea and sugar. Malawi's president recently urged farmers to consider growing other crops, such as cotton, as an alternative to the country's principal crop, tobacco, as cigarette consumption in the West continues to decline. However, the performance of the tobacco sector is essential for short-term economic growth as tobacco accounts for more than half of exports.

Malawi's economic reliance on the export of agricultural commodities renders it particularly vulnerable to external shocks such as declining terms of trade and drought. High transport costs, which can comprise over 30% of its total import bill, constitute a serious impediment to economic development and trade. The economy depends on substantial inflows of economic assistance from the IMF, the World Bank, and individual donor nations. In 2006, Malawi was approved for relief under the Heavily Indebted Poor Countries programme (www.cia.gov/cia/publications/factbook/geos/mi.html#Econ; http://en.wikipedia.org/wiki/Malawi).

The growth in real GDP for 2004 was estimated at 4.6%, being an improvement on the 3.9% registered for the previous year (MoEPD, 2005:4).

2.2 Demographic profile (including health, education and ICT indicators)

Table 1 summarises recent statistics for Malawi with regard to health, education, and information & communication technology (ICT) infrastructure.

Table 1: Summary of various demographic statistics for Malawi

Indicator	Statistic	Year	Source
General demographical			
Total population	12.884 mill	2005	World Health Organization [2]
Urban population (% of total population)	17%	2005	World Health Organization [2]
% of population 0-14 years	46.1%	2007 (est.)	CIA Factbook [3]
% of population 15-64 years	51.2%	2006 (est.)	CIA Factbook [3]
% of population 65+ years	2.7%	2006 (est.)	CIA Factbook [3]
Health			
HIV/AIDS adult prevalence rate	14.1	2005	World Bank [1]
Female life expectancy at birth	41	2004	World Health Organization [2]
Male life expectancy at birth	41	2004	World Health Organization [2]
Life expectancy at birth (years)	40.5	2005	World Bank [1]
Total fertility rate (children born per woman)	5.9	2005	World Health Organization [2]
Female child mortality per 1 000	172	2004	World Health Organization [2]
Male child mortality per 1 000	179	2004	World Health Organization [2]
Female adult mortality per 1 000	638	2004	World Health Organization [2]
Male adult mortality per 1 000	663	2004	World Health Organization [2]
Under 5 mortality per 1 000	125.3	2005	World Bank [1]

Infant mortality per 1 000 live births	78.9	2005	World Bank [1]
Total expenditure on health as % of GDP	9.3	2003	World Health Organization [2]

Table 1 Continued

Indicator	Statistic	Year	Source
Education			
Adult literacy rate (% of population age 15+)	61.1%	2006	World Bank [1], from UNESCO Institute for Statistics
Primary school enrolment, gross ratio	122.3	2005	World Bank [1], from UNESCO Institute for Statistics
Primary completion rate, total (% of relevant age group)	60.7	2005	World Bank [1], from UNESCO Institute for Statistics
Secondary school enrolment, gross ratio	28.3	2005	World Bank [1]
Ratio of girls to boys in primary and secondary education (%)	91.8%	2000	World Bank [1], from UNESCO Institute for Statistics
Information & Communication Technology (ICT)			
Telephone main lines per 1 000 people	8	2004	World Bank , ICT at a Glance [4]
Mobile subscribers per 1 000 people	12	2004	World Bank , ICT at a Glance [4]
Population covered by mobile telephony (%)	70%	2004	World Bank , ICT at a Glance
Internet users per 1 000 people	4.1	2005	World Bank [1]
Personal computers per 1 000 people	1	2004	World Bank , ICT at a Glance [4]
% of households with television	2%	2004	World Bank , ICT at a Glance [4]
Broadband subscribers per 1 000 people	0	2004	World Bank , ICT at a Glance [4]
International Internet bandwidth (bits per person)	0	2000	World Bank , ICT at a Glance [4]

[1] http://devdata.worldbank.org/external/CPProfile.asp?PTYPE=CP&CCODE=MWI

[2] http://www.who.int/whosis/database/core/core_select.cfm

[3] https://www.cia.gov/cia/publications/factbook/geos/mi.html

[4] http://web.worldbank.org/WBSITE/EXTERNAL/DATASTATISTICS/0,,contentMDK:20459133~menuPK:1192714~pagePK: 64133150~piPK:64133175~theSitePK:239419,00.html

Section 3: Science and technology system

3.1 Governance of S&T

Malawi's first S&T policy was formulated and adopted in 1991. However, the 1991 policy did not explicitly integrate S&T issues into national development planning. This weakness necessitated the government to review the policy and to adopt a new S&T policy in 2002. The revised policy contains clear-cut S&T development objectives and strategies for all priority sectors[1] of the Malawi economy (Gausi & Kalanda, 2005:3) The policy also articulates the government's commitment to increase funding for S&T as well to strengthen the institutional and legal framework for S&T (NRCM, 2002). The Malawian president has

[1] A total of 17 priority sectors are included: (1) Education and training; (2) agriculture, food and nutrition; (3) water resources and sanitation; (4) irrigation; (5) health and population; (6) energy; (7) industry; (8) commerce; (9) environment; (10) construction; (11) communications; (12) transport; (13) natural resources (forestry, fisheries, wildlife, and mineral resources); (14) urban and rural planning; (15) defence; (16) internal security; and (17) disability.

repeatedly emphasises that S&T development is vital to the country's overall development (SciDevNet, 2005b).

3.1.1 Ministry of Education, Science and Technology

A Ministry of Industry, Science and Technology (MIST) was created shortly after the May 2004 general elections. The articulated vision of MIST was to transform Malawi into an industrialised nation with scientifically and technologically led sustainable growth and development. Its mandate was to promote industrial development through the application of S&T, and the ministry consists of two technical departments, namely Science and Technology, and Industry.

However, MIST has since been dissolved[2], with the Industry Department now residing in the newly created Ministry of Industry, Trade and Private Sector Development. Control of the Department of Science and Technology has been moved to the Office of the President and Cabinet, meaning that the department directly reports to the president (SciDevNet, 2006b).

