Research Environment Study

A series of reports on Kenya, Malawi, Pakistan and Bangladesh undertaken by the Research Information Network on behalf of the International Network for the Availability of Scientific Publications

March 2012

Contents

1 Introduction

1.1 About this report

This report has been prepared by the Research Information Network (RIN)[1] on behalf of the International Network for the Availability of Scientific Publications (INASP)[2]. INASP commissioned the RIN to undertake desk-based research to explore and provide insights and understanding into the policy and financial commitments within the research sectors of selected countries with which INASP works with. Four countries were selected from INASP's partner countries within the Programme for the Enhancement of Research Information (PERii): Kenya, Malawi, Pakistan and Bangladesh.

Each of these country level reports presents information on key issues including:

- the size and make up of the research sector
- research productivity over the last 10 years and how this productivity may have changed
- the national level bodies that support, promote and evaluate research at national levels
- the key policies in the last 10 years that relate to strengthening research
- the financial or budgetary support that can be identified as being allocated to support research
- the general status of research as judged by key productivity indicators, reports, stakeholders
- policy and budgetary developments under development that may be relevant to strengthening the research sectors

Separate reports have been produced for each of the four countries, using a common template, though the scope, quality and amount of information that could be gathered differed significantly for each country. The four country level reports are presented here as a single document.

1.2 Context and background

INASP and others have been working with these countries over the last 10 years, helping to build the capacity of the research and research communication sectors. Whilst this work has only actively been engaging policy makers in the last 3-4 years, the wider policy and financial frameworks in which these sectors sit has and continues to be of great interest to those working in and with these sectors.

Understanding these frameworks better is useful for organisations like INASP and others working in this area, at a number of levels:

- It allows us to see what the policy and financial frameworks are that exist today
- It allows us to see how these policy and financial frameworks have been changing over time

[1] http://www.rin.ac.uk/

[2] http://www.inasp.info

- It allows comparison within and between countries of these policy and financial frameworks
- It provides insights into important stakeholders and partners for programme design and implementation in this area

However, undertaking this kind of work is not an easy matter. The range and availability of appropriate information sources to underpin this kind of work is extremely variable. There are some great information sources available to help in this regard but they are also significant "black holes" of information that is either missing or simply not available. The limited nature of this research being desk based should be noted in this regard.

Even with these limitations, there is much of interest in this report and we hope that readers find it interesting and useful. There is no doubt that further work could be undertaken to elucidate further some of the issues raised in the reports, and to answer some of the questions they raise. The RIN and INASP will be working together to explore ways of how that could best be done.

1.3 About INASP and PERii

PERii is the second five-year phase of INASP's Programme for the Enhancement of Research Information. Focusing on the needs of people in developing and emerging countries, PERii works with partners to support global research communication by further strengthening:

- the knowledge and skills of people working in research communication
- participation in international knowledge networks
- research communication policy and practice

Taking advantage of the possibilities offered by ICTs, the core programme areas focus on:

- access to international scholarly literature
- successful writing, publishing and communication of research from developing and emerging countries
- effective use, evaluation and management of ICTs to support research
- development of modern, digital research libraries
- advice and advocacy around the role of research communication and the people engaged in it for sustainable and equitable development

The PERii programme is undertaken with generous support from DfID, Sida and Norad and with significant financial contributions from within participating countries.

Martin Belcher, Director of Programmes, INASP
31 December 2011

1.4 About the Research Information Network

The Research Information Network (RIN) is a community interest company (CIC), with three key consultants: Michael Jubb, Stéphane Goldstein and Ellen Collins. All three worked with the RIN in its former incarnation as a research and policy unit funded between 2005 and 2011 by a consortium of public bodies led by the Higher Education Council for England (HEFCE). We have a strong track record in producing high-quality reports which have made a real difference, on issues from the economics of publishing and disseminating research findings, to researchers' patterns of behaviour as both producers and consumers of information resources and services.

RIN works with and for representatives of all the key players in the research and information landscapes: researchers, research funders, publishers, universities and libraries. We aim to:

- improve accessibility, availability and understanding of research information resources and services; and
- promote the development of effective policies and strategies for the benefit of researchers and all those interested in their findings.

You can find out more about us on our website: www.researchinfonet.org ; and contact us at Research Information Network, 20-24 Tavistock Square, London WC1H 9HF, telephone +44 (0)20 3397 3649.

2 Country report: Kenya

2.1 Policy frameworks and priorities

The key policy frameworks and priorities for research in Kenya are set currently by the Vision 2030[3] published in October 2007, and the Medium Term Plan (MTP)[4] published in 2008. Under the heading of Science, Technology and Innovation, the Vision and the Plan set the following strategic priorities:

1. strengthen technical capabilities, with an emphasis on technological learning, and on technologies and processes to enhance national competitiveness;
2. develop a highly-skilled human resource base, to improve the national pool of skills in national priority areas, with a specific emphasis on postgraduate training in science and technology;
3. intensification of innovation in priority areas, with an emphasis, alongside other things, on increased funding for basic and applied research at HE institutions and for research and development in collaboration with industry;
4. enhance awareness of science, technology and innovation among policy-makers and the general public; and
5. strengthen the STI performance management framework (not in the Vision, but added in the Medium Term Plan), with a focus on international benchmarking and tracking the implementation of STI initiatives.

Kenya shares the African Union goal that one per cent of GDP should be devoted to research and development. But the MTP acknowledges that gaps remain in seeking to align the strategic priorities it defines with the Medium Term Expenditure Framework (MTEF). Hence, in addition to Government funding, including the setting up of a Kenyan National STI Fund, the MTP envisages targeting the private sector for venture capital, a national STI levy implemented as a private/public sector partnership arrangement, and seeking support from development partners.

2.2 National policy-making and funding structures

2.2.1 The Ministry of Higher Education, Science and Technology (MOHEST)

MOHEST is responsible for science, technology and innovation (STI) policy, for research development, for the authorisation of research (see below) and for the co-ordination of technical education. The Ministry was established in its current form in 2008. It stems from a Ministry of Research, Science and Technology which was established in 1987 to oversee the evolution of a sound research base. That in turn became the Ministry of Science and Technology in 2005, with an expanded remit including technical education.

MOHEST's policy priorities include:

- strengthening national STI standing and competitiveness
- improving quality, relevance, equity and access to HE and technical training
- promoting evidence-based policy-making and national development

[3] See www.kilimo.go.ke/kilimo_docs/pdf/Kenya_VISION_2030-final.pdf

[4] See http://tinyurl.com/785b8rq

- encouraging private sector participation in STI and technical education
- enhancing capacity in the national STI system
- promoting excellence, creativity, innovation and investment in STI, HE and technical education

2.2.1.1 Structure

Within MOHEST, the Directorate of Research Management and Development is responsible for:

- regional and international links and collaboration
- technology transfer and STI information
- adoption and use of STI, commercialisation etc
- resources for STI
- accreditation and standards
- monitoring and evaluation of research
- management and co-ordination of research
- advice on regulatory requirements

There is also a National Council for Science and Technology (see section xx below), though its precise relationship with the Ministry is not clear.

2.2.1.2 Strategic Plan

In its strategic plan for 2008-12[5] MOHEST identified the following strategic issues:

1. While Kenya has established many universities and S&T institutions, most of them are not well-coordinated, and often lack the resources and infrastructures to enable them to operate effectively;
2. While Kenya has achieved some success in various fields of research, especially medical and agricultural research, levels of social and economic impact have been limited, and levels of innovation awareness are low;
3. In universities, although the quality of students continues to improve, there is a shortage of doctoral level lecturers, as a result of rapid expansion of the sector, combined with a brain drain;
4. Funding for STI is inadequate, and without effective co-ordinating mechanisms; and
5. There is a lack of adequate information to facilitate regional and international benchmarking and to track the implementation of STI initiatives.

2.2.1.3 Capacity in the Ministry

In addition to these issues and problems, the Plan also identifies a need to develop and sustain MOHEST's own capabilities and capacity. The Plan states that in 2008, it had 365 staff in post, against an authorised establishment of 861, a vacancy rate of 58%. It was thus

[5] See http://chet.org.za/manual/media/files/chet_hernana_docs/Kenya/National/MHEST%20Strategic%20Plan%202008-2012.pdf

operating with a deficit of 308 in technical (professional) departments, and 188 in support services. Clearly, this represents a major impediment to the effective development and implementation of policy. Monitoring and evaluation of the implementation of the plan is identified, therefore, as a key strategic priority.

2.2.1.4 Possible restructuring

The Plan proposes the establishment of a number of new bodies, including:

- a National Commission for Science, Technology and Innovation
- a Kenya National Research Foundation
- a Parliamentary Office for Science, Technology and Innovation.

The NCST (see below) has taken the lead in drafting an STI Bill to implement the strategies set out in the MOHEST Plan, including setting up the new bodies listed above. That Bill has not yet passed.

2.2.2 National Council for Science and Technology (NCST)

The NCST was established under the Science and Technology Act 1977 with a role to advise Government on matters relating to science and technology, including priorities and funding requirements, and the application of the results of research to national development goals. The Council itself is made up of 12 scientists appointed by the Government, and nine permanent secretaries of ministries with interests in science and technology, plus the Council Secretary.

The Act did not give the Council a legal corporate identity, and the Council argues that the lack of autonomy constrains its ability to fulfil its mandate. For financial and other purposes it is located within the structures of MOHEST. The Council operates through a steering committee and a research committee which approves, monitors and evaluates all research activity in the country (under the Science and Technology Act, any person conducting scientific research is required to obtain authorisation and clearance).

2.2.2.1 NCST Activities

The Council's activities focus on:

- international co-operation with organisations including the International Atomic Energy Agency, the International Year of Planet Earth, the Square Kilometre Array, and various African and East African collaborative programmes;
- administration of the Science, Technology and Innovation Grant Fund, under which 213m K shillings (£1.4m) was spent on research projects and facilities in 2009. Success rates are relatively low: under the research and innovation grants scheme, 96 grants were made in response to 382 applications (25% success rate); under the research facility grant, 4 awards were made in response to 57 applications (7%); under the grants to women scientists, 14 awards were made in response to 148 applications (9%); and under the PhD and MSc students scheme, the success rates were 17% (20/119) for PhDs, and 19% (20/105) for MScs. Most grants are in the fields of environment and natural resources, agriculture, and energy;
- research clearance and authorisation, under which 1,058 applications were cleared in 2009, 855 for Kenyans and 203 for foreigners;
- promotion of research results and innovation, where the NCST runs conferences and organises exhibitions; and

- policy advice and formulation, where the NCST helps to establish committees on key issues such as nanotechnology and bioethics, as well as participating in various agency boards of management.

2.2.2.2 Key issues for NCST

Key strategic issues identified by NCST in its Strategic Plan for 2009-13 mirror those in the MOHEST Plan. It is notable, however, that the NCST Plan specifies in more detail some of the key activities required: for example, under the heading of strengthening technical capabilities, it specifies the need to facilitate international benchmarking; under enhancing skills the need for a skills and competency audit; and under strengthening the performance management framework the need to review STI policies, and to enhance documentation and dissemination services.

Like MOHEST, NCST also faces resource constraints. From a staff complement of 78, 36 posts (46%) were vacant in 2009, and the Council complains that remuneration is insufficient to recruit and retain the highly-qualified staff it needs.

2.2.3 Other national bodies

Kenya National Academy of Sciences, established in 1983 under the auspices of NCST, with a mission to mobilize the scientific community in the creation, maintenance and advancement of knowledge (including humanities and technology), to inform policy, to build capacity, and to provide solutions to improve the quality of life. Advocacy and public relations are at the heart of its activities. It also publishes the peer-reviewed Kenya Journal of Sciences in three series twice a year: physical sciences, biological sciences, and humanities and social sciences.

Institution of Engineers of Kenya, the learned society of the engineering professions, again with a learned journal.

2.3 Funding

Kenya, like Malawi, is one of the countries participating in the African Science, Technology and Innovation Indicators (ASTII) initiative; and one of thirteen countries which conducted surveys in 2007, the results of which are reported in the first African Innovation Outlook report for 2010, published in June 2011.[6] The ASTII initiative is funded by the Swedish International Development Co-operation Agency (SIDA) as part of the New Partnership for African Development (NEPAD). The aim is to build a system of STI indicators to support evidence-based policy.

The surveys on which the figures presented in the Innovation Outlook report are based were the first of their kind in Africa. The UNESCO Institute for Statistics has published series of R&D statistics but up to now many of the key statistics, including those on expenditure, have been missing for African countries.

The key international indicators on R&D expenditure are based on a calculation of gross domestic expenditure on R&D (GERD). Data are gathered from national surveys of expenditure by sector: business (BERD); Government (GOVERD); higher education (HERD); and private non-profit (PNP). GERD is the sum of the four components. Data are gathered and measured in national currencies. For comparative purposes, they are then converted into US dollars adjusted for their purchasing power in the country in question (PPP$).

[6] http://www.nepad.org/system/files/June2011_NEPAD_AIO_2010_English.pdf

The ASTII figures for 2007-08 show a gross expenditure on R&D of 7,642 million Kenya shillings. A summary of the sources of that funding, and the sectors in which it was spent, is shown in Table 1. It shows that over half of the funds came from the Government and the HE sector, the remainder from business (17%), non-profit organisations (13%) and from overseas (18%). It also shows that over three-quarters of the R&D recorded was undertaken in the Government and HE sectors. The figures should be treated with some caution, especially those relating to business expenditure on R&D, where the surveys may not capture all the activity and expenditure in the sector. The figures nevertheless imply that GERD was 277.8 million in PPP$, and that it represented 0.48% of GDP, just under half the goal set by the African Union.

Kenya gross expenditures (GERD) 2007-8
Millions of K Shillings

Sector of performance (columns) / Source of funds (rows)	TOTAL	Business	Government	HE	PNP
Business	1286.1	769.3	479.9	0	36.9
Government (direct)	1998.3	11.9	994.7	928.4	63.3
Government (general university funds)	0	0	0	0	0
HE	1998.8	0	757.9	1240.9	0
PNPs	1012	0	232.9	0	779.1
Funds from abroad	1346.4	110.9	236.9	110.9	887.7
TOTAL	**7641.6**	**892.1**	**2702.3**	**2280.2**	**1767.0**

It has not proved possible to reconcile these figures with those presented in the Kenya Government's Medium Term Expenditure Framework Report for the Research, Innovation and Technology Sector. The report shows total recurrent expenditure by Government of 22.5 billion Kenyan shilling (KES) in 2007-08, against original printed estimates of 10.9 billion, and revised estimates of 21.9 billion (The difference between the printed and revised estimates seems to relate to the transfer to MOHEST of responsibility for universities.) Actual recurrent expenditure rose to 27.5 billion in 2008-09.

The MTEF report (table 3.2.3-3, p 65)[7] shows a total resource requirement for research and innovation rising from 10.6 billion in 2009-10 to 21.3billion in 2012-13. It is unclear how much of this requirement will be met, and how much of it relates to R&D, as distinct from administrative expenditure. Nevertheless, it is notable that medical and agricultural research account for over 70 per cent (80 percent if tea, coffee and sugar research are included) of the total resource requirement.

Table 3.2.3-3 Research and innovations

	Sub Programme Name	(KES. Millions)			
		Printed Estimates 2009/10	Estimates 2010/11	Projected Estimates 2011/12	2012/13
1	Medical Research	4,335	8,318	8,905	9,552
2	Industrial Research	524	633	790	988
3	Agricultural Research	2,773	5,499	5,439	5,719
4	Forestry Research	719	954	1,032	1,118
5	Sugar Research	324	581	702	612
6	Crime Research	39.3	1,01.1	1,21.3	1,72.6
7	Tea Research	342	627	678	733
8	Coffee Research	679	398	422	474
9	Marine & Fisheries Research	495	1,021	1,391	1,531
10	Public Policy Research	265	351	369	353
11	Media Research (MOIC)	0	16.9	21.7	34.3
12	STI Research (MoHEST)	79.6	99.6	92.5	93.6
	TOTAL	**10,574.9**	**18,500.6**	**19,864.5**	**21,281.5**

[7] http://tinyurl.com/7sagu7q

2.4 Universities and research organisations

2.4.1 Universities

There are seven public universities, each with a number of affiliated colleges, making a total of twenty. There are in addition 26 private universities, many of them Christian foundations and theological colleges.

The **University of Nairobi** is by far the biggest university, with over 50,000 students (10,000 at Masters and 163 at doctoral levels in 2010) and over 1600 academic staff. Its expenditure in 2009-10 amounted to over 7 billion KES (£47m). The university is based around six colleges: agriculture and veterinary services; architecture and engineering; biological and physical sciences; education and external studies; health sciences; and humanities and social sciences. It was responsible for authorships for 2133 (20.3%) of the 10,508 papers published between 2000 and 2010 with Kenya-based authors. Medicine, biochemistry and immunology account for the great majority of these papers: 1609, or 75% of the total. Agriculture and biological sciences made up the great bulk of the rest.

Kenyatta University was established in 1984, and now has schools of agriculture; applied human sciences; business; economics; engineering; environmental studies; health sciences; humanities and social sciences; law; pure and applied sciences; visual and performing arts; and hospitality and tourism. It has established a Centre for Research, Science and Technology to co-ordinate its research activities, and also a Graduate School which oversees Masters and PhD programmes across six of the schools. The University's budget in 2010-11 amounts to 4.5bn KES (£28.5m). It was responsible for authorships for 607 (5.7%) of the papers published between 2000 and 2010 with Kenya-based authors. Agricultural and biological sciences were the single most productive areas.

