

Mapping research systems in developing countries

Country report: The Science and Technology system of Ghana



Published with the support
of the UNESCO Forum for
Higher Education, Research and Knowledge

Project Leaders:

CREST: Centre for Research on Science and Technology,
University of Stellenbosch, South Africa



IRD: Institute for Research on Development,
France



Table of Contents

Section 1: The political environment.....	1
Section 2: Country characteristics.....	2
2.1 Basic economic outlook.....	2
2.2 Demographic and health characteristics	4
2.4 Education	5
2.5 ICT infrastructure	6
Section 3: Science and technology system	6
3.1 Governance of science and technology.....	7
3.2 Science and technology landscape.....	12
3.3 Human capital for S&T.....	15
3.4 Financial resources (funding).....	25
3.5 Research outputs	30
3.6 Technological innovation.....	30
3.7 International co-operation and networks	35
3.8 Conclusion.....	37
4. References.....	39
Appendix A: Evolution of selected research institutes in Ghana	40
Appendix B: Summary of major policies driving research and institutional programmes	41
Appendix C: Summary of functions of S&T agencies.....	42
Appendix D: Public universities and key faculties in Ghana	43

THE REPUBLIC OF GHANA

Frank Teng-Zeng

Postdoctoral researcher, Centre for Research on Science and Technology, University of Stellenbosch, South Africa

Introduction

This report looks at the science, technology and innovation system of the Republic of Ghana. It is structured in three main parts. Section 1 briefly deals with the national political environment; Section 2 looks at the key country characteristics including the economic, demographic and health, education and information and communication technology infrastructure. Finally, Section 3, which forms the main part of the report, gives an overview and analysis of the science and technology system. This section is subdivided into seven thematic subsections covering the governance of science and technology, science and technology landscape, S&T human resources, funding, research outputs, technological innovation and lastly international co-operation and networks activities.



Section 1: The political environment

Ghana was the first of the colonial territories in Sub-Saharan Africa (SSA) that achieved political independence from the British Colonial Rule on the 6th of March 1957. It also became a Republic on the 1st of July 1960. Ghana is a constitutional democratic state that is divided into ten administrative regions with a unitary system of government and national administrative capital in Accra. The early years of Ghana's political independence was characterised by political stability through multi-party system but later drifted towards a de facto one-party system due to the dominance of the Convention Peoples Party (CPP) that led the country at independence. However, the first military coup d'état overthrew the Government led by the first President Dr Kwame Nkrumah on the 24th of February 1966. Although there were two successful multi-party elections in 1969 and 1979, each of the elected government were overthrown by the military. The last and the longest of the military regimes was the Provisional National Defence Council (PNDC) (31st December 1981-1992) by former President John Rawlings. The PNDC later became a political party- the National Democratic Congress (NDC) in 1992 and won the general election in that year under the leadership of former President John Rawlings. The PNDC ushered in a new democratic, multiparty, and a unitary system of government within a parliamentary constituency system under the 4th Republican Constitution since 1992. The ensuing democratic changes also made Ghana to become the first country in Africa where political power was successfully transferred from a ruling party (NDC) to an opposition (New Patriotic Party- NPP) following a peaceful national general elections in December 2000. One of their key developments was the establishment of the Commission on Human Rights and Administrative Justice (CHRAJ) with complete constitutional guarantees for its independence.

Ghana was one of the first of countries to sign up for the African Peer Review Mechanism (APRM), an initiative under the New Partnership for Africa's Development (NEPAD) and African Union (AU). The Ghana APRM Country report was the first to be completed and submitted to the Heads of States and Governments at the African Union meeting in June 2006. The current president is John Evans Atta Mills of the NDC elected on the 2nd of January 2009.

Section 2: Country characteristics

2.1 *Basic economic outlook*

Ghana's economy is natural resource-based. Its main export earners include commodities such as cocoa, gold and timber. Mining companies made huge investments in Ghana and it is Africa's second-biggest exporter of gold, after South Africa. Ghana is the world's second highest producer of cocoa. Although the agricultural sector is still very important, the contribution of agriculture to the country's gross domestic product (GDP) has been falling since 2001. The agricultural sector's contribution to GDP fell from about 40% in 2001 to 37% in 2005. Meanwhile the 2006 Budget Statement showed that the agricultural industry's percentage contribution to overall growth has been declining, falling from about 26% in 2002 to 24% in 2003 and then to 22.1% in 2004. While the level of employment in the agricultural sector dropped to 57% in 2005 compared to 58% in 2003 and 60% in 2001, however, the Sector continued to employ most Ghanaians.

In terms of overall economic growth rate, the Ghanaian economy had grown consistently in recent years with a GDP growth rate of 3.7% in 2000 to 6.3% in 2008 following a recovery period in the 1980s. National inflation rate has decreased from a high of 40.5% in 2000 to 16.4% in 2008. The local currency is known as the cedi (US\$ / Cedi - current exchange rate) 1. Both the new Ghana Poverty Reduction Strategy (GPRS I 2003-05) and the Growth and Poverty Reduction Strategy (GPRS II 2006-09) are aimed at making Ghana a middle income country with a per capita income of over US\$1000 by 2015 (i.e. Vision 2015). It envisioned within a decentralised and democratic environment (NDPC, 2005) as well as achieving the objectives and targets of the Millennium Development Goals (MDGs) and that of NEPAD.