The mandate of the Department of Science and Technology is to regulate, support, promote and coordinate the development and application of S&T in order to create wealth and improve the quality of life. The Department has four corporate objectives. These are:

- To initiate the promotion and maintenance of the regulatory framework of S&T for wealth creation;
- To establish an effective capacity building framework for efficient development, application and transfer of S&T;
- To develop and commercialise technology; and
- To enhance, promote, and popularise S&T.

In May 2007, it was announced that the Malawian president has merged Education, and Science and Technology under a single ministry of which he will personally take charge. (Chirwa, 2005:3; SciDevNet 2007e; www.malawi.gov.mw/OPC/Home%20%20OPC.htm)

3.1.2 National Commission for Science and Technology

The S&T policy of 2002 provides for the establishment of a National Commission for Science and Technology (NRCM, 2002) and, in late 2003, a Science and Technology Act was introduced to establish the commission (GoM, 2003). However, up to this point in time the Commission is not yet operational. Efforts are underway to transform the National Research Council of Malawi (see Section 3.2.1.1) into a National Commission for Science and Technology (Gausi & Kalanda, 2005:3).

[2] There appears to be a lack of direction with regard to the location of S&T at ministerial level. Prior to 2004, there was a Ministry of Education, Science and Technology. After the 2004 election, it became the Ministry of Industry, Science and Technology. In January 2005, the government announced a plan to restructure the ministry into four key departments: science and technology, industrial development, planning, and finance (SciDevNet, 2005a). This, however, did not materialise. Presently there is again a Ministry of Education, Science and Technology.

The Commission's function is to advise the government and other stakeholders on all S&T matters in order to achieve a science and technology-led development. Among its various responsibilities, the Commission will also (GoM, 2003:9-10):

- Chart out national direction and establish national priorities in S&T development in relation to socio-economic development needs;
- Source funding from within and outside Malawi to finance the national R&D effort and allocate funds to institutions based on set priorities;
- Promote and advocate for the development of S&T human resources by building capacity in S&T education and training programmes;
- Encourage the establishment and promote the co-ordination of research institutions that undertake R&D activities;
- Develop and synthesize S&T indicators;
- Prepare a biennial report on the state of Malawian S&T for the National Assembly.

The Commission will have various important committee structures (NRCM, 2002), such as:

- A *Parliamentary Committee responsible for Science and Technology*, which will provide a voice for S&T matters in the National Assembly. The Committee will ensure that S&T is integrated into the national budget by the time it is approved by Parliament and that S&T is integrated in the socio-economic development processes of the country.
- A *Cabinet Committee responsible for Science and Technology*, which will monitor the development and application of S&T in national development processes.
- *Sectoral Committees*, which will be composed of S&T directors from the relevant sectoral ministries as a link between the sectoral ministry and the Commission. The overall responsibility of the S&T directors will be to co-ordinate S&T issues in their relevant ministries.

3.1.3 Ministries with S&T responsibilities

Various sectoral ministries have S&T responsibilities. The most significant ones are:

- Ministry of Agriculture and Food Security
- Ministry of Industry, Trade and Private Sector Development
- Ministry of Mines, Energy and Natural Resources
- Ministry of Education and Vocational Training
- Ministry of Health
- Ministry of Irrigation and Water Development

3.2 S&T landscape

3.2.1 S&T supporting agencies

3.2.1.1 National Research Council of Malawi

The National Research Council of Malawi (NRCM) is the co-ordinating body for R&D and S&T in the country. It was established in 1974 and operates within the purview of the Office of the President and Cabinet. The main purpose of the NRCM is to serve as an advisory organ of the government on all matters relating to scientific research and technological development. The Council also finances R&D to a limited extent, and has a number of subject specialist committees with representation from all relevant stakeholders.

The Council's functions can be summarised in terms of the following strategies:

- To promote and co-ordinate research and innovation in all sectors of the economy; and
- To develop and implement programmes for strengthening research and innovation capabilities; and
- To promote application of research results and innovation; and
- To strengthen national and international collaboration and liaison among research institutions, researchers, and end-users, in order to optimize application of research results and use of resources; and
- To develop and maintain a national research information system to meet the socio-economic needs of the nation.

  (Gausi & Kalanda, 2005:3; www.nrcm.org.mw/about.html)

3.2.1.2 National Health Sciences Research Unit

In 1988, the then Ministry of Health and Population established the National Health Sciences Research Unit (commonly referred to as the research unit). This unit was given the mandate to promote and co-ordinate health research in Malawi. At that time, all research proposals were reviewed and cleared by the National Health Sciences Research Committee (NHSRC), whose secretariat was located at the NRCM. In order to improve efficiency, the NRCM decentralised the functions for review and clearance of research proposals and the NHSRC secretariat was transferred to the research unit of the Ministry of Health in 1993.

3.2.1.3 National Economic Council

The National Economic Council (NEC) was created in 1998 and is one of the central planning agencies responsible for national economic planning and management. Its secretary will enjoy representation in the National Commission for Science and Technology, once the latter is in full operation. The Council's main mandate is to provide professional advice and technical support to the government and the public on economic and social policy development and management, in order to achieve faster and sustainable economic and development (MoEPD, 2002:10).

The major roles and objectives of the NEC are as follows:

- To formulate medium and long-term national development goals and policies;
- To co-ordinate inputs to government from both the private and public sectors;
- To monitor the implementation of national development policies, projects and programmes;
- To set up medium-long term national development goals, objectives and strategies;
- To analyse sectoral polices and programmes to ensure that they are consistent with national goals and policies; and
- To evaluate the impact of national development plans and programmes.

The NEC also plays a central role in the monitoring and evaluation of the Malawi Poverty Reduction Strategy. The ECD does so mainly through its Poverty Analysis Unit (MoFEP, 2002).