Moi University was also established in 1984, and now has 22,000 students, 19,000 of them undergraduates. It has schools of aerospace; arts and social sciences; business and economics; dentistry; education; engineering; human resources; information sciences; law; medicine; and public health. Its budget for 2010-11 is 4.4bn KES (£28m). It was responsible for authorships for 562 (5.3%) of the papers published between 2000 and 2010 with Kenya-based authors. Agricultural and biological sciences were the single largest area, with medicine not far behind.

Egerton University was originally established in 1939 as an agricultural college. It achieved the status of a chartered public university in 1987. It is the leading agricultural university in Kenya, but has broadened to other areas of research and teaching including natural resources, applied sciences, education, computer science, medical sciences, engineering and business studies. Its budget for 2010-11 amounts to 3.2bn KES (£20.4m). It was responsible for authorships for 479 (4.6%) of the papers published between 2000 and 2010 with Kenya-based authors, the great majority of them in agricultural and biological sciences.

Jomo Kenyatta University of Agriculture and Technology was founded as a college of agriculture and technology in 1981 and became a university in 1994. In addition to agriculture, it now has school and faculties covering engineering, architecture and building, sciences, and law. Its budget for 2010-11 amounts to 2.6bn KES (£16.6m). It was responsible for authorships for 324 of the papers published between 2000 and 2010 with Kenya-based authors.

The other two public universities – **Maseno University** and **Masinde Muliro University of Science and Technology** – are significantly smaller, with budgets of 1.6bn KES (£10.2m) and 1.0bn KES (£6.3m) respectively, and correspondingly smaller levels of published research outputs. Of the private universities, none is making a significant contribution to research outputs.

2.4.2 Research Institutions

MoHEST lists 17 research bodies funded from public sources, with a focus on agricultural, medical, industrial, environmental, and policy research. There are in addition a number of international research organisations with bases in Kenya, again with an emphasis on agricultural and medical research. Taken together, these bodies are responsible for a high proportion of research activity and outputs.

2.4.3 Agricultural Research

Kenya Agricultural Research Institute (KARI)[8]. KARI was established in 1979, and is the leading national institution bringing together research programmes in food crops, horticultural and industrial crops, livestock and range management, land and water management, and socio-economics. It aims to promote sound agricultural research, technology generation and dissemination to ensure food security through improved productivity and environmental conservation. More recently, the role of its researchers has been expanded to include catalysing and facilitating innovation processes through active partnerships to ensure that concerted efforts are geared towards creating impact. Researchers are thus devoting more time to 'facilitative' roles in order to generate impact and demonstrate the utility of research results. This significantly changes the role and the profile of present and future researchers.

Besides the core research functions, KARI provides various research-related services to the public, including:

- advisory services, technical back-stopping and capacity building to the agricultural sector ministries, farmers and other agencies dealing with agricultural research for development
- management of human, physical and financial resources of research centres
- capacity development for non-governmental organizations (NGOs) and community-based organizations (CBOs)
- management of a national gene bank
- quality assurance of technologies developed and disseminated through uptake pathways
- commercialisation of its technologies and products and catalysing farmer linkages to markets
- development and management of agricultural research information systems
- building and sustaining partnerships with local, regional and international research for development organisations
- identification and prioritisation of research agenda together with partners
- policy formulation and advocacy
- laboratory and consultancy services

The bulk of KARI's staff - made up of 540 research scientists and 2,600 support staff - are based in nearly 40 research centres across the country. Authors associated with KARI were listed on 394 papers between 2000 and 2010.

KARI's latest strategic plan focuses on the Agricultural Product Value Chain (APVC) approach to agricultural research for development. This approach emphasises the full range of activities required to bring a product or service from conception through the full range of physical transformations, inputs of various producer services, delivery to final consumers, and

[8] http://www.kari.org/fileadmin/publications/Strategic_Plans/imp_framework_2009-14.pdf

disposal after use. It thus focuses on the whole chain up to the consumed products, rather than on commodities. This involves a radical shift from a traditional focus on production-side and linear technology dissemination, towards research, innovation and knowledge management systems that support agricultural value chains from resource to consumption. The thinking of KARI scientists will thus need to change from "pushing commodities" to a "market responsive products" approach.

Within this framework, the KARI plan sets out six research themes:

1. development and promotion of integrated crops product value chains
2. development and promotion of integrated livestock product value chains
3. enhancement of sustainable and integrated management of natural resources
4. enhancement of use of biotechnology and genetic resources
5. enhancement of utilization of socioeconomic and applied statistics information in research
6. enhancement of appropriate adaptive research, outreach and partnerships methodologies and approaches

KARI's total budget for 2009-10 appears to have been c 7.8bn KES (£50m), made up of 2.3bn KES in recurrent funding, 3.2bn in development funding, and 2.4bn in donor contributions. Research on crops, livestock, natural resources and biotechnology took up the lion's share of the expenditure on research. Funding is projected to fall slightly over the next three years. Authors associated with KARI were listed on 394 papers between 2000 and 2010.

2.4.3.1 Other agricultural research institutes

In addition to KARI, there are a number of other research institutes with a focus on specific crops of importance to Kenya.

The **Tea Research Foundation of Kenya (TRFK)**[9] has a mandate "to promote research and investigate problems related to tea and such other crops and systems of husbandry as are associated with tea throughout Kenya including the productivity, quality and sustainability of land in relation to tea planting; and matters ancillary thereto". These issues are important since it is estimated that 3 million Kenyans derive their livelihoods from the industry. In 2007, the country produced 369,606 tons of made tea of which 351,125 tons were exported, earning KES. 43.4 billion in foreign exchange. This represents about 26% of the total export earnings, and about 4% of GDP. The Foundation is responsible for all types (basic, strategic, applied and adaptive) research on tea, as well as technology packaging and transfer. The Foundation is recognized as a lead research institution nationally, regionally and internationally. Authors associated with the Foundation were listed on 32 papers published between 2000 and 2010. The Foundation's resource requirement has risen substantially since 2008-09, to over 600m KES (£3.7m) as a result of the decision to establish an adaptive research factory.

The **Coffee Research Foundation**[10] has a mandate parallel to the Tea Foundation's, and like the TRFK is funded mainly by a levy on sales, though its resource requirement is slightly smaller. Authors associated with the Foundation were listed on 11 papers published between 2000 and 2010.

[9] http://www.tearesearch.or.ke/index.php?option=com_rokdownloads&view=file&Itemid=33&task=download&id=6

[10] http://www.crf.co.ke/

The **Kenya Sugar Research Foundation (KESREF)**[11] was established in 2000, again with a parallel mandate. It is not a major producer of research papers: only four authorships have been found since 2000.

The **Kenya Forestry Research Institute (KEFRI)**[12] was established in 1986 to carry out research in forestry and related natural resources. It has a budget of just over 1bn KES (£6.3m), 90% of which comes from the Government. Authors associated with the Institute were listed on 64 papers published between 2000 and 2010.

The **Kenya Marine and Fisheries Research Institute ((KMFRI)**[13] was established in 1979, and its research is targeted on fisheries, aquaculture and their related subjects which will ensure the rational exploitation and sustainability of fisheries resources. Its research is structured in six programmes: aquaculture: environment and ecology; fisheries; information and database; natural products; socio-economic. Authors associated with the Institute were listed on 116 papers published between 2000 and 2010.

2.4.4 Medical Research

The **Kenya Medical Research Institute (KEMRI)**[14]**,** was established in 1979 as the national body responsible for health science research in Kenya. Its research is conducted in the main through eleven research centres:

- Centre for Biotechnology Research and Development (CBRD), focusing on biotechnological innovations such as diagnostic kits, vaccines and associated delivery technology
- Centre for Clinical Research (CCR), focusing on clinical trials in a range of diseases
- Centre for Geographic Medicine Research-Coast (CGMR-C), focusing on malaria and other parasitic diseases, HIV-AIDS, maternal/child health, and health systems
- Centre for Global Health Research (CGHR), focusing on infectious diseases
- Centre for Infectious and Parasitic Diseases Control Research (CIPDCR), focusing on leprosy, tuberculosis, HIV-AIDS, malaria, and geo-helminths
- Centre for Microbiology Research (CMR), focusing on diarrhoea and cholera, sexually-transmitted diseases, nosocomial infections, and schistosomiasis
- Centre for Public Health Research (CPHR), focusing on tuberculosis and other respiratory diseases, and environmental and occupational health
- Centre for Respiratory Diseases Research (CRDR), focusing again on tuberculosis and other respiratory diseases
- Centre for Traditional Medicine and Drug Research (CTMDR), focusing on traditional medicines and drugs
- Centre for Virus Research (CVR), focusing on haemorrhagic fevers, rabies, viral diarrhoea, viral hepatitis, and HIV-AIDS
- The Eastern and Southern Africa Centre of International Parasite Control (ESACIPAC), focusing on human resource development to strengthen research and control mechanisms for parasitic diseases

[11] http://www.kesref.org/index.php

[12] http://www.kefri.org/

[13] http://www.kmfri.co.ke/

[14] http://www.kemri.org/

In addition to these research centres, KEMRI also runs a Graduate School of Health Sciences and a production facility which aims to turn some of the results of research activities into tangible products and services.

The Medium Term Expenditure Framework report for 2009 puts the resource requirement for KEMRI in 2010/11 at 6.9bn KES (£44.3m) in recurrent, and 2.9bn KES (£18.5m) in development, which together with an indicative donor commitment of 3.1 bn KES (£19.8m) makes for a total of 12.9 bn KES (£82.9m). The Strategic Plan for 2008-12 specifies six programmes:

- biotechnology
- traditional medicine and drug development
- infectious diseases
- public health and health systems
- non-communicable diseases
- sexual, reproductive and child health

A paper on the KEMRI website states that its activities will focus on three major areas: research and innovation; capacity building; and service delivery through community outreach. Unfortunately, it has not been possible from online sources to find further information about KEMRI's strategies and plans, or about budgets, staff numbers and so on.

Authors associated with KEMRI were listed on 1247 papers between 2000 and 2010. That is the second-highest number after the University of Nairobi, and represents 11.9% of all the papers with Kenya-based authors.

The **KEMRI-Wellcome Trust Research Programme**[15] is well known internationally for its work tackling malaria and other infectious diseases, particularly bacterial and viral childhood infections. With links to the Wellcome Trust since the 1940s, the Programme was formally established in 1989, in partnership with KEMRI. It conducts basic and clinical research in parallel, with results feeding directly into local and international health policy, and aims to expand the country's capacity to conduct multidisciplinary research that is strong, sustainable and internationally competitive. The programme has strong community links, with an emphasis on capacity building and training to build scientific leadership and create a critical mass of support from trained research and non-research staff. The programme employs over 600 people, 95 per cent of whom are Kenyan. Of the 100 scientists in the Programme, 75 are East African. A £9 million award from the Trust is helping to train local researchers in areas such as translational research, social science and clinical trials. Authors associated with the programme were listed on 401 papers between 2000 and 2010. Through the programme, a number of UK universities, including Oxford and the London School of Hygiene and Tropical Medicine, have developed strong links with Kenya.

2.4.5 Heritage

The **National Museums of Kenya (NMK)**[16] produce a steady stream of research outputs. The Directorate of Research and Collection (DRC) is responsible for developing and implementing research projects that are focused on a sustainable use, conservation and preservation of Kenya's heritage. The collections that arise from the research and collection activities are identified, deposited and curated in the directorate's repositories. These form the core of national reference collection of natural as well as cultural heritage and are the basis for education, research and conservation in the various fields covered. Capacity for research comprises some 35 Doctorate and over 57 Master degree level officers. The directorate is

[15] http://www.kemri-wellcome.org/.

[16] http://www.museums.or.ke/content/blogcategory/44/83/

organised in six departments, dealing with botany, biodiversity, cultural heritage, earth sciences, resources, and zoology. Authors associated with NMK were listed on 524 papers between 2000 and 2010.

2.4.6 Social sciences and industrial research

In recent years, there have been efforts to develop research capacity in social and political sciences, and in industrial research. In terms of published papers, the outputs from the research institutes mentioned below have been modest so far; but as will be shown in the analysis of all published outputs from Kenya, social sciences have been growing fast over the last decade.

The **Kenya Institute for Public Policy Research and Analysis (KIPPRA)**[17] is an autonomous think-tank established in 1997 to provide objective public policy advice to the Government of Kenya, and other stakeholders, in order to contribute to the achievement of national development goals. KIPPRA conducts research and policy analysis in all sectors of the Kenyan economy, provides capacity building for policy making and implementation, and serves as a point of contact for exchange of views on public policy issues affecting Kenya.

The **Institute of Policy Analysis and Research (IPAR)**[18] is an independent, organisation established in 1994. It is a non-profit body which conducts social science policy analysis and research, and training, with the aim of improving human welfare. IPAR shares its policy findings with the government of Kenya, its development partners, private sector, and civil society. It focuses on producing discussion papers rather than contributions to scholarly journals.

The **Kenya Industrial Research Institute (KIRDI)**[19] is a national research institute established in 1979 under the Ministry of Trade and Industry and mandated to undertake multidisciplinary research and development in industrial and allied technologies. The major R&D departments are: Engineering, Energy and Environment, ICT, Leather &Textiles, and Food Technology Divisions.

2.4.7 International Research Organisations

A number of international research organisations have bases in Kenya, and some are major producers of published research outputs. Some of the more important ones are considered below.

The **International Livestock Research Institute (ILRI)**[20] has its headquarters in Nairobi, alongside a major campus in Addis Ababa. It recruits its staff mainly from Kenya and Ethiopia, along with 100 internationally-recruited specialists. It focuses on key livestock value chains of importance to the poor. It is funded by more than 90 private, public and government organizations from the North and South, and had an income of $45m in 2010. Its current strategy focuses on five areas: targeting and innovation; improving market opportunities; biotechnology; people, livestock and environment; and a system-wide livestock programme. Authors associated with ILRI in Nairobi were listed on 685 papers between 2000 and 2010.

The **World Agroforestry Centre**[21] is part of the alliance of the Consultative Group on International Agricultural Research (CGIAR) centres dedicated to generating and applying the best available knowledge to stimulate agricultural growth, raise farmers' incomes, and protect the environment. Its headquarters are in Nairobi, and it operates five regional offices in India,

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[17] http://www.kippra.org/

[18] http://iparkenya.blogspot.com/p/about-ipar.html

[19] http://www.kirdi.go.ke/

[20] See key documents at http://mahider.ilri.org/handle/10568/61/browse?type=dateissued&sort_by=2&order=DESC

[21] http://www.worldagroforestry.org/regions/eastern-africa/about_us

Indonesia, Kenya, Malawi and Mali. In Kenya it works with a number of partners including the Ministry of Agriculture, KARI and KEFRI on projects including the African Highlands Initiative (AHI, initiated in mid 90s to strengthen R&D in integrated natural resource management); the Water Management Unit that hosts the Southern and Eastern Africa Rainwater Network (SearNet) as well as specifically developing ICRAF strategies on improved water use efficiency at farm level; shed coffee; biofuels; and conservation agriculture. Authors associated with WAC in Nairobi were listed on 375 papers between 2000 and 2010.

The **International Centre of Insect Physiology and Ecology (ICIPE)**[22] was established in Kenya in 1970, based on a recognition that countries in the tropics had special problems that were not being adequately addressed by scientists and organisations in the North, and that there was a serious lack of indigenous expertise to resolve these problems. Its objectives are:

- to help ensure food security and better health for humankind and its livestock
- to protect the environment
- to conserve and make better use of natural resources

Much of the basic strategic research is carried out at icipe's international headquarters on the Duduville campus in Kasarani, Nairobi, with fieldwork being conducted at the major research and training field station at Mbita Point on the shores of Lake Victoria. Its work is structured around divisions dealing with human, plant, environmental, and animal health; and it employs multidisciplinary teams that include entomologists and acarologists, behavioural biologists, molecular biologists and biochemists, population and ecosystem ecologists, biomathematics and bioinformatics specialists, entomopathologists, biosystematics experts and social scientists and trainers. Capacity and institution building activities are integrated into every project. Authors associated with ICIPE in Kenya were listed on 703 papers between 2000 and 2010.

The **Sub-Saharan Africa regional centre of the International Potato Centre**[23] is in Nairobi. It has a focus on improving lives for women as producers and consumers of sweet potato, developing sustainable seed systems, breeding weevil-resistant varieties, and improving the quality and range of available varieties to meet local demands. Authors associated with the centre in Kenya were listed on 49 papers between 2000 and 2010

The **International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)**[24] is a non-profit, non-political organization that conducts agricultural research for development in Asia and sub-Saharan Africa. It is based in Hyderabad, India, but the regional hub for its Eastern and Southern Africa (ESA) is based in Nairobi. There are currently nineteen scientists based in the ESA region, and the focus of activities is on public-private partnerships and market-led technology development; greater regional efficiency in crop improvement and dissemination (especially in terms of the development of seed systems); and the pursuit of more sustained poverty alleviation, especially in the context of relief and recovery programs. Authors associated with ICRISAT in Kenya were listed on 53 papers between 2000 and 2010.

2.5 Subjects, disciplines and research priorities

It will be clear from the previous sections that medicine and associated life science disciplines, along with agricultural and biological sciences, account for the vast majority of research expenditure and of research outputs in Kenya. They attract by far the greatest proportion of financial support both from Government and from external sources. This is common across Africa, with a focus on tropical diseases and related health problems in sub-

[22] http://www.icipe.org/about-us/about-us.html and its Medium Term Plan at http://www.icipe.org/images/stories/pdf/about_us/mtp.pdf

[23] http://cipotato.org/regions/sub-saharan-africa

[24] http://www.icrisat.org/icrisat-aboutus.htm

Saharan Africa. International research co-operation focuses on these areas, and contributes both to their over-representation, but also to the visibility and impact of the research being undertaken. As Tijssen (2007)[25] has noted, however, Kenya stands out among leading African research nations as having a strong concentration of international research in the medical and life sciences. But like other African nations, Kenya shows an under-representation of physical sciences and engineering.