In terms of general economic policy reforms, Ghana was one of the first developing countries to adopt the Structural Adjustment Programme (SAP) supported by World Bank and the International Money Fund (IMF) and for some time was hailed as an economic success story under these programmes in the 1980s. Despite some of the successes, the country's external debt grew which prompted the current government to adopt the Heavily Indebted Poor Country (HIPC) introduced by the Bretton Woods twins (World Bank and IMF) by introducing a new economic policy under GPRS I and GPRS II respectively.²

The World Bank announced that it has started cancelling Ghana's International Development Association (IDA) debt under the Multilateral Debt Relief Initiative (MDRI) in 2006. The process,

¹ As part of the economic recovery programme introduced under the World Bank/IMF Structural Adjustment Programme, the previous government devalued the Ghanaian cedi in the 1980s. However, the present government announced in late 2006 that the national currency will be re-denominated and will take effect from July 2007. This will also affect the value of current exchange rate to the US dollar. The current exchange rate is US\$1 = c8871.14-9604

² Like the adoption of SAP, the induction into HIPC is also seen as success story so far, but concern is whether it will not also lead to a new unsustainable external debt in the near future.

which started on 1 July 2006, will see Ghana receiving \$4.429 billion total debt relief (Ghanaweb Business News, 7 July 2006). In addition, an amount of \$547 million was allocated to Ghana as part of the US Government Millennium Challenge Account (MCA) programme to be spread over a period of five years. The overall economic rate of return of the MCA Ghana Compact is estimated at 20% (MCC 2006a; MCC 2006b; MCC Ghana Compact 2006c). Multilateral debt relief and bilateral aid donor supports continue to be a critical element of the country's socio-economic development and transformation strategies.

Tables 1 and 2 illustrate some selected basic economic data and competitiveness ranking of Ghana in Africa. Since the publication of the first African Competitiveness Report in 1998, the overall competitiveness ranking of Ghana has slipped from 9th to 10th position. Tanzania ranked 16th in the first competitiveness report replaced Ghana in the last report in 2004. The poor performance of the industrial sector in agro-processing and agricultural modernisation remains a challenge (refer to Section 3).

Table 1: Ghana Selected Basic Economic Data

Category	1997	1998	1999	2000	2001	2002	2003	2004	2005	2007	2008
Gross domestic product, real (US \$ million, constant 2000 prices)	4391	4597	4800	4978	5187	5420	5702				
Gross domestic product Growth Rate (%)	4.2	4.7	4.4	3.7	4.2	4.5	5.2	5.8	5.9	6.1	6.3
Net aid from all donors, Real (US\$ millions, constant 2002 prices)	277	365	337	372	408	406	421				
Net aid from all donors as share of recipient GDP (%)	7.2	9.4	7.9	12.1	12.1	10.5	12.1				
National Inflation Rate (%)				40.5	21.3	15.2	23.6	11.8	14.8		16.4

Source: Compiled CREST

Table 2: Changes in Ghana Competitiveness Ranking in Africa, 2004

Country	2004 Rank (out of 25)	2004 Score	2000 Rank (out of 24)	Rank changes 2000-2004
Botswana	1	4.56	3	+2
Tunisia	2	4.49	1	-1
South Africa	3	4.37	7	+4
Mauritius	4	4.12	2	-2
Namibia	5	3.99	4	-1
Gambia	6	3.93	n/a	n/a
Egypt	7	3.84	6	-1
Morocco	8	3.77	5	-3
Tanzania	9	3.49	14	+5
Ghana	10	3.46	9	-1

Source: Own compilation from WEF Africa Competitiveness Reports 2000 and 2004.

2.2 Demographic and health characteristics

Ghana's population at the last national census was estimated at 18.9 million in 2000 but the current estimate for 2009 is 23.8 million (GSS, 2005 and CIA The World Factbook, 2009). Use of maternal care is almost universal but only 44% of all births take place with skilled attendants. With HIV/AIDS prevalence at 3.1% among those of reproductive age, the government has adopted a multi-sectoral approach to control the pandemic (UNFPA& PRB, 2006). There has been a significant increase (32.6%) in the number of hospitals, from 251 hospitals in 1991 to 333 in 2001. While the number health centres also increased significantly from 1,138 in 1991 to 1693 in 2001 with a national population per facility at 11, 289 in 2001 (GSS, 2005b:77). The total health manpower fell by 5.5% from 15,379 in 1996 to 14,527 in 1999 before increasing to 16838 in 2001(GSS, 2005b:69).

However, a major challenge facing the public health system is the training and retention of health professionals with brain drain as one of the key issues.³ For example, between January 2002 and December 2005, a total of 3,126 nurses and midwives sought verification from the Council. The year 2003 recorded 923 cases and the highest number of verification before dropping to 786 the following year. In 2005, 686 nurses and midwives sought verification from the Council. Table 3 below shows a list of selected demographic characteristics and public health work force.