3.2.1.4 Malawi Bureau of Standards

The Malawi Bureau of Standards (MBS) was established approximately 30 years ago. The Bureau is a statutory institution under the Ministry of Industry, Trade and Private Sector Development. It is responsible for standards development, quality assurance, testing, and metrology. The laboratories at the MBS are not yet accredited (MBS, 2004).

The MBS is specified as a role-player in the implementation of the country's National ICT for Development (ICT4D) Policy. Specifically, it is tasked to develop, promote and enforce high international standards in ICT (MoIT, 2006:37).

3.2.2 R&D performing institutions

3.2.2.1 Higher education institutions

Higher education[3] in Malawi comprises two universities, as well as a number of teacher training, technical[4], nursing, and agricultural colleges (Mtegha, 2005:1). The two universities are the University of Malawi and Mzuzu University. The establishment of a third university is underway, namely the Lilongwe University of Science and Technology.

Since universities are the main R&D performers in the higher education sector[5], only these will be discussed next.

The University of Malawi was founded in 1964. It has a federal structure, spanning five constituent colleges in three cities. The constituencies are as follows: Bunda College of Agriculture (in Lilongwe), Chancellor College (in Zomba), College of Medicine (in Blantyre), Kamuzu College of Nursing (in Blantyre and Lilongwe), and the Polytechnic (in Blantyre). The university's central administration is located in Zomba (Chimombo, 2003:416).

In the national S&T policy, it is proposed that some of the constituent colleges of the University of Malawi be established as separate universities and that at least one be designated as a University of Science and Technology (NRCM, 2002, Point 4.2.2.4).

The University of Malawi is a strong national research entity. About 10% of the university's overall budget for its development strategy is devoted to capacity building in research and consultancy, ensuring research quality, and improving dissemination and utilisation of research findings (UNIMA, no date: 39). The university further allows its staff to spend 25% of their time on research and 75% on teaching. It conducts basic as well as applied research on agriculture and livestock; environmental protection and health; energy sources and utilisation; engineering and construction; and health and medical issues (Phiri, no date). Moreover, the

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[3] There is some debate as to whether or not to split the national Ministry of Education into a Ministry of Basic Education and a Ministry of Higher Education, in order for higher education to gain its rightful place at ministerial level. The creation of a National Council for Higher Education is also strongly argued for (Mkandawire, 2005). A mere inspection of the website content of the Ministry of Education (www.malawi.gov.mw/Education/Home%20%20Education.htm) confirms that higher education (specifically university matters) is almost invisible at the ministerial level.

[4] Malawi has 4 government-aided and 3 state technical and vocational training institutions that offer formal training in about 22 trades in the fields of building/construction, engineering, horticulture, and printing (MoE, 2004:14).

[5] According to the 2001 Directory of S&T institutions in Malawi (NRCM, 2001), a number of colleges also have some research function. These are the Domasi College of Education, Malamulo College of Medical Sciences, Malawi College of Health Sciences, Malawi Institute of Education, and the Natural Resources College. The directory does not specify the Lilongwe Technical College as having any research function. However, the college is the largest public technical college in the country and currently houses a project that investigates the practicability of locally manufactured ethanol-fuelled vehicles. The latter is a joint project with the Department of Science and Technology, to the value of US$1 million, which is financially supported by the Malawi government (DST, no date; SciDevNet, 2006d).

university has a variety of training equipment and purpose-built laboratories for its programmes. In addition, it has qualified faculty trained in well-established universities in Europe and the United States (Mtegha, 2005:5).

Table 2 gives the annual headcount of students for the period 1997 to 2006.

Table 2: Headcount of students at the University of Malawi (1997 to 2006)

Constituent colleges	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Bunda College of Agriculture	498	490	509	454	592	590	634	666	814	737
Chancellor College	1493	1292	1448	1508	1555	1693	1710	2011	2258	2234
College of Medicine	93	93	95	91	88	149	149	179	179	308
Kamuzu College of Nursing	239	263	233	248	270	263	336	331	331	371
Polytechnic	1064	1041	1050	1101	1239	1538	1496	2343	2140	2256
Total	3387	3179	3335	3402	3744	4233	4325	5530	5722	5906

Compiled from figures provided by the Malawian Department of Science & Technology, February 2007.

The various departments at the university are involved in research activities. An idea of the research foci of the university can be obtained from the list of centres and units summarised in Table 3.

Table 3: Centres and units at the University of Malawi

Constituent colleges	Centres and Units
Bunda College of Agriculture	Agriculture Policy Research Unit (APRU) within the Centre for Agricultural Research and Development (CARD)
Chancellor College	Centre for Educational Research and Training (CERT) Centre for Language Studies (CLS) Centre for Social Research (CSR) Demographic Unit Natural Resources and Environment Centre Molecular Biology and Ecology Research Unit (MBERU)* Renewable Energy Unit
College of Medicine	Bioethics Research Unit Centre for Reproductive Health

Table 3 Continued

Constituent colleges	Centres and Units
Kamuzu College of Nursing	Nursing, Midwifery and Health Sciences Research Centre (NUMHREC)
Polytechnic	Centre for Continuing Education Management Centre Polytechnic Commercial Technical Services Malawi Transportation Technology Transfer Centre (T^2C) Centre for Water, Sanitation, Health, and Appropriate Technology Development (WASHTED)

Compiled from the websites of the constituent colleges (www.bunda.unima.mw; www.chanco.unima.mw; www.medcol.mw; www.kcn.unima.mw; www.poly.ac.mw).

* MBERU has been transformed into the Biotechnology-Ecology Research and Outreach Consortium (BioEROC), according to Ambali and Msowoya (2004). The authors classify BioEROC as a private research firm but no additional information could be obtained in support of this classification.

Mzuzu University, in the northern region, was established in 1997 as Malawi's second public university. The first students were admitted in January 1999. Compared to the University of Malawi, Mzuzu University is significantly smaller and had 345 students in the 2001-2002 academic year (IAU, 2003:1332). In 2007, the number has increased to 461 students (Table 4).