Within its two leading groups of disciplines, however, Kenya shows a growing emphasis on translational research, seen for example in the focus on product value chains in agricultural research, and focus on translational and adaptive research, and the inauguration of the new production facility, at KEMRI. Building capacity in socio-economic research, applied statistics, knowledge management, outreach and innovation, as well as monitoring and evaluation of the research and innovation system itself, are key priorities for the future. However, finding the resources to support such capacity-building remains a major challenge. The large number of unfilled posts at MoHEST and NCST inhibit the capability to promote development and change.

2.6 Published outputs, 2000-2010

Various studies have shown that sub-Saharan Africa's share of world science, as measured in papers published in the journals covered by the Thomson Reuters and SCOPUS databases, has fallen dramatically in the past two decades. African outputs have not grown at the same rate as those in other parts of the world. Tijssen shows that South African and Kenya outperform other countries in terms of citation rates, and suggests that this is the result of their cultural heritage from English-language science systems. [26]

The Africa Innovation Outlook 2010 report puts Kenya in the second group of research-producers, alongside Nigeria and Algeria, but some way behind the two leading countries, South Africa and Egypt. The growth rate in publications was below that for other countries through the 1990s; and although it has tended to increase since 2000, Kenya is at the foot of the table of the nineteen countries covered in the report in terms of the increase in productivity as measured by the rate of papers per million in population. Kenya produced c 25 papers per million population over the period 2005-9, as compared with 135 in South Africa, and 969 in a country such as Greece.

If productivity is measured in terms of papers per number of researchers per year, in the period 2005-9, Kenya produced 0.28 papers per researcher each year. These figures should be treated with some caution, however, especially when making comparisons with other countries, since the survey of the number of researchers in each country conducted for the ASTII programme in 2007 may not have produced consistent results.

2.6.1 Analysis of SCOPUS database

Table 3 appended to this paper presents figures from the SCOPUS database, as at early September 2011. As the Africa Innovation Outlook 2010 notes, SCOPUS covers a much broader range of journal titles than the Thomson Reuters databases, even though it may not include some of the local and regional journals in which research that is focused on local or regional African issues may be published. Nevertheless, SCOPUS provides the best-available source of information about the outputs of African science that appear in journals that are internationally visible. Thus Table 3 shows the number of papers recorded in that database that were published in each of the years 2000 to 2010 which had at least one author affiliated to an institution in Kenya.

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[25] R Tijssen, (2007), Africa's contribution to the Worldwide Research Literature,: New Analytical Perspectives, Trends and Performance Indicators, Scientometrics, Vol 71, no. 2 pp 303-327.

[26] Tijssen (2007)

Panel 1 in the table shows that the number of such publications of any kind increased by 157% between 2000 and 2010, from 573 to 1472; and that the number of articles, reviews and conference papers increased by a similar amount, from 545 to 1271. For comparison, it may be noted that the number of papers published with UK-based authors rose by 56% between 2000 and 2010, and for Swedish authors by 64%.

In order to examine whether this increase in productivity has been bought at the cost of a fall in citation impact, we looked at the average number of citations each paper received. Since citations are gathered over a period of years, earlier papers tend to have a higher number of citations than more recent papers. In order to mitigate this effect, we calculated the average number of citations per paper within four years after the year of publication.[27] The four-year measure is a crude one; but it does provide an element of consistency in measuring citation impact. It also provides for a rather longer period to gather citations than the standard two-year window used in calculating journal impact factors. The table shows that the average number of citations fluctuated for papers published between 2000 and 2007, and since then has tended to fall, as one would expect. It is notable, however, that the rates are not far out of line with international comparators. The average number of citations by 2004 for articles from Kenya published in 2000 was 8.2, as compared with 10.5 for Sweden, for example.

The table also shows the H-index for all publications with an author from Kenya. The H-index is based on the highest number of papers included that have had at least the same number of citations, and is thus a measure of productivity as well as impact. As the table shows, it has tended to fall since 2000, which is not surprising, since newer papers have had less time to build up a significant number of citations.

Lastly, Panel 1 shows the number and the percentage of papers published each year which, by September 2011, had received no citations at all. Again, as might be expected, the numbers of papers with no citations has tended to rise since 2000, as in each successive year, there is a shorter time in which to gather the first citation. Again as might be expected, the rise is particularly sharp since 2008.

International collaboration is increasingly evident across the globe, and the proportion of Kenyan publications with co-authors from outside Africa has tended to rise, from around half in 2000 to around 60% in recent years. Hence we looked in Panel 2 at the numbers of papers published each year with no authors from outside Africa. The growth in numbers of such publications between 2000 and 2010 was slightly lower than for all papers, at 113%. It is notable also that except for 2002 and 2003, the average number of citations per publication does not reach half the level of that for all papers. Indeed, the citation average for papers with authors from outside Africa is three times that for papers without such authors. Similar patterns are evident for the H-index and for papers with no citations.

Panels 3 and 4 show the figures for publications in medicine, immunology and microbiology. The growth in productivity here between 2000 and 2010 has been particularly sharp, at 270%. The result is that such publications now account for nearly half all publications, as distinct from a third in 2000. The average number of citations in the four-year window is much higher than for all publications, and is in line with average figures for countries such as Sweden (where the average for papers in this field published in 2000 was 13.3) and for Canada (where the average for papers published in 2000 was 14.2). In Kenya, the average reached a peak of over 18 for publications in 2005. It is also noticeable that the H-index is more stable than for all publications, and the number and proportion on papers with no citations is much smaller.

[27] It is important to note that the citation half-life (that is, the number of years that a paper takes to receive half the number of citations it will eventually receive in total) varies across subjects; and that the SCOPUS database shows that Kenyan papers published in 2000 had received by 2004 only 37% of the citations they received in total by September 2011.

As with the figures for all publications, Panel 4 shows that publications with no authors from outside Africa have much lower rates of citation, much lower H-indexes and a much higher proportion of papers with no citations.

Panels 5 and 6 show the figures for publications in agriculture and biology, where there has been sustained growth, but at a lower level than in medicine. Citation rates are, as expected, much lower than in medicine, and lower again for papers with no authors from outside Africa.

Finally, Panels 7 and 8 show the figures for publications in social science, economics and business studies. Here the growth has been particularly high, at 302% between 2000 and 2010, albeit from a low base. Such papers constituted 17% of all papers in 2010. Compared with papers in agriculture, social science papers have a similar, or slightly higher, citation rate. And the number of papers with no authors from outside Africa has tended to exceed 50%.

2.7 Conclusions

Research activity and outputs in Kenya are concentrated in the University of Nairobi, the Kenya Medical Research Institute and the Kenya Agricultural Research Institute. Between them, these three institutions account for 36% of the internationally-visible scientific publications produced by Kenyan authors between 2000 and 2010. For these and other Kenyan research institutions, however, collaboration with foreign partners has become an increasingly common feature of their activities. The international contribution to the outputs of research from Kenya shows itself in two ways. First, international bodies with bases in Kenya, such as the International Centre of Insect Pathology and Ecology, and the International Livestock Research Institute are major contributors to Kenyan research outputs. Secondly, even for indigenous research institutions such as the University of Nairobi and KEMRI, co-publication with partners in research institutes and universities in Europe and North America – with the Wellcome Trust, Oxford University, and the London School of Hygiene and Tropical Medicine especially dominant - is an increasingly common feature. All this suggests a growing dependence on resources from those parts of the world to help in coping with infrastructural and financial constraints.

International visibility remains important, but there is also, as in the rest of the world, an increasing emphasis on building clear linkages between research and innovation: on the contribution that research makes to social and economic development. Thu there is much talk, as in Europe and North America, about the need for collaboration with industry and with key partners and agencies in social and economic development, and for closer relationships between research and policy-making. But there is also a focus on developing capabilities and capacities in the research base, and building a better understanding of the research base, and how to support and manage it most effectively.

The resources to underpin further development of the research base are constrained; and various Government and related bodies are candid about the difficulties they have in building the capacity to develop an accurate evidence base on key features of the research base itself. Hence it is difficult for them to develop and implement evidence-based policies. Participation in the ASTII initiative may help to address part of the problem, but there is clearly some way to go.

3 Country report: Malawi

3.1 Policy frameworks and priorities

The key policy frameworks for research in Malawi are set by the Malawi Growth Development Strategy (MGDS). The MGDS for 2006-11 noted Malawi's weakness in scientific and technological development and utilisation, and the constraints that impede the integration of science and technology into national development planning processes. Those weaknesses include the poor co-ordination of research, science and technology; weak institutional capacity; and inadequate funding. Key priorities, therefore, are:

- co-ordination of science and technology generation and dissemination
- efficient and effective operation of research institutions
- increased uptake and enhancement of technologies
- prioritised and focused research and development

In order to achieve those goals, the MGDS set out strategies including:

- establishing a National Science and Technology Commission (NSTC) as the apex body to coordinate all activities relating to research, science and technology
- strengthening the capacity of research, institutions
- generating and disseminating appropriate technology through public-private partnerships, including commercialising science and technology in areas that contribute significantly to socio-economic development
- promoting the development and utilization of indigenous technology through the 'Malawi Award for Scientific and Technological Achievement' (MASTA)
- establishing funding mechanisms to promote research by individuals and institutions, including private sector investment
- designing syllabi that achieve a balance of science and technology, arts and humanities in basic, secondary, higher and technical education levels

Lack of funding has made it difficult to implement these strategies, and the NSTC was established only at the beginning of 2010.

3.2 National Policy-making and funding structures

Up to the beginning of 2010, the Ministry of Education, Science and Technology was responsible for science and technology, in concert with the National Research Council of Malawi. The science and technology department of the Ministry has now been merged with the Research Council, to form the new National Commission for Science and Technology (NCST)[28]. Its functions are, in summary, to:

- advise the Government and other stakeholders on all science and technology matters
- create science and technology awareness and generate commitment at the political and other levels of society, and solicit support from Government and the private

[28] http://www.ncst.mw/

sector in order to promote the formulation of policies and strategies for science and technology

- source funding from within and outside Malawi to finance research and development and allocate funds to research institutions
- establish national priorities in relation to socio-economic development needs
- review, survey, monitor and evaluate research and development programmes, plans, projects and institutions
- promote the development of human resources by building capacity in science and technology
- create a conducive working environment for science and technology personnel in order to retain them and attract those outside Malawi to return
- develop professional standards, ethics and guidelines and support professional science and technology associations
- encourage the establishment and promote the coordination of research institutions
- organise science and technology fairs and open days and promote the role of information technology
- promote the transfer of technology through information exchange and training, purchase and licence agreements and joint venture agreements with foreign partners
- promote patenting and commercialisation of research results in a manner that enhances economic diversification, competitiveness and employment
- develop science and technology indicators covering such aspects as research and development statistics, bibliometrics, technology balance of payments statistics, patent data, human resources and innovation data using internationally accepted procedures and standards

The Commission is appointed by the Government, with the Secretaries of the Ministries of Agriculture, Education, Heath, Natural Resources and Development as ex-officio members. The secretariat is organised in divisions covering research and knowledge transfer; planning, monitoring and evaluation; documentation and information services; and finance and administration.

The Commission is responsible for major projects to strengthen health research capacity; promoting access to information on sustainable development; field trials of genetically-modified crops; and the use of ethanol as an alternative energy source. Much of its work and responsibilities – including a small programme of research grants and work on databases and the development of science and technology indicators - were inherited from the former National Research Council; and it is not as yet clear how the Commission intends to develop its activities and strategies. Nor is it clear whether, or to what extent, it will take responsibility for research programmes and institutes run by other Ministries, including the Ministry of Health and the Ministry of Agriculture.

3.3 Funding and personnel

Malawi, like Kenya, is one of the countries participating in the African Science, Technology and Innovation Indicators (ASTII) initiative; and one of the countries which conducted surveys in 2007, the results of which are reported in the first African Innovation Outlook report for 2010, published in 2011.[29] The ASTII initiative is funded by the Swedish International

[29] http://www.nepad.org/system/files/June2011_NEPAD_AIO_2010_English.pdf

Development Co-operation Agency (SIDA) as part of the New Partnership for African Development (NEPAD). The aim is to build a system of STI indicators to support evidence-based policy.

The surveys on which the figures presented in the Innovation Outlook report are based were the first of their kind in Africa. The UNESCO Institute for Statistics has published series of R&D statistics but up to now many of the key statistics, including those on expenditure, have been missing for African countries.

The key international indicators on R&D expenditure are based on a calculation of gross domestic expenditure on R&D (GERD). Data are gathered from national surveys of expenditure by sector: business (BERD); Government (GOVERD); higher education (HERD); and private non-profit (PNP). GERD is the sum of the four components. Data are gathered and measured in national currencies. For comparative purposes, they are then converted into US dollars adjusted for their purchasing power in the country in question (PPP$).

The ASTII figures for 2007-08 show gross expenditure on R&D of 7,164 million Malawian Kwacha (MK). A summary of the sources of that funding, and the sectors in which it was spent, is shown in Table 1. It shows that a third of the funds came from Government, with a roughly equal amount coming from overseas. The remainder from came from business (23%) and from non-profit organisations (11%). The table also shows that just over half of the R&D recorded was undertaken in the Government and HE sectors. Just under a quarter (a much higher proportion than in Kenya) was undertaken in the business sector, and just over a quarter in the non-profit sector. As noted in the report on Kenya, these figures – and especially the comparisons with Kenya - should be treated with some caution, since it is not clear that the ASTII surveys were conducted on a consistent basis in different countries.

Nevertheless, the figures imply that GERD was 180.1 in PPP$, and that it represented 1.70% of GDP. It is notable that that percentage is well in excess of the 1% target set by the African Union, and the highest by some margin among the countries covered by the Innovation Report. The explanation offered in the report for this result – especially surprising since Malawi has the lowest GDP in the group – is that Malawi hosts a number of international research institutions in health and agriculture, that it receives considerable amounts of donor funding, and that there have been important capital investments, especially in health research.

Malawi gross expenditures (GERD) 2007-08					
Millions of Malawian Kwacha					
Sector of performance (columns)	**TOTAL**	**Business**	**Government**	**HE**	**PNP**
Source of funds (rows)					
Business	1631.3	852.1	244	297.6	237.6
Government (direct)	2354.3	594.4	860.9	867.5	31.5
Government (general university funds)	45.8	0	0	45.8	0
HE	0	0	0	0	0
PNPs[30]	761.7	182.8	186.9	0	392
Funds from abroad	2371.4	69.5	30.3	1088.4	1183.2
TOTAL	**7164.5**	**1698.8**	**1322.1**	**2299.3**	**1844.3**

[30] Private non-profits

It has not been possible to derive figures from the Ministry of Education, Science and Technology on the funding of research and development, though the financial statement for the Ministry for 2011-12 indicates that higher education expenditure in 2010-11 was 1.633 million MK.[31]

The African Innovation Outlook 2010 report indicates that Malawi had 2,884 research personnel in 2007-08, 733 of whom (25%) were researchers (that is, not technicians or support staff). Only 208 researchers were recorded as having a doctoral qualification. These figures imply c 194 research personnel and 49 researchers, per 1 million of the population. These figures imply that the ratio of research personnel to overall population is slightly higher than in Kenya, but that for researchers, the ratio is half than in Kenya. In other words, Malawi has many fewer qualified researchers per capita than Kenya.

As in Kenya, the majority (over 80%) of researchers work in either the Government or the HE sectors, though it is notable that a significant proportion (15%) work in the non-profit sector.

3.4 Universities and research organisations

Malawi currently has two public and two private universities. The University of Malawi, established in 1965, and the University of Mzuzu, established in 1998, are the public universities. Livingstonia University, established in 2003, and Catholic University, established in 2005, are the private universities.

The University of Malawi is based on a federal structure, with a central administration in Zomba, and five colleges: Chancellor College in Zomba; Malawi Polytechnic and the College of Medicine in Blantyre; Bunda College of Agriculture in Lilongwe; and Kamuzu College of Nursing in Lilongwe and Blantyre. Chancellor College is the largest multi-faculty college, covering science, social and political sciences, education, humanities, and law. Medicine and Agriculture are concentrated in the two colleges under those names.

The University was responsible for authorships of at least 1099 (52%) of the 2126 papers published by Malawi-based authors between 2000 and 2010. The College of Medicine alone was responsible for authorships on 718 (34%) of the papers; Chancellor College for 116 papers, and authors who gave their affiliation simply as the University of Malawi for 265.

Mzuzu University was established in 1995 and admitted its first students in 1999. It is a multi-faculty university built on the base of a former teacher training college. Its research profile is modest so far.

There are plans to establish a University of Science and Technology, but this depends on securing the necessary funding from overseas. It was responsible for authorships of 26 papers published by Malawi-based authors between 2000 and 2010, and Mzuzu Hospital for a further 19.

3.4.1 Research institutes and stations

The Ministry of Agriculture and Food Security has responsibility for a number of agricultural research stations, but only the Chitedze Agricultural Research Station, which undertakes research aimed at improving agricultural technologies for smallholder farmers, seems to produce a significant number of research publications (64 authorships between 2000 and 2010).

The Ministry of Health runs programmes on the control of malaria, HIV and tuberculosis, and produces a significant number of research outputs (163 authorships between 2000 and 2010).

[31] http://www.finance.gov.mw/index.php?option=com_docman&task=doc_download&gid=68&Itemid=114

But it has not proved possible to gather any significant information about the nature and funding of its research programme.