³ Ghana currently has 3 medical schools with an ongoing process to establish a 4th school.

Table 3: Selected Demographic and Health Characteristics

Indicator	Source Year	Estimate	Sources for the estimation
Demographic data			
Total population (millions)	2009	23.8	CIA The World Factbook
Population aged 15-49 (thousands)	2004	10697	APRM report
Annual population growth (%)	2009	1.9	CIA The World Factbook
Percentage of urban population	2008	50	CIA The World Factbook
Crude birth rate (per 1,000 population)	2009	28.58	CIA The World Factbook
Life expectancy at birth (years)	2009	59.85	CIA The World Factbook
Total fertility rate	2003	3.68	CIA The World Factbook
Infant mortality rate (per 1000 live births)	2009	51.09	CIA The World Factbook
Adults with HIV/AIDS (%) ⁴	2007	1.9	CIA The World Factbook
Health			
Doctors	2004	3240	World Health Report 2006
Dental Surgeons	2004	393	World Health Report 2006
Professional Nurses	2004	19707	World Health Report 2006
Midwives	2002	2568	Ecogas Economics and Social Statistics
Pharmacist	2002	296	Ecogas, Economics and Social Statistics

2.4 Education

Ghana's system of education has undergone several stages of restructuring over the past 25 years. The most dramatic change entailed phasing out the O-level and A-level system based on the British model and introducing a new Senior Secondary School system in the late 1980s designed to increase access to Ghana's educational system.⁵ Following the reforms, student enrolments in all the levels of education has increased significantly due expansion of access to educational facilities in recent years. In general, enrolment at the primary level is estimated at 3.28 million with a total gross enrolment ratio (GER) of 92.1% in 2005/06 up from 87.5% in 2004/05 and 86.1 in 2003/04 respectively. Male GER was 95.3% while that for females was 88.8%. Gender Parity Index (GPI) was

⁴ Figure represent national HIV/AIDS prevalent rate.

⁵ New educational system is being introduced again in 2007, which will increase the years spent at Senior High School.

0.95 at the primary level in 2005/06. At the Junior Secondary School level, total enrolment was 1.12 million with a total GER of 74.7, with males registering GER of 76% and females 68.7%. The GPI at this level was 0.94. Enrolment at the public university system has increased over 150% intake within the last 5 years. For example in September 2000, enrolment for the University of Ghana was 10,000 students and increased to 28,000 in 2005/06 (GoG, 2005). The literacy rates for the urban and rural areas in 2003 is estimate at 69.9% and 40.1% respectively (and combined national average of 57.9% in 2004 for 15 years and above). About 3.1% of the total population has tertiary level qualifications.

2.5 *ICT infrastructure*

Ghana was one of the first countries in Sub-Saharan Africa to undertake a programme of liberalization in the telecommunications sector in the 1990s, first through the five-year accelerated development programme (ADP) introduced in 1994. The implementation of the ADP led to the establishment of the National Communications Authority (NCA) in 1996, which oversaw the partial privation of Ghana Telecoms through the sale of 30% of its shares to G-Com Limited, a consortium led by Telekom Malaysia in 1997 (Frempong, 2005). The Information Communication Technology (ICT) industry in Ghana is one of the fastest growing on the African continent with significant improvements, particularly over the past five years. The capital inflows into the telecommunication industry by the end of 2005 was well over ₵3 trillion compared to ₵2.9 trillion in 2004 and 2.4 trillion in 2003 (Coomson, 2006). The telecom sector contributed 5.3 % of Gross Domestic Product (GDP) in 2004 (up from 1.8% in 2000).⁶ The resulted capital inflow led to an improvement in overall telephone penetration.

According to Oquaye (2007) "At the end of the year 2000, the total number of telephone subscribers in Ghana was 218,000. As at end of 2006, the number had risen to 5,428,000 subscribers representing 27.2 teledensity" (cited Ghanaweb.com, 23 February 2007). About 3.8 million of the telephone subscribers were mobile phone users in June 2006 (GoG, 2006). Benjamin Ntim, the deputy Minister of Communications, the aim of the ministry is to see all schools develop ICT and to get the tele-density to 50% by 2015 and internet access to 25% of the population, which is close to the 25% target of the Millennium Development Goals (MDGs) for Ghana. The telecommunication penetration is currently 20.7% and it was projected to reach 30% by 2007.