Table 4: Headcount of students at Mzuzu University (2007)

Faculty	Headcount	Percent
Information Science & Communications	80	17%
Environmental Sciences	80	17%
Education	231	50%
Tourism & Hospitality Management	37	8%
Health Sciences	33	7%
Total	461	100%

Source: www.mzuni.ac.mw (2007 intake)

The university has four faculties (education; environmental sciences; health sciences; and information and communication sciences), as well as the following centres:

- Centre for Open and Distance Learning
- Centre for Continuing Education
- The Test and Training Centre for Renewable Energy Technologies (TCRET)
- Centre for Security Studies
- Centre for Environmental Education, Training and Research

The government announced in 2005 that the Lilongwe University of Science and Technology would be up and running by the end of that year, and that it would be created by converting and upgrading facilities at Lilongwe Technical College and the Natural Resources College n Lilongwe (SciDevNet, 2005a). However, by March 2007 there was no significant progress with regard to the establishment of this university. The only developments were the establishment of a university secretariat, the university's inclusion in the national budget, the identification of possible campus locations, and the narrowing of potential areas of specialisation (SciDevNet, 2007d).

3.2.2.2 Government-based research institutes

These institutes are set up and controlled directly by government. All their funding comes from the government revenue and development budgets. The little donor or stakeholder money they are able to attract also comes through the government system (Phiri, no date: 2). Table 5 lists the main government-based research institutes in Malawi.

Table 5: Government-based research institutes in Malawi

Research institute	Ministry where located
Central Veterinary Laboratory	Agriculture and Food Security
Central Water Laboratory	Irrigation and Water Development
Community Health Sciences Unit	Health
Department of Agricultural Research Services (DARS)	Agriculture and Food Security
Fisheries Research Unit	Mines, Energy and Natural Resources
Forestry Research Institute of Malawi (FRIM)	Mines, Energy and Natural Resources
Geological Survey Department	Mines, Energy and Natural Resources
Health Sciences Research Unit (HSRU)	Health
Meteorological Department	Transport and Public Works
National Aquaculture Centre	Mines, Energy and Natural Resources
Wildlife Research Unit in the Department of Parks and Wildlife	Mines, Energy and Natural Resources

More information is provided below on two of these government-based research institutes, namely the Department of Agricultural Research Services, and the Forestry Research Institute of Malawi.

The Department of Agricultural Research Services (DARS) is located in the Ministry of Agriculture and Food Security. It is the largest of the government-based research institutes and Malawi's principal research agency. In 2001, it accounted for about 45% of the country's agricultural research staff and expenditures. DARS conducts applied agricultural commodity research and provides technical and advisory services to stakeholders in the areas of crop production, livestock production, seed production and plant protection. Tobacco, tea and sugar are excluded from DARS' activity areas. DARS has eight research stations[6] spread throughout the country (Beintema, Mwenda & Mtukuso, 2004:2; Phiri, no date: 2).

The Forestry Research Institute of Malawi (FRIM) in Zomba is placed within the Ministry of Mines, Energy and Natural Resources. It started in 1957 as the Silvicultural Research Station

[6] At Chitedze, Bvumbwe, Makoka, Lifuwu, Mbawa, Kasinthula, Chitala, and Mkondezi. (www.malawi.gov.mw/Agriculture/Home%20%20Agriculture.htm)

in Dedza, under the then Agricultural Research Council of Central Africa. FRIM's mandate has evolved over the years from conducting research mainly on plantation forests to providing information and improved germplasm and to carrying out stakeholder-oriented research on the sustainable management, utilisation and conservation of trees and forests in Malawi. FRIM has a 5-year programme and strategy for 2002-2007, that is aligned to the National Forestry Policy and the National Forestry Programme (DoF, 2001). The institute's research is organised around four technical strategy areas: (1) indigenous woodland management; (2) trees on farms; (3) plantations; and seed and tree improvement (www.frim.org.mw). FRIM is responsible for research in all aspects in forestry that include nursery establishment and management, silvicultural systems, indigenous forest management, social forestry, tree improvement, seed supply and variability, wood utilisation and marketing, and plant protection (IFRPI, 1998:19).

3.2.2.3 Statutory research institutes

These are government-assisted institutes that work outside normal government settings. The most notable here are the Malawi Industrial Research and Technology Development Centre, and the National Herbarium and Botanic Gardens of Malawi.

The Malawi Industrial Research and Technology Development Centre (MIRTDC) is the only industrial research institute in the country. It was set up as a trust with a mandate to conduct industrial research and develop technologies for sustainable utilisation of natural resources by industry. Its programmes include, among others, the development of agricultural implements and machinery for cottage and light industries (Phiri, no date: 2).

As part of its activities, MIRTDC has developed a number of technologies to support the small-scale poultry industry, including a low cost electric egg incubator, feed mixing technologies, cages and brooders. It has also developed and disseminated improved beehive technology. At micro and rural enterprise level, MIRTDC is promoting solar driers that can be used for production of dried vegetables and fruit products (MIRTDC, no date: 31-37).

The major constraints of MIRTDC include the lack of appropriate office premises and workshop facilities, inadequate incentives to staff and limited financial base due to its overdependence on government and donor funding and a weak revenue generation capacity. The Centre has a staff level of about 10 professionals in different fields of expertise (MIRTD, no date: 69). There is a central facility as well as four technology dissemination satellite centres (Phiri, no date: 2). MRTDC is affiliated to the Ministry of Industry, Trade and Private Sector Development.

The National Herbarium and Botanic Gardens of Malawi (NHBG) is a para-statal botanical institution and the principal authority on botanical and related matters in the country. Its roots date back to 1891 when the first botanic garden was established in the city of Zomba and to 1930 when the first herbarium was established in the same city. The research activities of NHBG include taxonomic research, ethnobotanical surveys and vegetation surveys (www.sdnp.org.mw/enviro/herb). NHBG is affiliated to the Ministry of Mines, Energy and Natural Resources.