3.4.2 International research organisations

The Malawi-Liverpool-Wellcome Trust Clinical Research Programme was established in 1995, and operates as a partnership between the University of Malawi's College of Medicine (where it is based), the University of Liverpool, the Liverpool School of Tropical Medicine, and the Wellcome Trust. It also works closely with the Ministry of Health. The Programme carries out health research, notably on malaria, HIV and tuberculosis; and it trains clinical and laboratory scientists from Malawi and abroad. It employs around 35 scientists, the majority of whom are Malawian. The programme and its two partners in Liverpool were responsible for authorships on 467 (22%) of the papers published by Malawi-based authors between 2000 and 2010.

3.5 Subjects, disciplines and priorities

As in Kenya, medicine and associated life science disciplines, along with agricultural and biological sciences, account for the great majority of research activity in Malawi. International funding and co-operation focuses on these disciplines, and even the relatively small amount of social science research tends to relate to health and agriculture. The physical sciences and engineering are almost entirely absent. Until the NCST becomes more firmly established, however, it will not be possible to ascertain any clear directions for the future of research or priorities.

3.5.1 Published outputs, 2000-2010

The African Innovation Outlook 2010[32] report puts Malawi in the third group of research nations in terms of outputs of published papers, alongside (although some way behind) such nations as Ghana and Senegal.[33] SCOPUS figures indicates that Malawi produced only around a seventh of the papers that Kenya produced in 2010 (202 as against 1472), even though its gross expenditure on research and development is running only a third lower in PPP$ according to the Outlook figures.[34] The growth rate has been in the middle range among African countries over the past couple of decades, and the Outlook report calculates productivity in terms of papers per million population over the period 2005-09 at 14.[35] That is some way below the 25 for Kenya, but significantly above the single digit ratios for countries such as Angola, Mozambique or Ethiopia.

If productivity is measured in terms of papers per number of researchers per year, in the period 2005-9, Malawi produced 0.29 papers per researcher each year (almost the same as for Kenya at 0.28). These figures should be treated with some caution, however, especially when making comparisons with other countries, since the survey of the number of researchers in each country conducted for the ASTII programme in 2007 may not have produced consistent results.

3.5.2 Analysis of SCOPUS database

Table 3 appended to this paper presents figures from the SCOPUS database, as at early September 2011. As the Africa Innovation Outlook 2010 notes, SCOPUS covers a much broader range of journal titles than the Thomson Reuters databases, even though it may not

[32] http://www.nepad.org/humancapitaldevelopment/knowledge/doc/2418/african-innovation-outlook-2010

[33] Table 5.1 in the Outlook report

[34] Table 3.1 in the Outlook report

[35] Table 5.4 in the Outlook report

include some of the local and regional journals in which research that is focused on local or regional African issues may be published. Nevertheless, SCOPUS provides the best-available source of information about the outputs of African science that appear in journals that are internationally visible. Thus Table 3 shows the number of papers recorded in that database that were published in each of the years 2000 to 2010 which had at least one author affiliated to an institution in Malawi.

Panel 1 in the table shows that the number of such publications of any kind increased by 85% between 2000 and 2010, from 109 to 202; and that the number of articles, reviews and conference papers increased by a similar amount, from 102 to 192. For comparison, it may be noted that the number of papers published with UK-based authors rose by 56% between 2000 and 2010, and for Swedish authors by 64%. But it is also notable that the growth rate is half that shown for Kenya.

In order to examine whether this increase in productivity has been bought at the cost of a fall in citation impact, we looked at the average number of citations each paper received. Since citations are gathered over a period of years, earlier papers tend to have a higher number of citations than more recent papers. In order to mitigate this effect, we calculated the average number of citations per paper within four years after the year of publication.[36] The four-year measure is a crude one; but it does provide an element of consistency in measuring citation impact. It also provides for a rather longer period to gather citations than the standard two-year window used in calculating journal impact factors. The table shows that the average number of citations fluctuated for papers published between 2000 and 2007, and since then has tended to fall, as one would expect. It is notable, however, that the rates are not far out of line with international comparators. The average number of citations by 2004 for articles from Malawi published in 2000 was 9.3, as compared with 10.5 for Sweden, for example.

The table also shows the H-index for all publications with an author from Malawi. The H-index is based on the highest number of papers included that have had at least the same number of citations, and is thus a measure of productivity as well as impact. As the table shows, it has tended to fall since 2000, which is not surprising, since newer papers have had less time to build up a significant number of citations.

Lastly, Panel 1 shows the number and the percentage of papers published each year which, by September 2011, had received no citations at all. Again, as might be expected, the numbers of papers with no citations has tended to rise since 2000, as in each successive year, there is a shorter time in which to gather the first citation. Again as might be expected, the rise is particularly sharp since 2008.

International collaboration is increasingly evident across the globe, and the proportion of Malawian publications with co-authors from outside Africa has tended to rise, from around half in 2000 to around 70% in recent years. Hence we looked in Panel 2 at the numbers of papers published each year with no authors from outside Africa. The growth in numbers of such publications between 2000 and 2010 was lower than for all papers, at 47%. It is notable also that with few exceptions, the average number of citations per publication is well under half the level of that for all papers. Indeed, the citation average for papers with authors from outside Africa is typically three times that for papers without such authors. Similar patterns are evident for the H-index and for papers with no citations.

Panels 3 and 4 show the figures for publications in medicine, immunology and microbiology. The growth in productivity here between 2000 and 2010 has been higher than that for all papers, at 126%. The result is that such publications now account for more than three-quarters of all publications, as distinct from a three-fifths in 2000. The average number of citations in the four-year window is much higher than for all publications, and is in line with

[36] It is important to note that the citation half-life (that is, the number of years that a paper takes to receive half the number of citations it will eventually receive in total) varies across subjects; and that the SCOPUS database shows that Kenyan papers published in 2000 had received by 2004 only 37% of the citations they received in total by September 2011.

average figures for countries such as Sweden (where the average for papers in this field published in 2000 was 13.3) and for Canada (where the average for papers published in 2000 was 14.2). In Malawi, the average reached a peak of just over 14 for publications in 2003. It is also noticeable that the H-index closely follows that for all publications, which reflects the dominance of medicine and immunology among those publications.

As with the figures for all publications, Panel 4 shows that publications with no authors from outside Africa have much lower rates of citation, much lower H-indexes and a much higher proportion of papers with no citations.

Panels 5 and 6 show the figures for publications in agriculture and biology, where growth has been patchy, and at a much lower level (42%) than in medicine. As a result, whereas agriculture and biology accounted for 24% of all papers in 2000, that proportion had fallen to 18% in 2010. Citation rates are, as expected, much lower than in medicine, and lower again for papers with no authors from outside Africa.

Finally, Panels 7 and 8 show the figures for publications in social science, economics and business studies. Here the growth has been particularly high, at over nine times, between 2000 and 2010, but starting from a very low base. Such papers constituted 3% of all papers in 2000 and 14% in 2010. Social science papers have a low citation rate. And the numbers show that the growth has tended to come through collaboration with authors from outside Africa. Well over half the papers involve such collaboration.

3.6 Conclusion

Research activity and the resources to support it in Malawi display some paradoxes. Malawi is much smaller than Kenya, and has a much lower GDP per capita. But the available figures indicate that expenditure on research and development is high: at 1.7% of GDP it is considerably in excess of the African Union target of 1%. This seems to be the result of high levels of support from international donors, and also high levels of R&D investment from the business sector. But number of researchers is low (only 208 with PhDs); and volumes of peer-reviewed publications are also low.

Activity is concentrated in the University of Malawi's College of medicine, and its partnership with the Liverpool-Wellcome Trust Clinical Research Programme. Over 70% of publications involve international co-authors, and over 75% are concentrated in medicine and the biosciences. This level of concentration on international partnerships in medicine in particular is much higher than that seen in Kenya.

The policy challenges in establishing national priorities, building capacity, securing the necessary funding, promoting knowledge transfer, and evaluating performance are all acknowledged in the mission and functions of the newly-established National Council for Science and Technology. The delays in setting up the Council, and the acknowledged need to formulate policies for science and technology afresh, indicate the scale of the challenge.

4 Country report: Pakistan

4.1 Policy frameworks and priorities

The *Vision 2030*[37] published by the Pakistan Government's Planning Commission in 2007 notes that prosperity and quality of life can be increased only through research, which helps to promote both planned and unplanned pathways for development.

The Vision notes that research in Pakistan has improved in recent years, but that it is still hampered by lack of critical mass and insufficient skills in design and instrumentation. Increases in funding for the development of academic staff in universities, along with awards for doctoral study, are addressing the need to build capacity; but there is an acknowledged need for a strengthened focus on quality, with greater competition for funds, greater diligence in peer review, deeper accountability, and incentives for linkages with the private sector. The Vision also speaks of the need for grants and tax subsidies to promote research in the private sector; and for public sector research labs to be "brought into the national industrial network" as well as greater use of patents and income sharing.

The Vision is also notable in arguing that it is essential not to deny funding and support for a broad base of fundamental, untargeted research, since it is the unplanned application of such research that generally has the greater impact. Nevertheless, it stresses the importance of research relating to four technologies – energy, materials, biology, and computational power- which, it claims, drive the 'techno-socio-economic revolution of the 21st century'.

The Vision also recognises that research and development have international dimensions. There are thus opportunities for developing countries to offer the skills, knowledge and support systems that could until recently be provided only in developed countries. Pakistan's ability to exploit these opportunities is constrained by a shortage of scientists and engineers. Hence it must seek technology transfers through collaboration with other countries. It has already made some contributions to major international initiatives such as the building of the Large Hadron Collider.

The Economic Growth Framework[38] formulated by the Planning Commission and published in 2011 lays emphasis on the development of the higher education and the science and technology sectors, and on strengthening their institutional infrastructure. It thus stresses human resource development, R&D, technology development and innovation management, and on developing some key and cutting-edge technologies to achieve rapid economic growth. It recognises that "intellectual capital […] now overshadows physical capital, bringing the realization that knowledge is its main ingredient and human capital is the source of it all, including intellectual property".

In the light of such a framework, there is a major focus in the Annual Plan for 2011-12 on human resource development in key productivity areas such as biotechnology and genetic engineering, material science and nanotechnology, minerals and mining, engineering, alternate energy sources, IT and telecoms.[39] Efforts are being made to strengthen linkages between Higher Education Institutions (HEIs), R&D organizations and industry, by setting up technology parks and incubation centres, and by encouraging foreign entrepreneurs and industries to collaborate with local industry. Universities of high standing are encouraged to develop and strengthen centres of excellence in key areas, and to collaborate with universities from other countries with a view to acting as their foreign campuses.

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[37] See http://www.pc.gov.pk/chapterwise.html

[38] See http://www.pc.gov.pk/hot%20links/5th_revision_pakistan_framework_for_economic_growth_2011-may28-2011.pdf.

[39] See http://www.pc.gov.pk/annualplan2011-12.htm

4.2 National policy-making, advisory and funding structures

The Ministry of Science and Technology is the national focal Ministry for planning, co-ordination and direction of efforts to initiate scientific and technological programmes and projects, with an agenda to:

- promote economic development
- build technological capacity
- develop human resources, and reverse the brain drain
- 'integrate soft technology infrastructure into hard modern technological base'
- strengthen technological institutions and effective S&T governance
- enhance the capacity of indigenous innovation systems

The Ministry has five main 'wings' dealing respectively with technology, international liaison, electronics, policy and co-ordination, and planning and development.

The Ministry is responsible for a number of science and technology institutions, the largest of which are the Pakistan Council of Scientific and Industrial Research (PCSIR), the National University of Science and Technology (NUST) and the COMSATS Institute of Information Technology (CIIT). See Section 4 below for further information on each of these.

The **Pakistan Council for Science and Technology (PCST)**[40] was founded in 1984 as an advisory body with 27 members under the Presidency of the Minister for Science and Technology. The members are drawn from heads of research organisations and industry, eminent scientists, and representatives of provincial governments. Its role is to advise the Government on S&T policies and plans, and to suggest measures for their promotion, development and application. PCST is also intended to provide the secretariat to the National Commission on Science and Technology, a body chaired by the Prime Minister as the supreme decision-making body for S&T policy; but that body appears not to have met since 2001. In 2010, however, the PCST prepared for the Ministry of Science and Technology a draft science, technology and innovation policy. The policy envisages a paradigm shift, in which innovation is recognized as an integral part of the S&T system. The policy is demand-driven and people-centric, with an emphasis on education and training to develop human resources. The Council has also undertaken a series of studies on the state of S&T in Pakistan, trends and growth in S&T organisations, and evaluations of research productivity; and it has proposed the setting up of an S&T Policy Research Institute to conduct research into current and emerging issues and to provide advice to Government, industry and academia.

The **Pakistan Technology Board**[41] is chaired by the Minister for Science and Technology and is responsible for promotion and commercialization of technology by bridging gaps between the Ministry and other organizations through technology foresight, technology transfer, and joint ventures, both at national and international levels. Its functions include proposing a comprehensive package of incentives for the development and growth of key future technologies and determine the period for which the incentives package should operate.

The **Pakistan Science Foundation (PSF)**[42] is the apex body for the promotion and funding of scientific and technological research and the popularisation of science. It is responsible for the promotion of research in universities and other institutions, establishing science centres, promoting scientific societies, organising conferences, exchange visits with scientists from

[40] http://www.pcst.org.pk/

[41] http://www.ptbmost.gov.pk/Test/mandate.php

[42] http://www.psf.gov.pk/

other countries, and the award of prizes and fellowships. It is also responsible for two subsidiary bodies, the Pakistan Museum of Natural History, and the Pakistan Scientific and Technological Information Centre. The PSF provides institutional support in the form of equipment grants; grants to support conferences in Pakistan, and to enable scientists to travel to conferences in other countries; and grants to scientific societies. It also supports individual projects, and has an industry programme to support and promote knowledge transfer.

In recent years, the **Higher Education Commission (HEC)**, which was established in 2002, has been a major driver of reform and development in research as well as higher education, with a mission to facilitate the development of HEIs to serve as 'engines of growth for the socio-economic development of Pakistan'. The HEC was established in a context where higher education had been rather neglected, and there were concerns about the quality as well as the size of the sector, and also about ineffective governance and accountability. The HEC gained substantial authority, in part because of the strong leadership of its Chairman and Executive Director. Its oversight of the funding of federal universities (and part of the funding for provincial universities) helped it to mobilise support for reforms to university governance and management, and for its development programmes. The focus on quality gave rise to controversy, however, and there were also concerns about the distribution of resources, especially to the smaller and less-developed provinces of Pakistan. The Commission's budget was cut, and there were moves early in 2011 to devolve the Commission and its work to the provinces. This in itself aroused considerable controversy, and a campaign to preserve the Commission, which has now established Regional Centres to provide enhanced services in the regional capitals.

In addition to a focus on improved access by increasing HE enrolments, and on quality assurance, the HEC has initiated developments of direct relevance to research in the following areas:

- faculty development, including scholarships to undertake doctoral research both in Pakistan and in other countries; and a Foreign Faculty Hiring Programme. Pay scales have been increased, and a tenure track system introduced.
- promoting excellence in research, with measures including the establishment of central research laboratories at public sector HEIs; links with leading foreign universities: a grant programme to support research in all disciplines; upgrading laboratories and libraries; and establishing an HEC digital library.
- developing university-industry linkages, including a University-Industry Technology Support Programme; establishing new departments and centres in areas of direct relevance to industry; and promoting internships and the setting up of technology parks.

In its initial stages, the HEC focused on the internal development of universities as centres of learning and research. In terms of disciplines, there was a focus on engineering and scientific disciplines, in particular health sciences, agricultural sciences, as well as support for the basic science disciplines (physics, chemistry, mathematics and biology). More recently, the HEC sponsored the creation of an Arts, Humanities and Social Sciences (AHSS) Research Council to give focused attention to those areas of research; and the Medium Term Development Framework (MTDF) 2011-15[43] acknowledges the need for further development of both undergraduate provision and research in the AHSS disciplines.

The MTDF sets a large number of objectives for research and innovation, based around the aim of developing and sustaining a research sector that is dynamic and has the capacity to respond flexibly to a changing research environment. The objectives include:

- working with the sector to develop a system for assessing research to enhance the power of the research base;

[43] http://www.hec.gov.pk/InsideHEC/Documents/MTDF%202011-15%20FINAL.pdf

- reforming postgraduate programmes and enhancing enrolment in them;
- supporting programmes to develop digital libraries, and establishing national data centres (among the significant achievements of the HEC has been the development of a digital library service for the whole HE sector);
- providing start-up research grants for newly-appointed faculty;
- actively supporting research in arts, humanities and social sciences;
- generating external research funding, and facilitating international university linkages and joint research programmes;
- establishing policy research centres;
- establishing research, innovation and commercialisation offices in all universities and supporting university-industry collaborative programmes;
- launching a knowledge transfer programme; and
- launching a programme to facilitate commercialisation of research, and setting up business incubation centres in major universities.

The MTDF also envisaged identifying certain centres in universities as 'national centres' in priority areas with direct relevance to socio-economic development, such as energy, food security, and water. The centres would serve as focal points for research in these areas, and receive special funding in pursuit of excellence. It also stressed, however, the need to support basic science in key institutions, as well as cutting edge technologies such as biotechnology and nanotechnology.