Section 3: Science and technology system

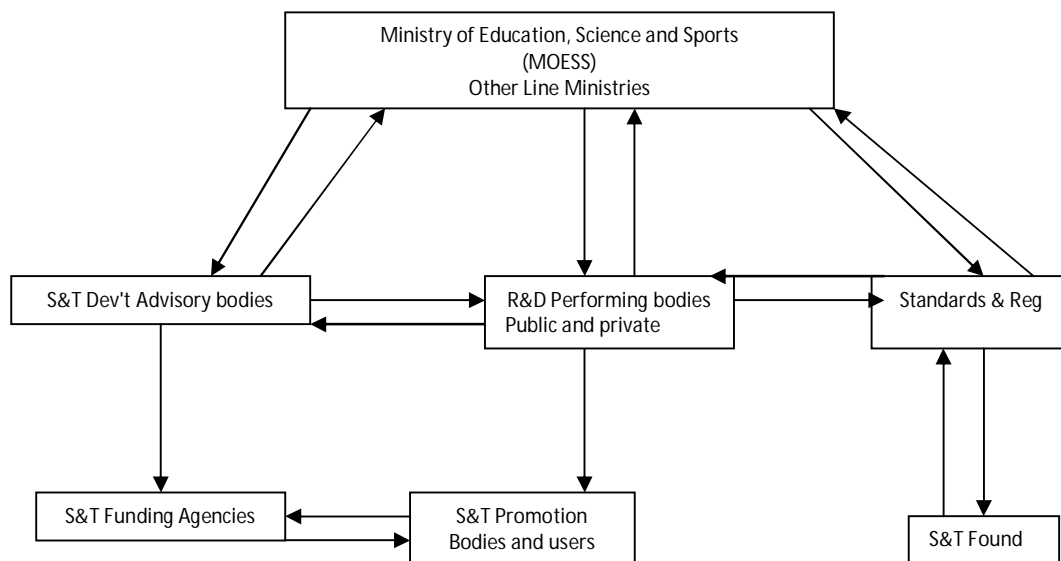
When Ghana gained her independence in 1957, there was no dedicated ministry for science and technology and no policy to help with the institutionalization of science and co-ordination of scientific activities. Soon after independence, some conscious attempts were made to organize, plan and to 'pursue science and technology development as a major instrumental component of overall national economic and social development' (UNESCO, 1986). Indeed, the first seven-year development plan formulated by Ghana in the 1960s firmly placed science and technology as central to the country's development efforts (personal interview with Ayensu, 2006). For instance, the Seven-Year Plan among others laid greater emphasis on the modernisation of the country's agriculture and on rapid expansion of industrial activity, with the educational system geared to meet the needs of all key sectors of the economy (see Ghana Planning Commission, 1964). However, the optimism in the early 1960s soon gave way to despair due to the political interference by the military in political governance and poor economic performance up to the early 1980s. Nevertheless, there is still political interest in creating scientific and technological institutions to promote socio-

6 \$40m for Implementation of ICT Program at <http://www.ghanaweb.com>, general news, 3 August 2006; accessed 4/8/2006

economic development even though these institutions were not and are still not given adequate financial resources for them to carry out their prescribed mandates. Recent economic and social development documents namely the Ghana Vision 2020 and the revised Ghana Growth and Poverty Reduction Strategy I & II identify the need to apply modern science and technology in country's development efforts. This section looks at the overall science and technology system in Ghana.

3.1 Governance of science and technology

Figure 1: Ghana Science and Technology System



Source: Compiled by author

Although colonialism and the colonial administrations did very little to promote scientific and technological development in the colonies particularly in Africa⁷, they nevertheless, bequeathed some institutions to the newly independent states. These institutions were either 'national' research institutions or regional research institutions serving a number of colonial territories for example, in the case of British Colonial African territories. After independence, the headquarters of these institutions were turned into national ones. The institutions that were established in the Gold Coast (now Ghana) became the basis for scientific research and were mostly in the agricultural and plant sciences. The first of these research stations was the Aburi Agricultural Station, which was established in 1890 (see Appendix A).

These early stations helped in a varied way to identify plant types and knowledge about some pests and plant diseases.⁸ The structures of these research stations laid down part of the foundation for the development and institutionalisation of modern science and technology on Ghana's attainment of independence in March 1957. For example, following the dissolution of the West African Regional Association in 1962, the Ghanaian government took over WACRI and renamed it the Cocoa Research

⁷ Forje, JW (1989) *Science and Technology in Africa*. Essex: Longman Group.

⁸ Yudelman, M, "Imperialism transfer of agricultural techniques" in Duignan, P and Gann LH (ed.) *Colonialism in Africa 1870-1960*. Volume 4 of *The Economics of Colonialism* (Cambridge University Press, New York, 1975), pp. 329-359.

Institute of Ghana (CRIG). CRIG has since then been responsible for improving the production of cocoa through its research activities in Ghana.⁹ Figure 1 provides the organisational structure of the Ghana science system.

3.1.1 Ministry of Education, Science and Sports (MOESS)

The domain of science and technology covers different fields of knowledge and no single line ministry can adequately promote scientific and technological development. However, one important trend that was emerging from most developing countries during the 1970s and 1980s was the establishment of a substantive Ministry of Science and Technology and for formulating science and technology policies and identifying national research and development priorities. For instance, when Ghana gained her independence in 1957, there was no substantive ministry for science and technology and no policy to help with the institutionalization of science and co-ordination of scientific activities. This led to the promulgation of the Research Act of 1958 (No. 21) and the actual establishment of the National Research Council (NRC) which became effective from 14 February 1959. The NRC was to promote and co-ordinate all aspects of research including the application of research results in Ghana (UNESCO, 1986:41). This made Ghana and Egypt the pioneers in independent Africa to incorporate science and technology into their national development plans.¹⁰ However, the establishment of the Ministry of Industries, Science and Technology (MIST) in September 1979, was an important boost to the institutionalization of S&T; in particular bringing the Council for Scientific and Industrial Research (CSIR), which was under the Ministry of Finance and Economic Planning, to that of MIST (Enos, 1994). The Ministry of Industries, Science and Technology was renamed Ministry of Environment, Science and Technology (MEST) in 1990s.