3.2.2.4 Private research institutes

These include research institutes that have been set up by associations or groups of stakeholders to perform research in specific areas or commodities (non-profit private research institutes). Funding is obtained from a levy imposed on sales of produce by farmers with no direct government funding. The two primary examples are the Agricultural Research and Extension Trust, and the Tea Research Foundation. Both are affiliated to the Ministry of

Agriculture and Food Security (Phiri, no date: 3). The category also includes for-profit private research institutes, such as Illovo Sugar (Malawi) Ltd.

The Agricultural Research and Extension Trust (ARET), a non-profit organisation, was established in 1995 through a merger of the Tobacco Research Institute of Malawi (TRIM) and the Estate Extension Service Trust (EEST). ARET is funded and controlled by the Tobacco Association of Malawi (TAMA). Research is demand-driven, aimed at developing improved technologies, such as varieties and production techniques that increase the production of high quality tobacco (Beintema, Mwenda & Mtukuso, 2004:3; www.sdnp.org.mw/webwshp/dbanda/index.html).

The Tea Research Foundation of Central Africa (TRF) is located in Malawi but conducts tea research for Malawi, Zimbabwe, South Africa and Zambia. The TRF is a non-profit organisation, mainly funded by the Tea Associations of Malawi and Zimbabwe (Beintema, Mwenda & Mtukuso, 2004:2). Apart from tea research, it also includes coffee and other plantation tree crops in its portfolio. It was established in 1966 (Rooseboom & Pardey, 1993:4).

Illovo Sugar (Malawi) Ltd is part of the Illovo Sugar Group, a leading, global sugar producer and significant manufacturer of downstream products, with agricultural, manufacturing and other interests extending over six southern African countries. Until 2005, the organisation was known as the Sugar Corporation of Malawi Limited (SUCOMA), a state-owned corporation. During its SUCOMA years, the organisation had three researchers, focusing on sugar-related agronomic research and herbicide use (Beintema, Mwenda & Mtukuso, 2004:3; Illovo Sugar, 2006).

3.2.2.5 International research institutes

These are international research organisations that have established centres in Malawi. Key organisations are the WorldFish Centre, the International Centre for Research in Agroforestry, and the International Crops Research Institute for the Semi-Arid Tropics.

The WorldFish Centre is an autonomous non-profit international scientific organisation, with its headquarters in Penang, Malaysia. In 1987, the Centre established an aquaculture project office at the National Aquaculture Centre in Domasi, Malawi. The project office was established with funding from the Deutsche Gesellshaft fur Technische Zusammenarbeit (GTZ), which also provided funds for vital research and training. The WorldFish Centre's office in Malawi services the Southern African Development Community (SADC). It undertakes research in partnership with the Malawi Department of Fisheries, the University of Malawi, and the Zambian Department of Fisheries. The focus is on fisheries research within the broad context of watershed management (WorldFish, no date).

The International Centre for Research in Agroforestry (ICRAF) has a programme in Malawi, which is based at the Makoka Agricultural Research Station. ICRAF-Malawi has particular strength and expertise in soil fertility improvement technologies, fruit tree domestication, sustainable tree seed systems, fodder for livestock production, strengthening grassroots capacity, empowerment through training and scaling up of the proven technologies. In the past three years, the programme has also significantly increased its expertise in fruit processing and product and enterprise development. The staff strength is about 23, comprising three internationally recruited staff members, five national professional staff (two of them seconded by the Malawi government), and 15 support (including three staff based in the outreach site in Lilongwe). The programme has supported more than 10 postgraduate research projects in the last five years. It currently supports four PhD and two MSc students (www.icrafsa.org/national_programmes/malawi.html).

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is a non-profit, non-political organisation that does innovative agricultural research and capacity building for sustainable development with a wide array of partners across the globe. Its research unit in Malawi is based at the Chitedze Research Station of DARS, in Lilongwe (www.icrisat.org).

Lastly, in early February 2007 the Malawi president has pledged to create an international scientific centre of excellence in Malawi. The centre would build capacity to diagnose epidemics and bring together experts to discuss issues such as hydrology, genetic engineering and biotechnology (SciDevNet, 2007b).

3.3 Human capital for S&T

3.3.1 Size and structure of the R&D workforce

The NRCM has very limited influence on the S&T institutions, which affects the collection and compilation of S&T and R&D data. As a result, some of the crucial S&T data is difficult to obtain and sometimes unavailable altogether (Gausi & Kalanda, 2005:6-7).

The NRCM conducted in 1999 a survey of human resources in agricultural and natural resources research in the country. Of the 243 researchers with graduate qualifications, 45 held BSc's, 127 MSc's and 71 PhD's. The largest concentration of PhD's was in DARS (32%) and Bunda College of Agriculture at the University of Malawi (20%). Among the sectors, agriculture accounted for 83% of total researchers, and fisheries and forestry for 8.5% each (Phiri, no date: 3).

Moreover, the *2001 Directory of S&T institutions in Malawi*, compiled by the NRCM, includes the number of scientists per S&T institution. If one adds the number of scientists for every institution that has a specified research function, a headcount of 781 is obtained.

Lastly, we also provide the headcount of academics at the University of Malawi and Mzuzu University, respectively (Tables 6 & 7). In the case of the University of Malawi, the figures are for 2007 and in the case of Mzuzu University; the figures pertain to the 2001-2002 academic year.

Table 6: Headcount of academic staff at the University of Malawi (2007)

Constituent colleges	Headcount	Percent
Bunda College of Agriculture	140	20%
Chancellor College	221	32%
College of Medicine	82	12%
Kamuzu College of Nursing	56	8%
Polytechnic	198	28%
Total	697	100%

Compiled from *University of Malawi Staff List*, January 2007 (www.unima.mw/downloads.htm).

'Academic staff' includes Professor, Associate Professor, Head of Department, Senior Lecturer, Lecturer, Assistant Lecturer and Staff Associate.