How much of the programme set out in the MTDF will actually be supported is unclear. It envisaged financial support for the promotion of research rising from 800 million rupees in 2010 to 3,000 million in 2016. But it was reported in June that the budget for HE as a whole has been cut from 16 billion rupees in 2010 to 14 billion in 2011, and it is not clear how much of this will be devoted to research.[44]

The Pakistan Academy of Sciences[45] was established in 1953 as a non-governmental scientific body of distinguished scientists. It has the status of an advisory body to Government on all matters relating to the development of science. It publishes the Proceedings of the Pakistan Academy of Sciences, as well as a newsletter; and it supports training programmes, conferences and workshops.

4.3 Funding

Data from the UNESCO Institute for Statistics[46] on gross domestic expenditure on R&D (GERD) in Pakistan rupees are shown in Table 1. As will be evident, no information is available on business expenditure on R&D, nor on the amount of R&D performed in the business or private non-profit sectors. With those important omissions, the figures indicate that gross expenditure on R&D in 2009 was 59 billion rupees, or 2 billion PPP$. Government (84%) and the HE sector (12%) are shown as the predominant funders of research, with relatively small sums coming from the non-profit sector, from abroad, and from other sources. For international comparative purposes, these figures can be converted into US dollars adjusted for their purchasing power in the country in question (PPP$). That calculation shows that GERD amounted to 2,055 million PPP$ in 2009, representing 0.46% of GDP.

[44] University World News, 26 June 2011 http://www.universityworldnews.com/article.php?story=20110626093115712

[45] http://www.paspk.org/

[46] See http://stats.uis.unesco.org/unesco/ReportFolders/ReportFolders.aspx

Pakistan gross expenditures (GERD) 2009				
Source of funds (millions of Pakistan rupees)			**Sector of performance**	
Business	n/k		**Business**	n/k
Government	49,695.7		**Government**	44,351.2
HE	7,165.0		**HE**	14,791.6
PNPs	983.1		**PNPs**	n/k
Funds from abroad	544.5			
Other	754.6			
TOTAL	**59,142.9**		**TOTAL**	**59,142.8**

As to sector of performance, 75% of R&D was performed by Government and its agencies, and 25% by the HE sector. The UNESCO statistics show some fluctuation in these percentages in the decade since 2000: the proportion of R&D undertaken in universities rose from 19.6% in 2000 to 32.4% in 2005, but has since fallen back, with corresponding fluctuations in the proportion undertaken by Government agencies.

It has not proved possible to reconcile these figures with those presented in Annual Budget Statements. The statement for 2011-12 shows the budget estimate for development expenditure on basic research in 2010-11 at 2.049 billion rupees,[47] but a revised estimate of 0.688 billion, and an estimate for 2011-12 of 1.636 billion. The equivalent figures for tertiary education are 17.647 billion, 14.668 billion and 14.356 billion. Somewhat different figures are given in the associated published demands for grants and appropriations.[48]

In September it was reported that the Prime Minister had approved a new science, technology and innovation policy, with a central role for universities, the development of specialised research laboratories, increased salaries for researchers, and a strengthening of the human resource development programmes undertaken by the HEC.[49] No public announcement has been made to date (17 October), however, and it is not clear whether additional money will be provided to underpin the new policy. In October, however, the World Bank released a US$ 300 million loan to support the HEC's higher education development programme.

4.4 Universities and research organisations

4.4.1 Universities

The HEC recognises 132 universities in Pakistan, 73 public and 59 private. Some of the larger and more research-active universities are noted below.

Quaid-i-Azam University was established in 1967 as the University of Islamabad and renamed in 1976. It is recognised as one of the top-ranking universities in Pakistan (ranked

[47] Available at http://www.finance.gov.pk/budget/abs_11_12.pdf.

[48] See the White Book (http://www.finance.gov.pk/fb_2011_12_summary_whitebook.html) and the more detailed tables in the demands for grants for current (http://www.finance.gov.pk/budget/Non-development%202011-2012/Non-development%202011-2012.rar) and development (http://www.finance.gov.pk/budget/Development%202011-2012/Development%202011-2012.rar) expenditure.

[49] University World News, 30 September 2011 http://www.universityworldnews.com/article.php?story=20110930120142293

first by the HEC in 2006)[50]; and it has established research collaborations with universities in Europe, the US and South Asia. It is structured in four faculties – natural sciences, social sciences, medicine, and biological sciences – and it houses six federally-funded research centres and institutes in areas including gender studies, area studies, Pakistan studies, and Asian Civilization. More than 80% of the faculty have doctorates. It was responsible for authorships of 3,452 of the 34,390 papers published between 2000 and 2010 with Pakistan-based authors. The majority of these papers were in physics and astronomy, chemistry, materials science and engineering, with smaller numbers in a broad range of other subject areas. Papers in medicine are evident only from 2009.

The **University of Karachi** was established in 1951, and is one of the biggest universities in the country, with over 24,000 students. It has more than 50 departments organised in eight faculties: arts, engineering, Islamic studies, law, management, medicine, pharmacy, and science. It also houses 17 research centres and institutes, in areas including applied economics, European studies, chemistry, genetics, proteomics, and marine science. Members of the university were responsible for authorships of 2,825 papers published between 2000 and 2010. In subject areas, chemistry, and agricultural and biological sciences dominated, and together accounted for over three-quarters of the papers published. Significant numbers of papers were published also in biochemistry and pharmacology.

The **University of the Punjab** claims to be the biggest as well as the oldest university in the country. It was founded in 1882 at Lahore, and now operates across 4 Campuses, 13 Faculties, 9 constituent colleges, over 63 Departments, Centres, Institutes, and over 500 affiliated colleges. It has over 620 permanent faculty members involved in teaching/research and over 30,000 on-campus students. Its expenditure budget for 2009-10 was 3648 million PKR (US$42m, £27m), with a grant from the federal government of 1182 PKR. Members of the university were responsible for authorships of 1,785 papers published between 2000 and 2010. They were spread across a range of subject areas, the two largest of which were agricultural and biological sciences, and physics and astronomy.

The **Aga Khan University** is a private university that operates in East Africa, Afghanistan, Egypt, Syria and the UK as well as Pakistan, where its main base is in Karachi. It was granted its charter in 1983 as Pakistan's first private, autonomous university. It offers programmes in nursing, medicine and education, and operates alongside the University Hospital. There are plans for the development of a Faculty of Arts and Sciences. In the HEC ranking of universities in Pakistan, the Aga Khan University ranked first in Health Sciences, and first overall based on the global impact of its research. Members of the university were responsible for authorships of 1,755 papers published between 2000 and 2010, together with a further 1,585 from the University Hospital, making a total of 3,340 overall. For obvious reasons, the papers published focused on medicine and related disciplines; and the authorships represented just under 30% of all the papers in medicine and immunology published between 2000 and 2010. According to Wikipedia, the University accounts for 70% of the biomedical research conducted in Pakistan. The University has its own endowment to support research, and a Grants Review Committee reviews proposals – using external reviewers as appropriate- before passing them to the University Research Council for approval.

The **National University of Sciences and Technology (NUST)** is a multi-campus university spread all over Pakistan. Its central campus is in Islamabad with other campuses at Rawalpindi, Risalpur and Karachi. In addition to a business school (NBS) and a School of Art, Design and Architecture (SADA), it has schools of chemical and materials engineering (SCME), civil and environmental engineering (SCEE), electrical engineering and computer science (SEECS), mechanical and manufacturing engineering (SMME), and a College of aeronautical engineering (CAE)). It also houses the National Institute of Transportation (NIT), the Institute of Environmental Science and Engineering (IESE), the Institute of Geographical Information Systems (IGIS), the NUST Institute of Civil Engineering (NICE), the Research

[50] http://qau.rozee.pk/view.php?lid=NzQrQg==

Institute of Microwave and Millimeter-Wave Studies (RIMMS), the Army Medical College (AMC), the College of Electrical and Mechanical Engineering (CEME) , the Military College of Signals (MCS), the NUST Center for Virology and Immunology (NCVI), the NUST Institute of Peace and Conflict Studies (NIPCONS), the Research Center for Modelling and Simulation (RCMS) the Military College of Engineering (MCE) , and the Pakistan Naval Engineering College (PNEC). The Directorate of Research is responsible for developing NUST into a leading research- led university, and promoting and facilitating research, both academic and sponsored, within the University. It helps the colleges, schools and centres to undertake sponsored projects funded through a range of external agencies, from Pakistan and abroad. Members of the university were responsible for authorships of 1,331 papers published between 2000 and 2010, over 90% of them in engineering and computer science.

Government College Lahore was raised to the status of GC University Lahore in 2002. The College was founded in 1864, initially affiliated to the University of Calcutta, but then to the University of the Punjab once that was established. It has over 7,500 students, and over 400 faculty, some 140 of whom have doctorates. It is organised in four faculties: science and technology; arts and social sciences; languages, Islamic and oriental learning; and engineering. Members of the university were responsible for authorships of 1,106 papers published between 2000 and 2010, over 70% of them in physics, astronomy and chemistry.

4.4.2 Research Institutes

The **Ministry of Science and Technology** funds a number of research institutes and centres which taken together are responsible for a significant proportion of research activity, though their published outputs are not on the same scale as the major universities.

The **Pakistan Council of Scientific and Industrial Research (PCSIR)**[51] was established in 1953 with the objective of setting up research establishments across the country, with a focus on the utilisation of indigenous raw materials and on problems faced by industry. It runs laboratory complexes in Karachi, Lahore, Peshawar and Quetta. The labs cover a wide range of S & T disciplines and are organized into quasi-independent Centers / Divisions including applied chemistry, minerals & metallurgy, glass & ceramics, biotechnology & food, environmental protection, medicinal and botanic, fine chemicals & pharmaceuticals, rural technologies, instrumentation & electronics, industrial liaison, polymers & plastics, and marine resources & applied biology. It is also responsible for the National Physical & Standards Laboratories (NPSL) at Islamabad. the Fuel Research Centre (FRC) and the Leather Research Centre (LRC) at Karachi, PCSIR Labs for Rural Technologies at Hyderabad, and a Food Processing– Demonstration/Training Unit at Skardu. The Scientific Information Centre (SIC) at Karachi deals with the dissemination of scientific and technological information and is responsible for the publication the Pakistan Journal of Scientific & Industrial Research (PJSIR). The Council employs in total over 700 scientists and technologists, and a similar number of technicians and support staff. Members of staff were responsible for authorships of 715 papers published between 2000 and 2010, with a focus on chemistry and engineering.

The **COMSATS Institute of Information Technology (CIIT)**[52] was set up in 1998. The Commission on Science and Technology for Sustainable Development in the South (COMSATS) is an international organization which aims to reduce the gap between the developed and developing world through useful applications of science and technology. It is based in Islamabad, and CIIT is its principal activity in Pakistan, with campuses also in six other cities. It has degree-awarding powers, and runs both undergraduate and graduate programmes, with more than 18,000 enrolled students. It employs more than 1,700 faculty, 320 of whom have PhDs, the rest Master's level qualifications. CIIT has established linkages with a number of universities abroad, with a focus on the UK, the US and China. Members of staff were responsible for authorships of 1,210 papers published between 2000 and 2010,

[51] http://www.pcsir.gov.pk/

[52] http://www.ciit.edu.pk/

across a wide range of disciplines, with mathematics, engineering, computer science, and physics and astronomy at the top of the list.

The **Pakistan Agricultural Research Council (PARC)**[53] was established in 1981. Its Council is chaired by the Minister of Food, Agriculture and Livestock. The Council runs a number of research establishments including the National Agricultural Research Centre (NARC) at Islamabad; the Southern Zone Agricultural Research Centre (SARC)at Karachi; the Arid Zone Research Centre (AZRC) at Quetta; the Arid Zone Research Institute (AZRI) at Bhawalpur; the National Tea Research Institute (NTRI) at Mansehra; the National Sugar Crops Research Institute (NSCRI) at Thatta; the Mountain Agricultural Research Centre, (MARC) at Gilgit; and the Summer Agricultural Research Station (SARS) at Kaghan. It undertakes research in plant and crop sciences, animal sciences and social sciences. And it aims to contribute to the national agricultural research system by funding projects and programmes of national importance; planning and co-ordination of research review and evaluation; training of agricultural scientists; providing information and database services; and linkages with international research centres. NARC is the largest of the PARC research centres, and members of staff were responsible for 540 papers published between 2000 and 2010.

The **Pakistan Council of Research in Water Resources (PCRWR)**[54] was established in 1964 to undertake research in all aspects of water resources., including irrigation, drainage, surface and groundwater management, groundwater recharge, watershed management, desertification control, rainwater harvesting, water quality assessment and monitoring, and development of innovative water resource management, conservation and quality improvement technologies. The Council runs a number of laboratories and field stations, and like the Agricultural Research Council, is responsible for various information services as well as training and human resource development.

The Ministry of Science and Technology is also responsible for a number of smaller research institutes including:

- The **Council for Works and Housing Research**[55], established in 1964 to guide and foster research in civil engineering, with a special focus on affordable housing. Much of its work involves non-destructive testing, but it also undertakes research into construction materials, through the National Building Research Institute
- The **National Institute of Oceanography**[56], which has 30 qualified marine scientists working on ocean biology/productivity, marine chemistry and environment, physical oceanography/coastal hydraulics, marine geology and geophysics. Its work focuses on the north Arabian Sea
- The **National Institute of Electronics**[57], which undertakes design and development work in vital areas of electronics, including test and control equipment, computing, data processing and data transmission, and opto-electronic devices. Its aim is to develop know-how in advanced electronic techniques, and to impart advanced training in electronics
- The **Center of Applied Molecular Biology**[58], which is based at the University of Punjab and seeks to generate a cadre of people trained in molecular biology and recombinant DNA technology; to undertake research on specific problems related to economic needs of the country; to create a repository of DNA modifying enzymes, DNA cloning vectors, novel bacterial strains and other molecular tools for use in the

[53] http://www.parc.gov.pk/

[54] http://www.pcrwr.gov.pk/

[55] http://www.cwhr.gov.pk/home.asp

[56] http://www.niopk.gov.pk/intro-1.html

[57] http://www.nie.gov.pk/

[58] http://www.camb.edu.pk/Intro_camb.asp

Centre and other DNA research laboratories in Pakistan; and to organize seminars and conferences

4.4.2.1 Other major research institutes come under other Ministries

The **Pakistan Institute of Nuclear Science and Technology (PINSTECH)**[59] is a multi-program science and technology national research institute managed by the Pakistan Atomic Energy Commission. The institute offers a post-graduate and post-doctoral research in the field of nuclear and reactor technology. PINSTECH is the one of the largest science and technology research institutions in Pakistan, and is located near Islamabad. It conducts basic and applied research to build the nation's expertise in key areas of science; increase the ability of clean and peaceful use of nuclear energy; restore and protect the environment; and contribute to national security. PINSTECH performs a range of experiments for the Government, including research in nuclear reprocessing, and technical program management. It provides research and technical assistance to other organizations. Its work includes producing radioisotopes and radio pharmaceuticals catering to the needs of nuclear medical centers, industry and research establishments; and promoting applications of radiation and isotope technology in various scientific and technological disciplines to support national programs. Staff members were responsible for authorships on 1,189 papers published between 2000 and 2010.

The **Pakistan Medical Research Council (PMRC)**[60] was established in 1962, and is under the Ministry of Health. Its main functions are to:

- organize, coordinate and promote scientific research in various disciplines of medical sciences and public health;
- establish institutions for undertaking medical research;
- publish and disseminate technical and general information on scientific matters through seminars, meetings and conferences;
- establish scientific liaison with other national and international organizations;
- advise the Federal Government and Provincial Governments on all matters related to medical research; and
- carry out evaluations of different health programme in the country.

The PMRC is based in Islamabad, but has thirteen research centres across the country, attached to major public sector hospitals. It also funds a small number of projects outside the centres each year, and is responsible for the National Bioethics Committee, which oversees ethical guidelines and the review of health research projects. Like other Research Councils, it provides library and information services, and there are plans to establish a health information resources centre.

Seven of the PMRC centres, for child health, gastroenterology and hepatology, communicable diseases, traditional medicine, tuberculosis, metabolic diseases, and the development of diagnostic kits, are designated as specialist centres; the rest as non-specialised. Researchers based at the thirteen centres were responsible for authorships on over 1,800 papers published between 2000 and 2010.

The **Pakistan Space and Upper Atmosphere Research Commission (SUPARCO)**[61] was established initially in 1961, and was given the status of a Commission in 1981. It comes

[59] http://www.paec.gov.pk/pinstech/

[60] http://www.pmrc.org.pk/ . There are moves to reconstitute the Council as an autonomous body called the Pakistan Health Research Council. See the Annual Report for 2010 at http://www.pmrc.org.pk/PMRC%20ANNUAL%20REPORT%202010.doc

[61] http://www.suparco.gov.pk/pages/intro.asp

under the National Command Authority, the organization tasked with the command and control of Pakistan's strategic nuclear forces and strategic organizations. Its functions are to:

- undertake research and pilot studies on the applications of Satellite Remote Sensing (SRS) data and Geographic Information System (GIS) technology to natural resources surveying, mapping and environmental monitoring;
- undertake research in space and atmospheric sciences including satellite meteorology, satellite radiance, troposphere/stratosphere studies, atmospheric pollution, satellite geodesy and astronomy;
- undertake research relating to the ionosphere and associated radio wave propagation and geomagnetism;
- develop, design, fabricate, assemble, and launch communication and earth observation satellites, and sounding rockets for upper and middle atmospheric research;
- establish and operate ground receiving stations, and facilities for tracking satellites and rockets; and
- develop instrumentation and software for scientific and technological experiments.

SUPARCO has facilities across the country for remote sensing and telemetry, and for space and atmospheric research.