However, since the change of government at the beginning of 2001 there has been reorganisation of various ministries with the MEST becoming Ministry of Environment and Science (MES) before being dissolved completely in April 2006. The Ministry of Education and Sport now assumes the responsibility for Science and hence it's new name the Ministry of Education, Science and Sports (MOESS). The confusion in the institutional governance structure as far science and technology line ministry is concerned has been very uncertain and for most observers the current government does not give priority to science and technology to promote socio-economic development and transformation as it made to believe. Indeed the frequency of changing the names of ministries and reassigning research-performing institutes under different ministries repeatedly has been very disruptive to a proper governance system.

In policy terms during the 1990s, the Government of Ghana adopted Ghana-Vision 2020, aimed at making Ghana a middle-income country by the year 2020. The Government published the first medium-term development plan based on what it calls *Ghana-Vision 2020 (The First Step: 1996-2000)*, in which S&T fell under the heading of 'Enabling environment' and formally formulated a draft National Science and Technology Policy in 2000. The vision of the new national S&T Policy is "to support national socio-economic development goals with a view to lifting Ghana to a middle income status by the year 2020 through the perpetuation of science and technology culture at all the levels of society, which is driven by the promotion of innovation and mastery of known and proven technologies and their application in industry, and other sectors of the economy" (MEST, 2000:4). Therefore, the new national S&T policy will "put innovation above all else, and revere it to serve as

⁹ See for example Enos, J L, In *Pursue of science and technology in Sub-Saharan Africa* (Routledge, London, 1995), p. 63.

¹⁰ This however, may exclude South Africa, which has a long-standing scientific research experience in Africa in the modern era.

the critical force in national development. Science and technology innovation when properly nurtured will enhance the local capacity for developing environmentally-sound technologies and for selecting, acquiring, adapting and absorbing imported technologies appropriate to national needs, priorities and resources". (MEST, 2000:3).¹¹

At present MOESS is in the process of finalising a Strategic Plan for Science and Technology Development and Usage to derive the implementation of major Government programmes such as the GPRS II. This process was scheduled for possible completion in 2007 (GoG, 2006b).

3.1.2 *Other Line Ministries*

The crosscutting nature of science and technology means that for proper co-operation and co-ordination, the substantive ministry will work in co-operation with other important line ministries performing different but related S&T functions. These include the Ministry of Food and Agriculture (MOFA); the Ministry of Communications, Ministry of Health and Ministry of Energy and most importantly the Ministry of Finance and Economic Planning as well as Ministry of Trade, Industry & Special Presidential Initiatives (MOTIPSI). For example, the key Statutory Bodies, Departments and Agencies of the Ministry of Communications include: Ghana Post, National Communications Authority, Meteorological Service Agency, Ghana-India Kofi Annan ICT Centre of Excellence, Postal and Courier Services Regulatory Commission, Ghana Investment Fund for Telecommunications (GIFTEL), and Ghana Information Communication Technology Directorate (GICTeD) and all major Telecom Service Providers. To enhance the country's development, the ministry has formulated the Information and Communications Technology Policy for Accelerated Development (ICT4D) in Ghana in 2003, which aims at applying ICT in all sectors of development and making Ghana the ICT Hub in the West African sub-region. The Ministry is in the process of finalising its strategic plan. Therefore, proper functioning and co-operation between MOESS and the communication ministry cannot be over-emphasised, especially in the area of ICT infrastructure provisions in the higher education sector and research institutes as well as in industry.

The Ministry of Health (MoH) has specific mandate to access and monitor the country's health status, advise central government on health policies and legislation, formulate strategies and design programmes to address health problems of the country, and implement, monitor and evaluate (in collaboration with other related sectors and agencies) all health programmes and activities in the country. It has as its objectives to addressing issues of inequalities between and within regions and districts emergency care, diseases eradication, elimination, financing policy and health insurance, chemotherapy and HIV/AIDS and quality care. The Ministry has identified seven priority areas, which include HIV/AIDS and sexually transmitted Diseases, Malaria, Guinea Worm, Tuberculosis, Reproductive and Child Health, Expanded Programme of Immunisation, and Emergency care (<http://www.ghana.gov.gh/governing/ministries/social/health.ph>). MoH finalised a draft Ghana Health Sector Policy in 2006.

3.1.3 *Science and technology priorities*

Ghana's current development policy is crafted within the framework of GPRS I&II. In 2005, the government redirected its five priorities into a three-pronged priorities including human resource development, Private Sector Development and continued Good Governance. Within the context of

¹¹ Following the change of government after the December 2000 elections, the new government changed the name of Ministry of Environment, Science and Technology (MEST) to that of Ministry of Environment and Science, moving technology into a new Ministry of Communication and Technology in 2001.