Table 7: Headcount of academic staff at Mzuzu University (2001-2002)

Academic staff	Headcount			% of total with doctorate
	Male	Female	Total	
Full-time	**34**	**5**	**39**	**15%**
Part-time	**10**	**1**	**11**	**45%**
Total	44	6	50	22%

Source: IAU (2003:1332)

3.3.2 Trends in masters and doctoral enrolments

No information could be obtained on the number of masters and doctoral enrolments at the University of Malawi. As far as Mzuzu University is concerned, of the 461 students in 2007 (see Table 4), only 13 (i.e. 3%) are postgraduate students. All of them are enrolled for the MSc Degree in Information Theory, Coding and Cryptography (www.mzuni.ac.mw).

3.3.3 Masters and doctoral graduate output

The number of masters and doctoral degrees awarded by the University of Malawi over the period 1996 to 2006 are presented in Table 8. As can be seen there are almost no doctoral degrees. In the few instances where doctoral degrees do exist, they were all awarded within the social sciences and humanities.

Table 8: Masters and doctoral degrees awarded at the University of Malawi

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
MASTERS	**12**	**10**	**38**	**10**	**40**	**44**	**50**	**45**	**0**	**83**	**55**
Social sciences & humanities	9	2	14	2	23	13	13	13	0	55	32
Natural sciences, engineering & health	3	8	24	8	17	31	37	32	0	28	23
DOCTORAL	0	0	1	3	4	2	5	3	0	5	3
Social sciences & humanities	0	0	1	3	4	2	5	3	0	5	3
Natural sciences, engineering & health	0	0	0	0	0	0	0	0	0	0	0

Compiled from figures provided by the Malawian Department of Science & Technology, February 2007.

In all likelihood, the figures for 2004 do not represent true zeros but rather an absence of statistics.

3.3.4 Human and institutional capacity development strategies

Staff recruitment and retention has been raised by the Department of Science and Technology as a concern in its strategic plan for 2005-2010. The department realises that it is expensive to recruit and train staff for specific key technical and professional occupations. In this regard, the institutionalisation of a result-oriented management system is seen as of paramount importance (MIST, 2005:9).

Industry has also expressed concerns over the low quality of new graduates and/or professionals, in terms of their analytical and writing skills. This may be because of universities not shaping the current crop of graduates according to the needs of industry (Faiti, 2006:4).

The national S&T policy acknowledges the fact that Malawi needs to make significant strides in improving its S&T human resources. The policy states that a wide range of initiatives are already in place to address the shortfall in technical work force, among which the re-organisation and strengthening of technical, entrepreneurial and vocational education and training. To this end, the government has adopted a Technical, Vocational, Entrepreneurial Education and Training Policy. In order to achieve these objectives, the following strategies will be adopted (NRCM, 2002, Point 3.4.2):

- Strengthen university education in S&T and increase and diversify post-graduate training programmes;
- Ensure that the universities offer postgraduate studies leading to MSc's and PhD's on an on-going basis;
- Create institutions constituting an inter-disciplinary bridge between different faculties;
- Promote the involvement of professional institutions in the training of S&T human resources while ensuring gender equity;
- Promote an integrated, demand-driven, competency based modular technical, entrepreneurial and vocational education and training system;
- Monitor gaps between supply of and demand for technically skilled human resources;
- Ensure the retention of S&T human resources in Malawi; and
- Undertake national surveys of S&T human resources on regular intervals to establish the national stock as a basis for developing human resources in all S&T fields.

3.3.5 Scientific mobility

Malawi experiences health sector migration: the level of vacancies across the entire public health system is acute with an overall vacancy rate of 33% (Record & Mohiddin, 2006). This is even more critical for individual occupations, as shown in Table 9.

Table 9: Established posts and vacancies in Malawi's public health system (2004)

Occupation	Number of established posts	% Filled
Nurses (all grades)	6084	36%
Clinical officers	3852	73%
Medical assistants	692	47%
Surgeons	115	15%
Medical specialists	65	5%
Anaesthesiologists	14	29%
Pathologists	22	0%
Obstetricians/gynaecologists	126	9%
Paediatricians	60	8%
Total health professionals	21337	77%

Source: Malawi Ministry of Health, 2004, in Record and Mohiddin (2006)

3.4 Financial resources

3.4.1 R&D expenditure

According to Phiri (no date: 3) it is fairly difficult to analyse the amount, distribution and utilisation of funds allocated to S&T, largely because the conventional budgeting procedures do not allow for explicit and clear identification of funding on S&T. However, in 2005, Malawi spent about USD1.2 million on science, and the Finance Ministry was asked in 2006 to raise it to about US million, in order to reach a target of 1 percent of GDP (SciDevNet, 2006a).

Early in 2006 the Department of Science and Technology launched a 5-year strategic plan (2005-2010), intended to foster rapid industrialisation using S&T (MIST, 2005). It involves a budget of about US$8.3 million, and places a heavy emphasis on popularising science. The money will be spend in four main areas: capacity building (US$3.5 million), promoting and popularising science (US$2.3 million), developing and commercialising research (US$1.5 million) and administration (US$1 million). This is in addition to the annual science budget. It was also on the table to approach international donor agencies to partly fund the activities (SciDevNet, 2006a). Unfortunately, in January 2007, it was clear that the plan would need to be severely curtailed due to a lack of government funding and the subsequent reluctance by international donors to participate on their own (SciDevNet, 2007a).

As a result, in February 2007 it was announced that some planned S&T initiatives in Malawi would need to be shelved due to budgetary constraints. The activities to be shelved were the formulation of a policy on intellectual property to protect natural resources, and the production of a coherent research agenda for Malawi. Specific research projects – such as the testing of ethanol-fuelled vehicles (see Footnote 5) – were also at risk of being cancelled (SciDevNet, 2007c). However, a month later, in March 2007, the National Treasury announced a tripling of funding for S&T projects from around US$250 thousand to US$673 thousand (SciDevNet, 2007d).