4.5 Subjects, disciplines and research priorities

Pakistan is the biggest country included in this series of studies, with a much bigger research base (though still small by comparison with western countries and rapidly-rising research nations such as China and India). In comparison with the two African countries included in this set of four studies, it shows some marked differences. First, its research activities and outputs are more evenly spread across the range of scientific disciplines, and not nearly so much concentrated in the medical sciences, agriculture and biology. Indeed, as we shall see, the proportion of all research papers published by authors from Pakistan that come from medicine has fallen significantly over the past decade, while for the physical sciences and engineering it has grown. This reflects the strengths of the research base, but also the importance given to research that supports industrial development.

Second, however, alongside the increasing focus – as in many other countries – on the linkages between research, innovation and economic growth, there is also a recognition of the importance of building a research base that is dynamic and able to respond to new trends and developments in their disciplines, and to pursue new fields of enquiry. Thus the HEC's Medium Term Development Framework follows the Vision 2030 in talking of the importance of 'establishing the competitiveness of the research base in a global context', and of continuing its support for basic research.

A third key feature is the relatively low level of dependence on funding from abroad, and of collaboration with foreign research partners, as compared with Kenya, Malawi or Bangladesh. As already noted, data from the UNESCO Institute for Statistics indicate that the contribution to expenditure on R&D of funding from abroad is negligible; and as we shall see in Section 6, over two thirds of papers published by authors from Pakistan involve no collaboration with authors from outside the country. Researchers, universities and funders in Pakistan are fully aware of the importance of international collaboration, and are seeking to promote and foster it; the Government's Annual Plan for 2011-12 talks of the need to encourage collaboration with international industrial partners as well as universities from other countries. But the current relative lack of dependence on outside support – as compared with other countries in the developing world - means that institutions and funders are in a powerful position to pursue their own agendas.

4.6 Published outputs, 2000 to 2010

Table 3 appended to this paper presents figures from the SCOPUS database, as at mid-October 2011. It shows the number of papers recorded in that database that were published in each of the years 2000 to 2010 which had at least one author affiliated to an institution in Pakistan.

Panel 1 in the table shows that the number of such publications of any kind increased by nearly 500% between 2000 and 2010, from 1,175 to 6,985; and that the number of articles, reviews and conference papers increased at a similar rate, from 1,124 to 6,709. That is by far the highest rate of growth in the four countries covered in these studies. For comparison, it may be noted that the number of papers published with UK-based authors rose by 56% between 2000 and 2010, and for Swedish authors by 64%.

As in the other studies, in order to examine whether this increase in productivity has been bought at the cost of a fall in citation impact, we looked at the average number of citations each paper received. Since citations are gathered over a period of years, earlier papers tend to have a higher number of citations than more recent papers. In order to mitigate this effect, we calculated the average number of citations per paper within four years after the year of publication.[62] The four-year measure is a crude one; but it does provide an element of consistency in measuring citation impact. It also provides for a rather longer period to gather citations than the standard two-year window used in calculating journal impact factors. The table shows that the average number of citations grew significantly for papers published between 2000 and 2007 (with a blip for papers published in 2005). Since then it has tended to fall, as one would expect, since papers have not had full four years to gather citations.

It is notable, however, that the citation rates are the lowest of the four countries covered in this set of studies. Thus for Kenya the average number of citations gathered over four years for papers published between 2000 and 2007 fluctuated between 6.6 and 10.1, whereas for Pakistan, it ranged from 2.5 to 4.9. For a country such as Sweden, for example, the average rate was over 10.

Part of the explanation for this is the relatively low proportion of papers, as compared with Kenya or Malawi, in medicine and related areas, where citation rates tend to be higher; though as we shall see, citation rates for Pakistan papers in medicine tend to be low too. A bigger part of the explanation seems to lie in the relatively high proportion of papers from Pakistan that receive no citations at all over the four-year period. The proportion of such papers fluctuates between 30% and 39% between 2000 and 2007, while for Kenya it fluctuates between 9% and 20%.

The figures for the H-index, showing the highest number of papers that have had at least the same number of citations, fluctuated between 37 and 42, only a little lower than for Kenya, and higher than for Malawi and Bangladesh. This seems to indicate that the reason for the low average rate of citation does indeed lie in the high proportion of papers that are not cited at all, or have very small numbers of citations.

We have already noted that the proportion of articles with Pakistan-based authors and with no authors from outside Pakistan is relatively low compared with our other countries. In 2000, 75% of papers from Pakistan involved no external authors, though by 2010 this had fallen to 67% (in Bangladesh the proportion was 49% in 2010). Panel 2 shows that the growth in numbers of such publications between 2000 and 2010 was slightly lower than for all papers, at 430%. As noted with the other three countries, the average number of citations per publication is significantly lower than that for all papers; but the difference is not as large. The citation average for papers with authors from outside Pakistan is twice that for papers without

[62] It is important to note that the citation half-life (that is, the number of years that a paper takes to receive half the number of citations it will eventually receive in total) varies across subjects; and that the SCOPUS database shows that papers published in 2000 had received by 2004 only 37% of the citations they received in total by September 2011.

such authors. A similar pattern is evident for the H-index; but it is notable that the proportions of papers with no citations are broadly similar for those with and without external authors.

Panels 3 and 4 show the figures for publications in medicine, immunology and microbiology. The growth in productivity here between 2000 and 2010 is lower than that for all papers, at over 300%. The result is that such publications now represent 30% of all papers, as distinct from 41% in 2000. The average number of citations in the four-year window is (somewhat surprisingly, given the high citation rate in medicine) around the same as, or even lower than, that for all publications. The range, from 1.9 to 4.7, is significantly lower than that shown for our other three countries (for Kenya, it ranges from 12 to 18, and for Bangladesh from 5 to 10). It is also noticeable that the H-index is lower than for all publications at between 24 and 32; and the number and proportion on papers with no citations is relatively high, at 30% in 2006.

Panel 4 shows that publications in medicine with no authors from outside Pakistan have lower rates of citation, lower H-indexes, but a broadly similar proportion of papers with no citations.

Panels 5 and 6 show the figures for publications in agriculture and biology, where there has been sustained growth, at a higher rate than for all papers. Thus, albeit from a relatively small base, the number of papers with authors based in Pakistan has grown more than eight-fold. Papers in these subject areas now account for 20% of all papers from Pakistan, as compared to 14% in 2000. Citation rates are lower than in medicine, but not by much, ranging from 2 to 4. It is notable also that papers with no external author have grown at an especially fast rate, and now account for three-quarters of all the papers in these disciplines. Citation rates for papers with no external author are slightly lower than for those with a collaborator from abroad, but again not by much, ranging between 2 and 3.

Panels 7 and 8 show the figures for publications in the physical sciences and engineering (rather than the social sciences shown for the other three countries). These subjects are sources of strength in the Pakistan research base, and growth has been particularly strong, with the number of papers rising from 421 in 2000 to 3,311 in 2010 (541%). They now account for 47% of all papers published by authors from Pakistan. The average number of citations over a four-year period has also risen, from 2.4 in 2000 to 4.6 in 2007, only slightly below that for medicine; and the H-index has grown steadily too, and is now higher than that for medicine. The number and proportion of papers with no citations has tended to rise, however, to around 40%.

4.7 Conclusion

Pakistan is the largest country covered in these four studies, in terms both of population (187 million) and GDP (PPP$ 465million). It has a strong research base in some areas, with a total of 75,000 FTE personnel working in R&D, two-thirds working in Government bodies, and one-third in universities. It is universities that dominate the production of research papers, with the top six universities responsible for well over a third of all the authorships of papers produced between 2000 and 2010. And the production of papers has increased at a very rapid rate over the past decade, especially in agricultural and biological sciences and in physical sciences and engineering. All this has been achieved with the help of increased funding; but GERD is still under 0.5% of GDP, and Government funding seems now to be falling.

The bulk of the increase in productivity derives from universities, and it seems that the HEC can claim at least some of the credit for this, through its programmes to promote faculty development and research performance. It is not clear whether this progress will be sustained as budgets come under increasing pressure, and the future of the HEC remains uncertain. Its work has been praised by external agencies such as the World Bank and USAID, but there are clearly tensions with both the federal and the provincial governments.

The new science and technology policy framed by the Council for Science and Technology talks of a ‘paradigm shift’ with innovation being closely integrated into science and technology policies and strategies. But it is not clear whether this implies a retreat from the support given

up to now to basic, fundamental and untargeted research; nor whether adequate funds will be provided to meet the plan's objectives. Moreover, in seeking to encourage collaboration with industry both in Pakistan and abroad, the Government is starting from a low base. The wide range of bodies involved in policy and advice at senior level – the Council for Science and Technology, the Science Foundation, the Technology Board, the Higher Education Commission as well as the Research Councils, the Ministry of Science and Technology and other Ministries – mean that co-ordination of policy and strategy is a complex matter. These will be significant challenges for the future.

5 Country report: Bangladesh

5.1 Policy frameworks and priorities

An overarching national framework and forward plan for research and development in Bangladesh is contained in the *National Science and Technology Policy (NSTP)*[63], developed under the auspices of the Ministry of Science and ICT. This was originally set out in 1986 with an emphasis on "scientific and technological competence and self reliance and [stressing] the need for an effective synchronisation of the policy with the socio-economic, cultural, educational agricultural and industrial policies of the country." Following an initial revision in 2006, a new version of the NSTP was adopted in November 2010. This recognises the growing impact of globalisation and evolving intellectual property regimes. The new policy is intended to promote joined-up thinking and coordination across the public, semi-public and commercial sectors, in order to "integrat[e] all science and technology issues with the objective of enhancing sustainable development." The national research effort is thus perceived firmly in economic terms: "Value-addition to products and processes, which is the ultimate aim of S&T researches [sic], should be a central theme of all production processes." Not surprisingly, the development of a technological capacity, aimed at shifting the Bangladesh economy from its reliance on traditional, labour-intensive activities, features strongly in the Policy, for instance through the proposal to set up a National Centre for Technology Development and Transfer.

In this context, the Policy sets itself twelve broad aims:

1. To place S&T as the basis for formulation of national development plan for economic and cultural development
2. To build a strong foundation for development, promotion and application of S&T for sustainable prosperity
3. To develop quality human resources, infrastructures and institutions for science and technology so as to create a strong, creative, innovative and competitive nation in the world wide knowledge-based society National Science and Technology Policy
4. To promote basic sciences and innovative practices and ensure effective use of science, engineering & technology to fulfil basic needs of its people
5. To encourage generation, adaptation, transfer and assimilation of technology appropriate for basic, applied and developmental research
6. To ensure the development and use of traditional science and technologies and upgrade indigenous community knowledge to provide quality goods and services to all sectors
7. To encourage research on green technology to harness natural resources; ecosystems which act as carbon sinks and a buffer against climate change; information and communication technology, biotechnology, nanotechnology etc.
8. To create adequate infrastructure of R&D in science and technology areas of national need and encourage [the] private sector to set up R&D centres for quality products
9. To provide adequate training and skill development opportunities and promote scientific literacy to empower and enrich the society

[63] http://www.mosict.gov.bd/index.php?option=com_docman&task=cat_view&gid=139&Itemid=390

10. To strengthen and protect intellectual property rights of various technologies generated in the country

11. To provide special technology support and services to export-oriented industries viz. agricultural, agro-industrial, pharmaceutical, medicinal and aromatic plants, jute, leather, textiles, readymade garments, handicrafts etc

12. To develop SME-friendly technology for the sustainable growth of small and medium enterprises

To achieve these aims, the NSTP identifies several strategic research priorities, to be developed through plans and targets, and subjected to monitoring. These are in the areas of environment science and technology; natural resources and energy, including agriculture and land reclamation; health and life sciences, notably nutrition and biotechnology; and ICT, including nanotechnology and materials science.

One noteworthy idea in the Policy is the creation of central facilities for the collection and dissemination of scientific information and research findings. To overcome a degree of fragmentation in the way that research information in Bangladesh is collated, catalogued and stored, the NSTP proposes a three-pronged approach:

1. strengthening and enhancing the Bangladesh National Scientific and Technical Documentation Centre (BANSDOC); according to its vision statement , BANSDCOC seeks to "transform [its] present traditional science library into a digital library with the ultimate goal of establishing it as a virtual library" [64]

2. setting up four specialist subject sub-groups (covering physical sciences, agricultural, medical/biological and engineering research), each located in appropriate institutions and with their own facilities for storage and documentation

3. maintaining the network of scientific institutional libraries, which would establish relationships with the above sub-groups

The ambitions of the NSTP are subsumed in the current version of the Bangladesh national planning instrument, the *Sixth Five Year Plan*[65] , covering the period 2011-15. Recognising the enormous challenges facing the development of the research infrastructure, the Plan recognises that "Bangladesh needs to come out of the "basic needs agenda" for research and come up with ambitious research programmes in the field of science and technology which are closely related to its aspirations of becoming a middle income country with rapid poverty reduction." It lists a number of major current barriers, including severe lack of research funding and inadequate research facilities. The Plan sets out strategic directions relating to the development of a range of sectors, and goes on to list 19 separate instruments for achieving these aims – chief among which is increasing the public sector allocation for the advancement of science and technology; large-scale training of scientists and other specialists from key strategic areas in centres of excellence; and a range of proposals for encouraging knowledge transfer. Although there is much detail about proposed initiatives to promote such developments, no figures are provided about the required level of financial resourcing.

In addition to the NSTP and the Five Year Plan, a further national driver is provided by the *Strategic Plan for Higher Education 2006-2026*[66], devised by the Ministry of Education and published in May 2007. Much of this is concerned with the addressing of deep-rooted problems such as improving educational quality assurance and depoliticizing public universities, but it also includes recommendations on providing enhanced support for research.

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[64] http://www.bansdoc.gov.bd/sub/bansdoc_vision.php

[65] http://www.plancomm.gov.bd/SFYP-PDF-Final%2029-08-2011/SFYP-Final-Part-2-17-08-11.pdf

[66] In spite of extensive searching, it has not been possible to find the Strategic Plan online, nor to secure a copy.

The NSTP, the *Five Year Plan* and the HE *Strategic Plan* provide national overviews. Strategic and policy frameworks for given disciplinary areas are much less prevalent in Bangladesh. Of the major Bangladeshi research organisations, only the National Institute of Biotechnology (NIB) and the International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B) have published comprehensive plans. This may be a reflection of the relative absence, until recently at least, of planning and review mechanisms in most of the research sector.[67]

The NIB set out its National Biotechnology Policy[68] in May 2011. The main goal of this, also rooted in the need to address socio-economic challenges, is "to ensure sustainable development of agriculture-food and other crops; nutrition; health; environment and livelihood of people, enhance agricultural competitiveness in relation to global standards." It acknowledges that Bangladesh has not made as much progress as its neighbours in the field of biotechnology, but recognises the significant and diverse potential that this represents for the country. The Policy is complemented by a detailed Roadmap[69] , whose latest draft is also dated May 2011. This identifies the need for research investment across six broad subject areas: agricultural biotechnology; health/medical biotechnology; environmental and industrial biotechnology; bioengineering and nano-biotechnology; bioinformatics and IT-enabled biotechnology; and biodiversity conservation. The Roadmap also proposes a series of strategic actions, including the establishment of a Biotechnology Information and Training Centre (BITC), the setting of up a range of specialist MSc courses across the higher education sector, and measures to arrest what is perceived as a dangerous brain drain. The importance of liaison and collaboration is properly recognised, with proposals to encourage the coordination of R&D activity across the country and, crucially, to provide technology transfer opportunities and mechanisms through, for instance, the development of biotechnology parks, incubator facilities and a national technology transfer service.

The ICDDR, B is a more focused institution than the NIB, and its Strategic Plan 2020[70], covering the period 2010-2020, does not have the breadth of the National Biotechnology Policy. The Plan is articulated around three strands:

1. Development of a number of themes: healthy life-course; mitigating risk and vulnerability; combating priority diseases; and equitable health systems. Within these areas, research is categorised according to one of four types, known as 4Ds: discovery, development, delivery and delivery evaluation. Individual research programmes, reflecting the above themes, are to be undertaken within this 4Ds framework

2. Provision of support services, particularly those that have the potential to generate income from the Centre's research and non-research expertise

3. Organisational management, with a strong emphasis on nurturing, training and developing staff

5.2 National policy-making and funding structures

Several Government Ministries have a strong stake in Bangladeshi research capacity, not least the Ministry of Education and, given the thrust of much of the research effort, the Ministry of Agriculture. However, the leading agency is the Ministry of Science and Information & Communication Technology (MOSICT)[71]. Previously known simply as the

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[67] *Science and technology developments in Bangladesh: failure in policy implementation*, Iqbal Mahmud, Journal of Bangladesh Studies, vol 8 nr 2, 2006 http://www.bdiusa.org/Publications/JBS/Volumes/Volume8/jbs8.2-1.pdf

[68] http://www.nib.gov.bd/NationalBiotechnologyPolicyfinal%20draft-May2011.pdf

[69] http://www.nib.gov.bd/DraftStrategicActionplanofNationalBTPolicy-2011_May15.pdf

[70] http://www.icddrb.org/what-we-do/publications/cat_view/52-publications/10043-icddrb-documents/10059-strategic-plan/10080-strategic-plan-2020

[71] http://www.mosict.gov.bd/index.php

Ministry of Science and Technology, its name was changed in 2002 to reflect the importance that the Government attributed to the development of ICT.