GPRS II (2006-2009), it is stated that the major goal of National Science and Technology Policy is to establish an efficient research system, which contributes to national development objectives. Promotion of science and technology culture at all levels of society and the mastering of known and mature technologies and their application in agriculture and industry will accelerate economic growth and social transformation. Science and technology policy objective will therefore be to promote the adoption of appropriate technologies, both local and foreign, with the capacity to improve productivity and efficiency in the agricultural, industrial and services sectors especially for micro, small and medium rural enterprises; promote research and development in all sectors of the economy; build relevant linkages between research and production to ensure that research outputs are utilised; provide institutional and regulatory framework to promote the development of science and technology (NDPC GPRS II 2005:37).

In line with the Ghana Science and Technology Policy Document of 2000 and the GPRS I& II several areas scientific and technological development can be identified in Ghana's research and innovation system. Some sectoral policies and strategies have or are being developed for some of these research fields including: Information and Communication Technology (ICT), food and agriculture, biotechnology, health, nuclear research and energy. Appendix B provides a summary of major policies driving research and institutional programmes.

3.1.3.1 Biotechnology

In an interview in July 2006, the Director-General of CSIR, Professor Emmanuel Owusu-Bennoah indicated that the Government has provided equipment to two research institutes of the Council for Scientific and Industrial Research (CSIR) worth 7.6 billion cedis to enable them to undertake research into biotechnology. The Animal Research Institute in Accra would serve the research institutes in the southern sector while the Crop Research Institute based in Kumasi would serve the institutes in the northern sector. The facilities in the southern sector would be used to build capacity in the livestock industry to enable Ghana to achieve sustained growth in meat and dairy products and the production of vaccines, while the northern sector facilities would assist in the development of research and capacity building geared towards the improvement in crop yields and disease resistant crops (Ghanaweb, 12 July 2006).

3.1.3.2 Information and Communication Technology (ICT)

Ghana is positioning itself as the ICT Hub in the West African sub-region and therefore foreign investment and regional programmes are important. The country is directly connected to the World's First Undersea Optic Fibre Cable System around Africa to Europe and Asia, the "SAT3/WASC/SAFE" (South Atlantic Telecommunications Cable No. 3 / West African Submarine Cable / South Africa Far East) completed and inaugurated as part of the NEPAD framework of infrastructural development in May 2002. Recently, Microsoft selected Ghana as its hub for West Africa because of the country's improved infrastructure for Information and Communications Technology (ICT), while Nokia has established an ultra modern facility in Accra, to service and repair Nokia cell phones in the country. The United Nations is to assist Ghana to establish a science and technology park at the Kwame Nkrumah University of Science and Technology to support the country in its efforts to develop and test software and hardware components locally. The UN selected Ghana in 2005 for the project under its "International Partnerships on New and Emerging Technologies for Sustainable Development" to assist the country to develop and test IT programmes for use by the local industries such as the banks. While under the Micro Small and Medium Enterprises (MSME) project, the World Bank has approved US\$40 million funding towards the

construction of an ICT Park at the Free Zone Enclave in Tema to support industrial growth and technology development especially of ICT and innovation¹².

All the above initiatives fall in line with the Ghana Information and Communications Technology Policy for Accelerated Development formulated in 2003 which aims at applying ICT in all sectors of development and making Ghana a Regional Business and ICT Hub in the West African sub-region. The overall objective of the ICT4D is to engineer an ICT-led socio-economic development process with the potential to transform Ghana into a middle income, information-rich, knowledge-based and technology-driven economy and society (GoG, 2003). This policy has been adopted into Ghana's Growth and Poverty Reduction Strategy II (GPRS II).¹³

In 2004, the Ghana Investment Fund for Telecommunications (GIFTEL) was created and the fund started operation in January 2005 to facilitate partial investment funding to companies and entrepreneurs willing to implement eligible Universal Access Telecommunication projects in under-served and un-served areas. In April 2006, the US Securities and Exchange Commission sanctioned Ghana Telecom (GT) (the country's biggest telecommunications company), to proceed with its \$40 million bond issue. The country's leading stockbrokers, Databank Financial Services, raised \$40 million (around ₵275 billion) for GT, it was the first time that a Ghanaian company had successfully gone to the international market to raise money through bonds.

The Government of Ghana (GoG) and the United Nations Development Programme (UNDP) have started the establishment of community-based information centres around the country that would offer training in ICT to people in the rural areas. The centres know as "Community Information Centres" (CIC), are being established through the Ministry of Communications with assistance from software giants Microsoft to afford the rural folk a quick and easy access to the internet at the district level. Ghana Multimedia Incubator Centre (GMIC), another project being assisted by the UNDP.

Furthermore, at the formal inauguration of the Ghana Telecom University Council (GTUC) on 16 August 2006, President Kufuor argued that telecommunication was one of the fastest growing industries everywhere in the world, and government was establishing an open system fibre optic cable across the country. President Kufuor announced that a concessionary facility of US\$30 million has been granted by the government of China to support the first phase of the project for extension of the country's ICT backbone. He added that in the current spirit of modern technology and regional integration, plans were underway to ensure that newly established Ghana Telecom University College (GTUC) was developed into a centre for Education and Technology in Africa. The government was negotiating for an additional 70 million dollars from the Chinese government for the second phase of the national communications backbone infrastructure network to provide open access broadband connectivity nationwide (Ghanaweb.com, 23 February 2007).