3.4.2 National financial resources

The NRCM co-ordinates and administers a Research Grant Scheme that awards competitive research grants for researchers to conduct research in identified priority areas. During the 2004/2005 fiscal year, the Council funded 15 demand-driven projects under the following themes: water resources management; energy; environment and natural resources management; food security and sustainable livelihoods; agro-processing; maternal and child health; HIV/AIDS; government policy and industrial development; and culture and socio-economic development (www.nrcm.org.mw/news-events.html)

Moreover, the Science and Technology Act of 2003 have established an S&T Fund that is dedicated to the advancement of S&T in Malawi (GoM, 2003). This fund is not yet operational but will finance, by way of loans or grants, any research that engage in research matters relating to the development of S&T.

In 2002, the government also established a Biosafety Fund through an act of parliament (GoM, 2002). The fund was established to support the safe management of biotechnological activities, the fund may, *inter alia*, be applied to research, and training that can promote safe management. It is unclear whether this fund is operational yet.

3.4.3 International donor funding

The Agricultural Research and Development Fund (ARDEF) programme is a 5-year Norwegian funded national programme co-ordinated at Bunda College (University of Malawi). The programme aims to set up an initial competitive grant scheme (CGS) to fund projects in agriculture, natural resources and related fields to effectively contribute to addressing the

poverty reduction initially in selected pilot impact areas. An immediate outcome of the programme is to promote food security and income generation of small-scale farmers. The programme, which is running from October 2005 to June 2010, forms part of a NOK35.0 million support scheme from the Government of Norway. It is governed and managed by national structures such as the ARDEF Programme Board and ARDEF Management Group composed of various stakeholders, including the Department of Science and Technology, Ministry of Agriculture and Food Security, Ministry of Mines, Energy and Natural Resources, Ministry of Education and Vocational Training, Ministry of Finance. (Banda, Kaunda & Kanyama-Phiri, no date)

The Department of Meteorology announced in 2004 a strategic plan to completely automate and update Malawi's weather stations with modern computerised equipment to improve recording and monitoring of weather data. The plan cost US$1 million to implement and it was said that the Malawian government and international donors would jointly fund it. The European Union, The United Nations Development Programme and the Japanese International Corporation Agency were to be contacted with funding proposals (SciDevNet, 2004).

Apart from funding, Malawi has also been donated S&T equipment. An example is the state-of-the-art geology equipment – the International Earth Monitoring System – that was donated by the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organisation (CTBTO) in Geneva, Switzerland. It will improve Malawi's capability to detect natural disasters such as earthquakes and earth tremors, volcanic explosions and meteorites, and allow it to issue early warnings signals to its agriculture and aviation sectors (SciDevNet, 2006c).

Moreover, UNESCO financially supported an S&T Chair in Renewable Energy at the University of Malawi in 1999 (UNESCO, 2007:26).

Table 10 locates the main external donors for 2002-2005 under each pillar and associated thematic area of the Malawi Poverty Reduction Strategy Paper (MPRSP). The table is derived from a summary provided by the African Development Bank. Overall, all four pillars received widespread donor attention and funding. However, the tendency for donors was to focus on sectors such as agriculture, health, education, and livelihoods, where the linkages to poverty reduction are most explicit and results can be achieved more directly (ADB, 2005:26). Only Japan explicitly concentrated on S&T in its donor support to Malawi.

Table 10: Main donor support by MPRSP pillar and theme (2002-2005)

	PILLAR 1 Sustainable pro-poor growth								PILLAR 2 Human capital development				PILLAR 3 Improving quality of life of most vulnerable		PILLAR 4 Good governance			PILLAR 5 Cross-cutting issues			
Donor	Sources of growth	Agriculture	Natural resources	MSMEs	Manufacturing & agro-processing	Tourism	Small-scale mining	Enabling environment	Education	TEVET	Health	Nutrition	Safety nets	Disaster management	Political will & mindset	Security & justice	Responsive public institutions	HIV/Aids	Gender	Environment	Science & Technology
ADB																					
Canada																					
EU																					
IMF																					
FAO																					
Germany																					
Japan																					
Norway																					
Sweden																					
UK																					
UNICEF																					
UNDP																					
USA																					
WFP																					
WHO																					
World Bank																					

Source: ADB (2005, Annex VI)

3.5 Research outputs

The NRCM has produced a directory of publications by Malawian researchers, covering the period 1996-2002. The problem with this publication, however, is that it lacks in-depth analysis. All that is stated is that 40% of the publications within the reference period were done by Malawians, and of the publications produced by non-Malawians, 40% were co-authored by Malawians. It is further stated that the health sector has produced more publications than any other sector and that 10% of the publications in the health sector have been published by Malawians in internationally recognised journals (NRCM, no date: i).

The above attempt at analysis makes no reference to the number of publications per year, and also does not explicitly distinguish between the various kinds of publications, e.g. journal publications, conference proceedings, in-house publications, technical reports, etc.

Researchers world-wide generally consider a publication in journals listed by Thomson Scientific (referred to as 'ISI journals') as the first prize in scientific publication. Hence, we have extracted all publications with a Malawian affiliation from the Thomson Scientific database, for the period 2000-2006. Following standard practice, an ISI journal publication was taken to mean an article, review, letter or note. As can be seen in Table 11, researchers in Malawi produced, on average, about 120 publications per year in ISI journals. Unfortunately, given the limited scope of this report and time constrains, the publications could not be disaggregated in terms of the scientific field classification of journals.

Table 11: Number of ISI publications produced by authors with a Malawian affiliation

Year	Article	Review	Letter	Note	Total
2006	126	7	10	0	**143**
2005	113	4	11	0	**128**
2004	113	5	8	0	**126**
2003	114	4	4	0	**122**
2002	112	2	9	0	**123**
2001	99	4	8	0	**111**
2000	107	3	13	0	**123**

Source: Thomson Scientific database, using the following search criterion: Country=Malawi

3.6 Technological innovation

3.6.1 Technology balance of payments

No information could be obtained.

3.6.2 Patents

During the period 2000-2005, no patent with a Malawian inventor was filed or issued by either the European Patent Office or the United States Patent and Trademark Office (www.epo.org; www.uspto.gov).