MOSICT's remit, as summarised on its website[72], is as follows:

1. Formulate national policies on science and technology and coordinate science and technology based initiatives and activities of different Ministries
2. Implement recommendations of the National Council for Science and Technology (see below)
3. Provide grants and overall assistance to agencies related to the science and technology sector including non-government scientific organizations, to undertake survey, sampling, research and development in the science and technology sector and to take initiatives for fund for such activities
4. Liaise with different countries and international organizations in the science and technology sector and implement agreements and assistance programmes in the relevant sectors
5. Formulate policies relating to radio-activity and atomic energy and pursue matters relating to establishment of atomic energy stations
6. Coordinate the potential new technology based research activities including those of ocean resources, electronics and outer space and help develop infrastructure and human resources
7. Promote, extend and popularize new science related initiatives and organize National Science and Technology Week every year with support from research and educational institutions
8. Assist in the introduction of good governance in the country through use, application and expansion of information and communication technology

MOSICT is responsible for two major research organisations: the Bangladesh Council of Scientific and Industrial and Research, and the NIB. It also oversees the Bangladesh Atomic Energy Commission and BANSDOC.

In principle, the driver for Government science policy is the **National Council for Science and Technology (NCST)**[73]. This high-level body, instituted in 1983 and chaired by the Prime Minister, is intended to provide guidance to the Government, coordinate policy and help establish strategic priorities; it is supported by an Executive Committee chaired by the Minister for Science. However, although it is supposed to meet twice-yearly, in practice it has been convened only six times over the past twelve years, and doubts have been cast about its effectiveness at implementing programmes.[74] The rolling out of the revised NSTP may give the NCST a new lease of life,[75] with the beefed-up key objective of "formulat[ing] national policies on science and technology for social and environmental development and devise strategy for technological self-reliance".[76] The Prime Minister would retain the chairmanship of the NCST, emphasising the continued political importance of the structure. It remains to be seen whether it can become a genuine force for implementing change. Confusingly, the Sixth Five Year Plan proposes the replacement of the NCST with a new apex institution to be

[72] http://www.mosict.gov.bd/index.php?option=com_content&task=view&id=292&Itemid=375

[73] http://www.mosict.gov.bd/index.php?option=com_content&task=view&id=325&Itemid=380

[74] Mahmud, op cit

[75] Proposed terms of reference for the revamped NCST can be found at annex A of the NSTP, along with its composition, the composition of its Executive Committee, and a useful organogram outlining the landscape for science and technology policy implementation in Bangladesh. Note that the denomination of the NCST is changing from Council to Committee.

[76] Revised NST Policy 2010, op cit

charged with formulating and implementing schemes for enhancing the research infrastructure.[77]

The NIB is also endowed with a high-level oversight structure, in the form of the National Taskforce on Biotechnology of Bangladesh. This too is chaired by the Prime Minister, and is responsible for "generating and allocating need-based resources for operating and undertaking various activities through strong support from the Government and possible foreign assistance"[78]. Reporting to the Taskforce, the National Executive Committee on Biotechnology is responsible for the implementation of the National Biotechnology Policy.

The Ministry of Education, through its Directorate of Secondary and Higher Education, is responsible for the University Grants Committee (UGC), which channels funds to Bangladesh's 31 public universities. Founded in 1973, the UGC is tasked with:

- determining the needs of the universities
- receiving funds from the Government and allocating and disbursing these funds to the universities for their maintenance and development
- examining and critically appraising the developments plans of the universities
- overseeing the implementation of various development projects of the universities
- formulating plants for new universities
- collecting, analysing, and interpreting statistical data on university matters

Agricultural research is well-established in Bangladesh, with some research agencies dating back to the 1950s[79] , and is undertaken under the umbrella of the National Agricultural Research System (NARS)[80]. This consortium, set up in 1996, is coordinated by the Bangladesh Agricultural Research Council (BARC); it brings together a further eleven specialist public research institutes, listed in section 4 below, and also promotes collaboration with Bangladesh's four agricultural universities, NGOs and commercial players. The reporting lines to Government Ministries are complex: BARC and six of the eleven institutes are accountable to the Ministry of Agriculture; the remaining five are accountable variously to the Ministry of Fisheries and Livestock; the Ministry of Environment and Forests; the Ministry of Commerce; and the Ministry of Jute and Textiles.

Other Ministries have an interest in further discrete fields of research: the Ministry of Health and Family Welfare, which is responsible for the Bangladesh Medical Research Council (BMRC); and the Ministry of Planning, which oversees the Bangladesh Institute of Development Studies (BIDS) and the Bangladesh Social Science Research Council (BSSRC).

5.3 Funding

There is a dearth of information about the level of funding for R&D in Bangladesh. The 2010 UNESCO Science Report's statistical annex[81] , which includes information on GERD on a country-by-country basis, contains absolutely no data on Bangladesh (the statistical tables do however incorporate such data from India, Pakistan and Sri Lanka). Similarly, neither the

[77] Sixth Five Year Plan 2011-15, part 2, Sectoral Strategies, Programmes & Policies (see page 259) – http://www.plancomm.gov.bd/SFYP-PDF-Final%2029-08-2011/SFYP-Final-Part-2-17-08-11.pdf

[78] Strategic roadmap, op cit

[79] Briefing note from Mirza Hasanuzzaman, Sher-e-Bangla Agricultural University, on the National Agricultural Research System http://hasanuzzaman.weebly.com/uploads/9/3/4/0/934025/national_agricultural_research_system.pdf

[80] An overview of NARS, along with the lines of accountability of constituent institutes to the various Ministries, can be found at http://www.barc.gov.bd/nars.php

[81] http://unesdoc.unesco.org/images/0018/001899/189958e.pdf

World Bank indicators[82] nor the UN Development Programme's 2010 Human Development Report[83] carry data from Bangladesh on the percentage of GDP accounted for by public R&D (again, corresponding figures are available for India, Pakistan and Sri Lanka). However, a couple of Bangladeshi sources include a reference to this indicator: the Sixth Five Year Plan, covering the period 2011-2015, suggests that R&D activities amounted to 0.6% of GDP over the period 2005-10.[84] The Outline Perspective Plan of Bangladesh 2010-2021[85] gives a more precise figure of 0.62%, but there is no indication of how this figure is derived. The Five Year Plan calls for this proportion to increase to 1.0% in 2015 and, aspirationally, to1.4% in 2021. Given that the GDP of Bangladesh was $100.1bn in 2010, it is deduced that total R&D expenditure currently amounts to $620.5m.

A breakdown of this figure has not been found. An approximation of the place of R&D in Bangladesh's national accounts is given by the budget of the Ministry of Science and Information & Communication Technology (MOSICT)[86], which amounted to Tk.5.11bn ($68.0m), equivalent to 0.22% of expenditure across Government Ministries. Another indicator is the level of funding from the Annual Development Programme (ADP)[87] allocated to MOSICT: Tk.1.70bn ($22.6m), or 0.49% of all ADP allocations. [88] The growth of MOSICT's ADP funding over the past seven years is charted in the table below.

Financial year	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12 (budget)
ADP funding to MOSICT (Tk. million)	607	460	662	1,021	1,050	1,169	1,700
% of overall ADP funding	0.31	0.26	0.35	0.56	0.54	0.45	0.49

As indicated above, a range of Government Ministries other than MOSICT are responsible for elements of R&D activity. However, it has not been possible to obtain any information about the levels of R&D expenditure committed by each of them. A broad breakdown of research activity can nevertheless be given by a breakdown of ADP allocations by major economic sector[89] – although the data that has been obtained is not more recent than 2004-05 (the latest ADP, for 2010-11, appears only to be available in Bengali)[90].

[82] Science and technology indicators http://data.worldbank.org/indicator

[83] http://www.beta.undp.org/content/dam/undp/library/corporate/HDR/HDR_2010_EN_Complete_reprint-1.pdf

[84] Sixth Five Year Plan 2011-15, part 1, Strategic Directions and Policy Framework; see table 1.4 covering the targets for the Sixth Five Year Plan; it is not clear whether the R&D figure relates to public expenditure or overall spend http://www.plancomm.gov.bd/SFYP-PDF-Final%2029-08-2011/SFYP-Final-%20Part-1-17-08-11[1].pdf

[85] See section 3.6 http://www.plancomm.gov.bd/Final_Draft_OPP_June_2010.pdf

[86] 2011-12 budget, drawn from Annual Financial Statement 2011-2012 http://www.mof.gov.bd/en/budget/11_12/afs/en/AFS_St_vii.pdf?phpMyAdmin=GqNisTr562C5oxdV%2CEruqlWwoM5&phpMyAdmin=XRGktGpDJ7v31TJLuZ5xtAQmRx9

[87] Bangladesh's Annual Development Programme, amounting to Tk.348bn in 2011-12, is defined as "an organised list of projects in various sectors, and allocations for them, for a year out of a five-year plan period for implementation of the government's development policies, programmes and investments in the plan"; a significant (but, in the long term, diminishing) proportion of ADP income comes from foreign donors – see the useful article in Banglapedia, http://www.banglapedia.org/httpdocs/HT/A_0394.HTM

[88] Table 36 of the Statistical Annex (part 3) of the Sixth Five Year Plan, http://www.plancomm.gov.bd/SFYP-PDF-Final%2029-08-2011/SFYP-Final-Part-3-17-08-11.pdf

[89] Table 4(b) in Mahmud, op cit

[90] http://www.plancomm.gov.bd/adp_2010_2011.asp

Broad economic sector	Industries	Power	Natural resources	Transport	Communication	Health	Agriculture
% of overall ADP funding on R&D, 2004-05	2.20	nil	nil	0.06	0.54	nil	7.80

The dominance of agriculture-related R&D is clear. Across sectors, the overall proportion of R&D investment from the ADP amounts to over 10% – considerably more than the level of ADP funding accounted for by MOSICT. In the absence of an English-language version of the ADP, it is not possible to explain the reason for this relatively high figure.

As outlined above, the University Grants Committee (UGC) allocates funds to Bangladesh's 31 public universities. However, the proportion of this investment allocated to research, as opposed to teaching, is tiny[91] , at just Tk.29m ($0.39m), under 1% of the overall grant to HE in 2001-2. A World Bank report from 1999 indicates a similar figure: 0.5% to 1.5% of university budgets are accounted for by research.[92] More recent data for the research component have not been identified. To provide context, the figures for the overall UGC allocation to universities over the ten year period to 2005-06 is given below.[93]

Financial year	1996-97	1997-98	1998-99	1999-2000	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06
UGC allocation (Tk. million)	1,800	1,943	2,159	2,535	2,865	2,888	3,202	3,864	4,326	4,944

A related and more recent figure is provided by the Bangladesh Bureau of Educational Information and Statistics (BANBEIS), which indicates a budget of Tk.5,274m ($70.13m) for university education in 2008-09, representing 7.4% of the overall education budget.[94]

Finally, the research infrastructure is also promoted through international interventions. In 2009, the World Bank, through its Higher Education Quality Enhancement Project for Bangladesh[95] , approved an $81m interest free credit aimed at "improv[ing] the quality and relevance of the teaching and research environment in higher education institutions through encouraging both innovation and accountability within universities and by enhancing the technical and institutional capacity of the higher education sector." The project is thus clearly intended to boost national research capacity, notably through the incentivisation of universities that can demonstrate vision, innovation and discipline. The project runs until the end of 2013, so it is too early to draw conclusions about its impact, but the latest status report, dated July 2011, suggests that progress towards achieving objectives is deemed to be moderately satisfactory.

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[91] *Higher Education in Bangladesh: Status, Issues and Prospects*, Mobasser Monem & Hasan Muhammad Baniamim, Pakistan Journal of Social Sciences, vol 30 nr 2, Dec 2010 – http://www.bzu.edu.pk/PJSS/Vol30No22010/Final_PJSS-30-2-09.pdf

[92] Cited in *The Role of Transnational, Private, and For-Profit Provision in Meeting Global Demand for Tertiary Education: Mapping, Regulation and Impact (case study for Bangladesh)*, Robin Middlehurst & Steve Woodfield, report commissioned by UNESCO and Commonwealth of Learning – http://www.col.org/SiteCollectionDocuments/03Transnational_Bangladesh.pdf

[93] http://www.ugc.gov.bd/finance/

[94] http://www.banbeis.gov.bd/db_bb/education_finance1.htm

[95] http://web.worldbank.org/external/projects/main?pagePK=64312881&piPK=64302848&theSitePK=40941&Projectid=P106216

5.4 Universities and research organisations

Publicly-funded R&D activity in Bangladesh is concentrated heavily in the network of research organisations accountable to the various Government Ministries described in section 2 above. Most of these are specialised, and many have a focus on aspects of agricultural science. Almost all of this research capacity relates to the life, physical or environmental sciences and technology; there is a limited capacity in the social sciences, and no evident infrastructure relating to research in the humanities and the arts.

Bangladesh faces significant challenges with regards to the management and evaluation of this research. Outside of the agricultural research sector, there is a notable absence of organised and well-planned research management systems, and peer review mechanisms are not always prevalent for the selection of projects in research institutes. This, combined with a shortage of competent manpower (with talented individuals lured abroad), contributes to undermine the potential of the national research environment.[96]

Bangladesh Council of Scientific and Industrial Research (BCSIR)[97]: Founded in 1973, the BCSIR is the only truly pluridisciplinary research organisation in Bangladesh, covering a wide range of subjects, including notably biology, food science, chemistry, physics and electronics. The emphasis is resolutely on the applied sciences and technology: the explicit aim of the Council is to aid the establishment and development of Bangladeshi industries. Not surprisingly, there is a focus on technology transfer and the industrial use of research processes, with a claim that most of Bangladesh's inventions have originated from research undertaken at the BCSIR. The Council runs three broad-ranging laboratories in Dhaka, Rajshahi and Chittagong, as well as six specialist institutes covering the following areas: food science and technology; fuel research; pilot plant and process development; glass and ceramics; leather; and mining, mineralogy and metallurgy.

Bangladesh Atomic Energy Commission (BATC)[98]: The BATC, also established in 1973, is charged with the development and promotion of Bangladesh's civil nuclear programme. As such, R&D forms only one facet of its activities, albeit an important one. The research function is concentrated at the **Atomic Energy Research Establishment (AERE)**[99], which undertakes fundamental and applied research through its ten institutes and units. These cover not just nuclear science and technology, but also derived fields such as food and radiation biology, tissue banking and biomaterials, and nuclear minerals. Electronics, computing and engineering (notably reactor engineering and control) are also encompassed in the AERE's research spectrum.

In addition to the AERE, the BATC runs 14 nuclear medicine establishments located in academic medical college and/or university hospitals. These centres are mainly involved with diagnosis and treatment of human disease, but academic research is also undertaken.

5.4.1 Biomedical research

National Institute of Biotechnology (NIB)[100]: As suggested above, the development of biotechnology capacity is considered a major strategic priority for Bangladesh. The NIB thus exists to address the challenges set out in the National Biotechnology Policy (NTP), particularly with regard to food security, health and environmental protection. Its research divisions cover plant, microbial, animal, fisheries, environmental and microbial biotechnology. Reflecting the socio-economic priorities of the NTP, the Institute's lofty mission is described as "[facilitating] a biotechnology network of people and facilities to enhance cross-disciplinary

[96] Mahmud, op cit

[97] http://www.bcsir.gov.bd/aimobj.php

[98] http://www.baec.org.bd/baec/index.php

[99] http://www.aere.org.bd/

[100] http://www.nib.gov.bd/

research and services that would ultimately increase agricultural productivity, augment farm income and reduce poverty, improving standards of living for rural as well as urban people of our country."

Bangladesh Medical Research Council (BMRC)[101]: The BMRC's mission stresses the importance of health research; so here too, there is an emphasis health outcomes and the effective use of research results for the benefit of the population. Recent data on main areas of research could not be found, but summary information on subject-wide distribution of research projects over the period 1993-2003 provides some indication of priorities[102] : during that time, 19.7% of projects related to health systems research, 16.5% to maternal health and 14.4% to child health; so these three areas accounted for over half of BMRC's research activity.

International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B)[103]: this is one of the two leading research institutions in Bangladesh, along with the University of Dhaka; on the basis of Web of Science metrics,17% of the country's publications originate from research undertaken at the Centre.[104] Founded in 1960 as the Pak-SEATO Cholera Research Laboratory, the Centre was re-established under its current designation in 1978. Its original focus was on diarrhoeal disease (research at the Centre was key to the discovery and implementation of oral rehydration therapy in the early 1970s, arguably one of the most important medical discoveries of the 20th century), but its remit is now far broader, with research activities covering such areas as microbiology, nutritional biochemistry, virology (including HIV/AIDS), parasitology, immunology and tuberculosis. As such, it addresses a wide range of public health challenges through the translation of its research findings into strategic health programmes. The Centre also runs an important international training programme, to improve research capacity and improve clinical skills. ICDDR,B has a mix of Bangladeshi and international staff. Its activities are supported by about 55 donor countries and organizations, including the Government of Bangladesh, UN specialized agencies, foundations, universities, research institutes and private sector organizations.

5.4.2 Agricultural research

Bangladesh Agricultural Research Council (BARC)[105]: within the National Agricultural Research System (NARS) described above, BARC takes the leading role in coordinating agricultural research in Bangladesh, notably through the NARS network of 11 specialist research organisations. Its mission is thus to "strengthen and mobilize research capabilities of the institutes of the NARS, universities, private sectors and other stakeholders in partnership in the generation of appropriate technologies and information for the development of agriculture sector." It has a strategic role in identifying priority areas for agricultural research, setting out plans and advising Government. It does not undertake research in its own right, but sets out frameworks for the strengthening and advancement of agricultural capacity. In this vein, it runs two major projects: the National Agricultural Technology Project (NATP), aimed at improving national agricultural productivity and farm income, with particular focus on small and marginal farmers, notably through increasing the efficiency and effectiveness of agricultural research; and the Agricultural Technology Transfer Project (ATTP), aimed at facilitating the dissemination of appropriate technologies through the agricultural sector.