¹² \$40m for Implementation of ICT Program at <http://www.ghanaweb.com>, general news, 3 August 2006; accessed 4/8/2006

¹³ "Ghana and the World Bank sign 55 million dollars grant agreement" (Ghanaweb business news 25 August 2006). The IFA-FTI is a fund basket of 11 million dollars, with various components to improve on teacher training, recruitment and deployment to deprived areas through provision of teacher accommodation, vehicles, motorbikes and bicycles.

Scancom, operators of Areeba, has reaffirmed its target of upgrading its switching centres to cater for their over three million subscribers in Ghana by contracting a total investment of US\$70 million. The expansion programme, which is to be completed by October 2006, is divided into two phases. The contract, which was signed in February 2006, included the construction of four MSCs, four BSCs, 230 new sites and the expansion of 120 sites. Among the USD\$70 million is the USD\$40 million loan contracted from International Financial Corporation. Meanwhile the MTN Group from South Africa has taken over Areeba, Ghana's biggest mobile operator July 2006. MTN announced that it has invested about \$150 million since the take over.

3.1.3.3 Health Research

Within the health sector, the Ministry of Health has identified seven priority areas. These are HIV/AIDS and sexually transmitted Diseases, Malaria, Guinea Worm, Tuberculosis, Reproductive and Child Health, Expanded Programme of Immunisation, and Emergency care.

To promote research within Teaching Hospitals, the Komfo Anokye Teaching Hospital (KATH), one of the two major hospitals in the country has set up a Research and Development Unit to encourage and co-ordinate research at the hospital. According to Anthony Nsiah-Asare (2006), they have made available 490 million cedis to support research by members of staff of the hospital in 2006. Nsiah-Asare indicated the objective of the initiative was to help create and nurture an enduring research culture at the hospital. Since this will enhance the capacity of staff to devise effective local solutions to local health problems through evidence-based care.

3.1.3.4 Nuclear Science and technology

The non-military applications nuclear science and technology in various sectors of the economy is a key aspect of Ghana's development efforts. Applications of these technologies in agriculture and health have been undertaken but a new area currently under consideration is energy sector applications in the wake of the on-going energy power crisis in the country. Post-graduate training programme in Nuclear and Allied Sciences has been initiated.

3.2 Science and technology landscape

3.2.1 S&T Agencies

There are different agencies operating in Ghana with some of them performing both advisory and research functions. These agencies include the Ghana Atomic Energy Commission (GAEC), Ghana Academy of Arts and Sciences (GAAS), Council for Scientific and Industrial Research (CSIR) and the National Council on Tertiary Education (NCTE), as well as the National Development Planning Commission (NDPC) and the Environmental Protection Agency and Ghana Standards Board. (See Appendix C for the details).

3.2.2 R&D Performing Institutes

The R&D performing institutions in Ghana may be categorized into the higher education sector institutions, public sector research and technology institutes as well as private sector research institutes. However, the private sector still performs limited research. The discussion below deals with the first two sectors only.

3.2.2.1 *Higher Education Sector*

Higher education in Ghana is provided by universities, university colleges, polytechnics and pre-service training institutes. All institutions of higher education fall under the jurisdiction of the National Council for Tertiary Education, which is administered by the Ministry of Education, Science and Sports.

At the time of independence, Ghana had only one University College (now the University of Ghana, Legon) which was created by the British Colonial Administration in 1948, and was affiliated to University of London in the UK. Following independence and the Subsequent gaining of republican status, the Government created three independent universities in the early 1960s. However, it was not until the early 1990s when new universities and university colleges were created due to the growing demand for higher education training and research. The university colleges were made fully-fledged universities. Today there are six public universities and one University college in Ghana that offers various diploma and degree programmes including science, technology and engineering related fields. All the universities have science, agriculture and engineering related field with medicine offered at UG, KNUST and UDS. However, UCC is in the process of establishing a faculty of medicine and has request the government for approval and support. The last two universities created and which are industry and field specific University of Mines and Technology at Tarkwa (2004/2005) and the Ghana Telecom University College, Accra (2006/2007).

Besides the seven public universities, there are 10 polytechnics, one in each of the ten Regional Administrative Regions across the country that offer certificate and Higher National Diploma (HND) programmes in the fields of science, engineering, commerce and management. These polytechnics are currently being upgraded and will soon be able to offer university-level degree courses after necessary legislation was passed in March 2007. In fact, this process has started with the commencement of Bachelor in Technology (B. Tech) programmes in Automobile Engineering and Hospitality and Tourism at the Ho Polytechnic in the 2007 academic year. Other important public training institutions are the Ghana Institute of Management and Public Administration (GIMPA) and the Management Development and Productivity Institute.