3.6.3 *Innovation strategies*

Apart from the Malawi Award for Scientific and Technological Achievement (MASTA), there are no other awards that promote innovation. In order to ensure that local S&T personnel are provided with adequate incentives and are suitably motivated, the national S&T policy (NRCM, 2002, Point 3.4.6) argues for the following initiatives:

- Revive the Malawi Award for Scientific and Technological Achievement, and ensure that its range of awards is diversified in order to open it to more recipients and that it is administered annually;
- Introduce new awards to complement MASTA such as the Outstanding Invention Award, Outstanding Entrepreneur Award and a Presidential Award in order to promote innovation;
- Provide for an administrative system that enables local scientists who develop specific technology applications to benefit directly from such works through payment of royalties;
- Encourage and fund participation of S&T personnel in local and international scientific and technological fora.

A technology strategy for sustainable livelihood strategy was produced by MIRTDC at the turn of the century. The strategy has identified key technologies with strong potential to impact on enterprise development in Malawi. The uptake of the strategy is however unknown. The technologies have been summarised in Table 13.

Table 13: Key technologies that are considered instrumental in increasing the productivity of enterprises in Malawi

Public/private	Technologies	
High potential public common assets	Renewable energy technologies	Solar energy
		Biogas technology
		Micro-hydro
		Windmill technology
	Water technologies	Water pumps
		Purification technologies
	Forestry and wildlife technologies	Beekeeping
		Utilisation of wild fruits (baobab, tamarind, marula, etc)
		Domestication of guinea fowls
High potential private common assets	Food processing technologies	Improved bakery ovens
		Kachasu stills*
		Juice extractor
		Maize dehuller
		Oil expeller
		Improved produce driers
	Poultry production technologies	Egg incubator
		Feed mixer
		Brooders, laying boxes and cages
	Mining technologies	Brick making
		Salt production

		Lime production
		Ceramics and clay roofing tiles
	Handicrafts and garments technology	Fabrication of leather hand tools and leather tanning tools, manufacturing of cane furniture, etc.
	Metalwork technology	

Source: Compiled from MIRTDC (no date: 43-51)

* Kachasu = A local rum distilled from a fermented mixture of cereals and sugar

3.7 International co-operation and networks

3.7.1 Bilateral co-operation

Malawi and Ethiopia signed in January 2006 an economic, trade, cultural and technical co-operation agreement in order to strengthen the two countries' long standing bilateral relations. The agreement served to formalise trade between the two countries, which have been engaged in informal trade since 1965. Malawi's Foreign Affairs and International Cooperation Minister commented that Ethiopia was well advanced in leather and handcraft industry, which Malawi could benefit from (www.malawi.gov.mw/story.php?id=34).

According to the Ministry of Foreign Affairs of Greece, Malawi has yet to answer to the 2001 proposal for drafting an Economic, Scientific and Technological Assistance Agreement (www.mfa.gr).

Norway and Malawi signed a memorandum of understanding in October 2000, with the overall objective of alleviating poverty in Malawi. The agreed programmes focused on good governance, HIV/AIDS, macro-economic reform and health sector development. Although agriculture was not defined as a priority area, Norwegian assistance has always contributed to applied research in the agricultural sector (www.norway.mw/development/agreement/agreement.htm).

The governments of Malawi and Japan signed in 2006 a technical co-operation agreement. The agreement, among others, provided a solid base for the continuation of the Japanese Technical Cooperation. The latter initiative serves to transfer specialised technical expertise to various sectors of the Malawian economy, e.g. telecommunications, transport, civil aviation, fisheries, health, and agriculture (www.nationmalawi.com/print.asp?articleID=15533).

An agreement on bilateral co-operation between South Africa and Malawi was signed on 7 May 2007. (www.info.gov.za/speeches/2007/07050714151001.htm). No further details are available.

3.7.2 Multilateral co-operation

Bioscience activities in Malawi form part of the Southern African Biosciences Hub that is located at the CSIR in Pretoria. It is a NEPAD initiative under the NEPAD Science and Technology Programme. The initial focus is to drive regional cooperation (in Southern Africa), with a long term vision of creating synergy between all four regional hubs in Africa (i.e. Southern, West, East and North Africa) (www.csir.co.za/plsql/ptl0002/PTL0002_PGE013_MEDIA_REL?MEDIA_RELEASE_NO=7303835)

3.8 Conclusion

There is no doubt that the Malawi government has a clear vision about the contribution of S&T to the socio-economic development of the country. The government recently articulated its intentions in this regard by means of a national S&T policy and a strategic plan for the Department of Science and Technology. However, the means to act upon these intensions appear to be lacking. Apart from limited government funding, considerable delays in the realisation of new organisational structures (such as the National Commission for Science and Technology, the Science and Technology Fund, and the Lilongwe University of Science and Technology) appear to be the rule rather than the exception.

In addition, from an outsider's perspective, it is not always clear to what extent an overlap exists in the activities of the main S&T governing bodies (i.e. the Department of Science and Technology, the National Research Council of Malawi, and the National Commission for Science and Technology, once in place). Moreover, if the NRCM were transformed into this commission, a vacuum could be created at the intermediary level of the country's science system. Institutions at the intermediary level of a national science system (national research funding bodies, science academies, etc) normally serve as bridging mechanisms between the practice and governance of science. They facilitate dual communication and interaction where (1) the directions set by science policy-makers are translated and made practical for the research community and (2) the needs and activities of the research community are communicated to policy-makers to inform current and new strategies. The existence of intermediaries is crucial to the efficient functioning of any national science system.

Of further concern is the current low level of innovation capacity – with obvious ramifications for future innovative ability – as reflected by the small number of postgraduate students. The lack of a critical mass of doctoral graduates over the last decade remains a serious problem. Moreover, Malawi not only has to bridge the gap between higher education supply and industry demand by introducing interface mechanisms (programmes, training initiatives, etc), but also need to build capacity in both the higher education and industry sectors. In this regard, South Africa can play a valuable role, especially in relation to building capacity in science domains and industrial spheres that are of crucial importance to the development of the Malawi economy, such as fisheries and aquaculture, forestry, water resources, and renewable energies.

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