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[101] http://www.bmrcbd.org/index.html

[102] http://www.bmrcbd.org/research_project_duration.html. Note: that this data refers to the number of projects, not their value

[103] http://www.icddrb.org/

[104] *Scientific research in Bangladesh and a comparison with India and Pakistan*, Dilruba Mahbuba & Ronald Rousseau, paper given to the Fourth International Conference on Webometrics, Informetrics and Scientometrics (WIS) and Ninth COLLNET Meeting, 28 July -1 August, 2008, Berlin – http://www.collnet.de/Berlin-2008/MahbubaWIS2008srb.pdf

[105] http://www.barc.gov.bd

The agricultural research effort is conducted by the 11 research bodies[106] operating under the umbrella of NARS:

1. **Bangladesh Agricultural Research Institute (BARI)**: as the largest multi-crop research organization, BARI is mandated to carry out research on a wide variety of crops such as wheat, tubers, pulses, oilseeds, spices, and horticultural crops. Besides crop variety development, the major areas of research are soil and water management, development of farm machineries, cultural management, disease and insect management and vertebrate pest management.

2. **Bangladesh Rice Research Institute (BRRI)** conducts research on all aspects of rice in order to develop modern varieties of rice with high yield potential for different ecosystems; to develop component technologies for improving productivity of rice-based cropping systems; and to transfer rice production technologies through training, workshops, seminars and publications.

3. **Bangladesh Jute Research Institute (BJRI)** conducts research to develop short duration high yielding varieties of jute, kenaf and mesta; to develop agronomic and crop protection technologies and processes and equipment for manufacturing new jute products; and to organize the production, testing and supply of improved pedigree jute seeds.

4. **Bangladesh Institute of Nuclear Agriculture (BINA)** conducts research adopting nuclear techniques for the purpose of ensuring a stable and productive agriculture through the evolution of new varieties of crops, the scientific management of land and water, the development of appropriate technology to improve crop production and the development of methods for disease and insect management.

5. **Bangladesh Sugarcane Research Institute (BSRI)** conducts research to develop high yielding, high sugar, and disease and pest resistant sugarcane varieties.

6. **Soil Resources Development Institute (SRDI)**: its objectives are to make inventory soil and land resources and to investigate soil-related problems for agricultural research and development.

7. **Bangladesh Fisheries Research Institute (BFRI)** conducts research to enhance the growth of fisheries production through optimal utilization of inland, brackish and marine water bodies and to develop scientific policies relating to the development of technology and management of fish culture and fish capture.

8. **Bangladesh Livestock Research Institute (BLRI)** is entrusted to generate and adopt technologies to solve livestock problems at the national and farm levels and also to train-up scientists in the appropriate field of research. The mandate is to take care of the livestock problems of small holders through multi and inter-disciplinary and inter-institutional research.

9. **Bangladesh Forest Research Institute (BFRI)** conducts research to develop management practices to increase productivity of national forests and village groves and to convert wastelands and marginal lands to forestry and agro-forestry uses; to develop technologies for rational utilization of forest products; to generate technologies to conserve or restore environment balances through increases stocking densities of both rural and urban forests; and to transfer technology through extension services and other agencies to end users.

10. **Bangladesh Tea Research Institute (BTRI)** conducts research to increase yields and quality of tea by developing improved production technologies and high yielding tea clones.

[106] Drawn from http://www.barc.gov.bd/nars.php#Bangladesh%20Agricultural%20Research%20Institute

11. **Bangladesh Sericulture Research Institute (BSRI)**: conducts research to develop disease, drought and water logging resistant high yielding and nutritionally rich mulberry varieties for rearing of silkworms.

5.5 Social science and public policy research

Bangladesh Social Science Research Council (BSSRC)[107]: as with much Bangladeshi research, the main objective of the BSSRC is highly practical: "to provide policy and planning advice to the Government of Bangladesh in the field of social science research." There is a clear imperative to provide planners and policy-makers with the means to make use of the results of social science research. The research programme is broad-ranging; studies relate to such areas as public health, education, socio-economic change (for instance, as a result of the impact of environmental factors), resource management, the status of women and micro-economic issues such as the availability of credit.

Bangladesh Institute of Development Studies (BIDS)[108]: this conducts policy-oriented, multidisciplinary research on development issues facing Bangladesh and other developing countries; an important aim is to strengthen research-policy links to promote informed national policy-making. Its research is enabled through five divisions, covering agriculture and rural development; general economics; human resources development; industry and physical infrastructure; and population studies. BIDS publishes its own quarterly scholarly journal, *Bangladesh Development Studies*[109] , and also produces a wide range of publications, including project reports, working papers and research monographs. Unlike the other research organisations covered by this paper, BIDS provides some summary information on its website about its financing: in 2009, the Government provided a Research Endowment Fund of Tk.200m ($2.66m) to support its core institutional research. Some donor agencies and foundations also provide resources for its activities.

5.5.1 IT infrastructure

Bangladesh Research and Education Network (BdREN)[110]: this is a service set up in 2008 by the University Grants Committee and supported through the World Bank-funded Higher Education Quality Enhancement Project (see above), with the aim of "integrat[ing] Bangladesh universities into the globalized world of knowledge". The development of an ICT network, founded on a dark-fibre backbone, is intended to provide connectivity between Bangladeshi universities, public and private, allowing access to high end computing, simulation tools and datasets.

5.5.2 Universities

Bangladesh currently numbers 91 universities: 34 are public, 55 are private and the remaining two are international institutions.[111]

Public universities are autonomous institutions, but nevertheless state-owned and funded almost entirely by Government, to the tune of about 95%.[112] Education in this sector is thus highly subsidised, with students paying little more than a nominal fee. Of the six largest universities, with 15,000 or more students, all but one are public. Although they remain a

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[107] http://www.bssrcbd.org/

[108] http://www.bids.org.bd/

[109] http://www.bids.org.bd/BDS_intro.php

[110] http://www.bdren.net.bd/

[111] Information on the breakdown of universities is derived from Wikipedia (http://en.wikipedia.org/wiki/List_of_universities_in_Bangladesh) and the University Grants Commission (http://www.ugc.gov.bd/)

[112] Monem & Baniamim, op cit

relatively popular choice for students, notably because of the range of courses on offer, there are serious concerns about what is perceived as deterioration in the quality of their educational offering in recent years.[113]

Legislation[114] passed in 1992 allowed for the establishment of private universities. These have since proliferated, providing a more market-driven environment, with a tendency to run more courses in fewer numbers and that are jobs-oriented; they are funded essentially through tuition and other enrolment fees, and are therefore inaccessible to large sections of the population.[115] In spite of this, poor educational quality appears to be as much an issue for them as for institutions in the public sector.[116]

The two international universities form a small sub-category. Along with private universities, they do not receive state funding, but are supported by international foundations.

Annex A provides a full listing of all Bangladeshi universities, along with the date of their establishment, the number of students (undergraduate and postgraduate) where known, their location, their specialisation and their status. It is noteworthy that, of the 91 institutions, 29 are specialist; the table below gives a breakdown of their generalist/specialist offering

	Number of universities	Of which		
		Public	Private	International
Generalist	**62**	13	48	1
Science & technology	**8**	8	0	0
Engineering	**6**	5	1	0
Technology	**6**	0	5	1
Agriculture	**4**	4	0	0
Medical	**1**	1	0	0
Veterinary science	**1**	1	0	0
Textiles	**1**	1	0	0
Women's studies	**1**	0	1	0
Islamic studies	**1**	1	0	0
TOTAL	**91**	34	55	2

In all cases, little or no information is available on individual budgets and on universities' research specialisms, nor indeed on the number of researchers or research students. It is therefore difficult to ascertain the contribution that the university sector make to Bangladesh's research capacity, but it has historically been low, in both the public and private sectors. A short overview of the six largest institutions is provided below.

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[113] Monem & Baniamim, op cit

[114] Act nr 34 of 1992, to provide for the establishment of private universities – http://www.sai.uni-heidelberg.de/workgroups/bdlaw/1992-a34.htm

[115] *Private higher education in Bangladesh*, Mahmudul Alam, M Shamsul Haque & Syed Fahad Siddique, UNESCO and International Institute for Educational Planning, 2007 – http://www.unesco.org/iiep/PDF/pubs/Bangladesh.pdf

[116] Monem & Baniamim, op cit

University of Dhaka (public, 32,000 students – founded 1921) is not only the largest and oldest university, but also arguably Bangladesh's leading research institution, accounting for 18% of the country's publications.[117] The university runs 38 specialist research centres across the spectrum of disciplines, including the humanities. The curriculum is arranged within 13 faculties: arts, fine arts, social sciences, education, law, business studies, science, biological sciences, medicine, postgraduate medical sciences & research, pharmacy, engineering & technology, and earth & environmental sciences. The university is also responsible for 9 semi-autonomous institutes, which variously provide teaching and research facilities: education, business administration, statistics, social welfare, modern languages, health economics, nutrition & food Science, information technology and renewable energy.

Jagannath University (public, 25,000 students – founded 2005): although this institution acquired university status relatively recently, it was established as a college in 1908. It is spread across four faculties: arts, science, social science and business studies, each of which runs its own scholarly journal.

Rajshahi University (public, 25,000 students – founded 1953) is spread across nine faculties: arts, law, social science, business studies, science, life & earth science, engineering and agriculture. It also hosts five teaching and research institutes: the Institute of Bangladesh Studies, a notable national, interdisciplinary centre; the Institute of Business Administration; the Institute of Education Research; the Institute of Biological Science; and the Institute of Environmental Science.

University of Chittagong (public, 22,000 students – founded 1966) is made up of five faculties: art, law, business administration, social science and science. The university runs two specialist research centres: the Social Science Research Institute, and the Research Centre for Mathematical and Physical Science.

Stamford University Bangladesh (private, 18,000 students – founded 2002) is the largest private university in Bangladesh. Its name is somewhat misleading, as it bears no relation to Stanford University in California. The institution numbers 28 departments, a quarter of which are focused on biomedical sciences, particularly in applied fields.

Bangladesh Agricultural University (public, 15,580 students – founded 1961) is the largest specialist university in the country, and is clearly aimed at providing Bangladesh with a cadre of agriculturalists and agricultural scientists to meet national needs and modernise the agricultural infrastructure. Its six faculties (agriculture, veterinary science, animal husbandry, agricultural economics and rural sociology, agricultural engineering and technology, and fisheries) are supported by a network of ten experimental farms. The research effort at the university is driven and coordinated by BAURES, the Bangladesh Agricultural University Research System.

5.6 Subjects, disciplines and priorities

The subject and disciplinary breakdown of the research infrastructure is covered in sections 3 and 4 of this chapter. It is clear that agricultural science, in its different and often highly specialist forms, represents a major and well-established component of the national research landscape, as evidenced notably by the dominance of agriculture in the R&D component of the National Development Programme. This investment effort, which has been sustained since the 1980s, goes some way to explain the significant increases in agricultural productivity, and particularly food grain production, experienced by the country over this period.[118]

[117] Mahbuba & Rousseau, op cit

[118] Mahmud, op cit

In other disciplinary areas, the research infrastructure remains relatively weak and underdeveloped, with the notable exception of the internationally-funded International Centre for Diarrhoeal Disease Research. The national policy frameworks described in this document recognise this, and seek to boost research capacity in areas deemed of strategic importance, such as biotechnology – but a gap subsists between ambitious and laudable intentions, and the financial and human resources that Bangladesh is currently able to deploy.

5.7 Published outputs, 2000-2010

5.7.1 Analysis of SCOPUS database

The table at Annex 2 presents figures from the SCOPUS database, as at early September 2011. It shows the number of papers recorded in that database that were published in each of the years 2000 to 2010 which had at least one author affiliated to an institution in Bangladesh. Previous research in this area has used Web of Science data to explore bibliometrics in Bangladesh, but we have used SCOPUS to ensure consistency with the other countries in this study.[119] Where applicable, the comparable Web of Science data is shown, and any differences are discussed.

Panel 1 in the table shows that the number of such publications of any kind increased by 370% between 2000 and 2010, from 558 to 2066; and that the number of articles, reviews and conference papers increased by the same amount, from 544 to 2015. For comparison, it may be noted that the number of papers published with UK-based authors rose by 56% between 2000 and 2010, and for Swedish authors by 64%.

In order to examine whether this increase in productivity has been bought at the cost of a fall in citation impact, we looked at the average number of citations each paper received. Since citations are gathered over a period of years, earlier papers tend to have a higher number of citations than more recent papers. In order to mitigate this effect, we calculated the average number of citations per paper within four years after the year of publication.[120] The four-year measure is a crude one; but it does provide an element of consistency in measuring citation impact. It also provides for a rather longer period to gather citations than the standard two-year window used in calculating journal impact factors. The table shows that the average number of citations per paper rose fairly steadily between 2000 and 2005: since then, it has declined. The decline from 2007 can be explained by the four-year window that we are using to track citation rates, but the decline from 2005-2007 is less readily explained. Overall, citation rates are considerably lower than international comparators. The average number of citations by 2004 for articles from Bangladesh published in 2000 was 3.25, as compared with 10.5 for Sweden, for example.

The table also shows the H-index for all publications with an author from Bangladesh. The H-index is based on the highest number of papers included that have had at least the same number of citations, and is thus a measure of productivity as well as impact. As the table shows, it increased between 2000 and 2005, and then began to fall. This is not surprising, since newer papers have had less time to build up a significant number of citations.

Lastly, Panel 1 shows the number and the percentage of papers published each year which, by September 2011, had received no citations at all. This figure fluctuated until about 2005, at which point it began to rise steadily. The late rise can be explained by the fact that in each successive year there is a shorter time in which to gather the first citation: however, this does not explain the earlier fluctuation.

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[119] Mahbuba & Rousseau, op cit

[120] It is important to note that the citation half-life (that is, the number of years that a paper takes to receive half the number of citations it will eventually receive in total) varies across subjects; and that the SCOPUS database shows that Bangladeshi papers published in 2000 had received by 2004 only 29% of the citations they received in total by September 2011.

International collaboration is increasing in all countries, and the proportion of Bangladeshi publications with co-authors from outside Bangladesh has tended to rise, from around 40% in 2000 to around 51% in 2010. Mahbuba and Rousseau use Web of Science data to find that the USA was Bangladesh's chief collaborator between 2000 and 2007, followed by Japan, the UK and India. Panel 9, however, based upon SCOPUS data, suggests that Japan was the top collaborator, followed by the US, the UK and India. This lends credence to the thesis, advanced by Mahbuba and Rousseau, that geographical proximity is an important determinant of collaboration. This is supported by relatively high levels of collaboration with Malaysia, Thailand, China, Pakistan and Nepal, all of which are in Bangladesh's top 20. Panel 9 also shows that the top four collaborators for Bangladesh do not change if we shift the focus to 2000 to 2010.

In order to understand the specific dynamics within the Bangladeshi research sector, Panel 2 isolates the papers that have been published without collaborators outside Bangladesh. The growth in numbers of such publications between 2000 and 2010 was slightly lower than for all papers, at 300%. Citation rates for papers with exclusively Bangladeshi authors hover between a third and a half of those for all papers, and the H-index for such papers is rarely more than half of that for all papers.

Panels 3 and 4 show the figures for publications in medicine, immunology and microbiology. The growth in productivity here between 2000 and 2010 is lower than the growth for all papers, at 274%. As a result, articles in this discipline now account for around a quarter of all publications, whereas in 2000 they accounted for a third. The average number of citations in the four-year window is consistently higher than for all publications, but remains low compared to countries such as Sweden (where the average for papers published in 2000 was 13.3) and Canada (where the average for papers published in 2000 was 14.2). In Bangladesh, the figure was 5.41.

As with the figures for all publications, Panel 4 shows that publications with no authors from outside Bangladesh have much lower rates of citation, much lower H-indexes and a much higher proportion of papers with no citations.

Panels 5 and 6 show the figures for publications in agriculture and biology. Here, growth has been roughly in line with growth in all papers at 348%; agriculture and biology publications comprise around a fifth of all publications in both 2000 and 2010. Citation rates are lower than in medicine, both for papers with and papers without non-Bangladeshi authors, although the difference narrows for papers without non-Bangladeshi authors.

Finally, Panels 7 and 8 show the figures for publications in social science, economics and business studies. Here the growth has been slightly higher, at 419% between 2000 and 2010, albeit from a low base. Such papers constituted 9% of all papers in 2000, and 11% in 2010. Compared with all papers, social science papers have a similar, or slightly lower, citation rate.

5.8 Conclusions

Research activity in Bangladesh has for long focused on the biosciences, with a particular emphasis on agriculture and the related biosciences, and medicine. The large number of research institutes devoted to agricultural research attest to the importance attached to research in this area, although the number of peer-reviewed research papers produced is not particularly high (438 in 2010, just over a fifth of all the papers published by Bangladeshi authors). There has been a steady increase in research outputs over the past ten years, although not at the same rate as has been achieved in Pakistan. It is notable also that a much higher proportion of research outputs (just over half) than in Pakistan are co-authored with researchers from other countries. Such international collaboration is clearly sensible when one of the acknowledged priorities is to build research capacity.

Outside the areas where international collaboration is well-entrenched – as in the work of the ICDDR,B) – the research base is not as strong as in Pakistan. The National Science and Technology Policy is ambitious in seeking to promote research beyond the well-established

areas; to develop capacity in science and technology as a foundation for national development; and to shift beyond the ‘basic needs’ agenda. The emphasis on building infrastructure and capacity in areas such as biotechnology is one example of this shift. A key challenge will be to secure the funds to support major growth in science and technology: the call in the current Five-Year Plan for an increase in expenditure on R&D from 0.6% to 1.0% of GDP will not be easy to achieve.