3.2.2.2 *Public Research Institutes*

The Ghana Atomic Energy Commission (GAEC) with its three main operational (research) institutes and the Council for Scientific and Industrial Research with its 13 research institutes operating across the country constitutes the core of the public research and innovation system of Ghana outside the university and polytechnic sector. However, the Ministry of Health also has some research centres and while the Cocoa Research Institute of Ghana, which is another important research institute in country falls under the aegis of the Ghana Cocoa Marketing Board.

3.2.2.2.1 *Council for Scientific and Industrial Research (CSIR)*

Public sector research in Ghana is dominated by the Council for Scientific and Industrial Research (CSIR) was established under NLC Decree 293 of October 10, 1968 and re-established by CSIR Act 1996 (Act 521) on November 26, 1996. However, the CSIR traces its ancestry to the erstwhile National Research Council (NRC) which was established by Government in August 1958 to organize and co-ordinate scientific research in Ghana. The new Act makes the commercialization of the research findings a priority and to enable it generate at least 30% of its funding. The CSIR research activities are undertaken by various research institutes that it inherited or established over the years. Today there are 13 CSIR research institutes categorized into three groups including natural

resources, agricultural, and industrial and social sectors operating across the country although with concentration in Accra and Kumasi two of Ghana's largest cities. These institutes, nine of which are agro-based include:

- Animal Research Institute
- Crops Research Institute
- Food Research Institute
- Oil Palm Institute (OPRI)
- Savanna Agricultural Research Institute
- Institute of Industrial Research
- Building and Road Research Institute
- Institute for Scientific and Technological Information
- Science and Technology Policy Research Institute
- Soil Research Institute
- Water Research Institute
- Plant Genetic Resources Centre
- Forestry Research Institute of Ghana

The Ghana Atomic Energy Commission (GAEC) has three main research institutes that are:

- National Nuclear Research Institute (NNRI)
- Radiation protection Institute (RPI)
- Biotechnology and Nuclear Agriculture Research Institute (BNARI)

Another important public scientific research institute is the Cocoa Research Institute of Ghana (CRIG), which is central to the development, sustainable growth and competitiveness of the Cocoa industry in Ghana. CRIG has three sub-stations that include Bunso for cocoa, kola and coffee research; Afosu for coffee and Kola research and Bole for shea nut and cashew research activities. CRIG is under the management of the Ghana Cocoa Board.

Other important public R&D and technology-oriented institutions include the GRATIS Foundation, which evolved out of the Ghana Regional Appropriate Technology Industrial Service (GRATIS) Project. It was established by the Government of Ghana in 1987 and mandated to promote small-scale industrialisation in Ghana. To accomplish this mandate, GRATIS established Intermediate Technology Transfer Units (ITTUs) now designated Regional Technology Transfer Centres (RTTCs) in nine regions of Ghana to transfer appropriate technologies to small-scale industrialists through training, manufacturing and the supply of machine tools, plants and equipment. There is the Development and Application of Intermediate Technology (DAPIT) that was under MEST and ceded to the Ministry of Communication and Technology in October 2001. Since then the applied technology portfolio had been receded to Ministry of Trade and Industry following the renaming of Ministry of Communications (MoC) in Executive Instrument No. E.I.6 of 4th July 2003.

Additional research institutes under the Ministry of Health include the Centre for Scientific Research into Plant with a provisional budget of 4.41 billion cedis in 2004, the Ghana Institute of Clinical Genetics at Karle-Bu and Research Units including the Narvon and Kimtampo Health Research Centres, while the Kofi Anan ICT Centre of Excellence falls under MoC.

3.2.2.3 *Private research institutes*

Private sector research institute besides the private universities most of which are still affiliated to public universities or outside institutions and not fully-fledged and autonomous institutes are still very limited and largely teaching oriented. The most visible private research institutes are in the social sciences-related fields include the Centre for Democratic Governance (CDG), Centre for Economic Policy Analysis (CEPA) and the Kumasi Institute of Technology and Environment (KITE) that is involved in energy sector research.

3.3 *Human capital for S&T*

Scientific and technological workforce is critical to the functional operations of any national research and innovation system. Therefore, the development of skills and technical capacity and how to retain the high-level skills has been a challenge in Ghana, especially due to the high-level skills migration. The official and national objective for science, engineering and technology (SET) student enrolment to the social sciences and humanities is in the ratio of 60:40 percent. However, the various universities and polytechnics have their specific norms. For instance, the University of Ghana is expected to achieve a norm equal to the national objective, while KNUST is charged with the responsibility to achieve a ratio of 90:10 in favour of SET students and programmes GSS 2005b). However, the College of Art and Social Sciences at KNUST accounted 35% of total students' enrolment during the 2005/2006 academic year (KNUST, 2006). The current national enrolment ratio is 36% SET to 64% in the social sciences and humanities down from 47.6% in 1991/92 (GSS 2005b). This downward trend will affect the structure and dynamism of the scientific workforce, research and the training of post-graduate students in terms of creating a critical mass of researchers and technicians and therefore on issues of scientific mobility. The NCTE has therefore expressed its concern about the situation and is currently engaging with the sector ministry and the GETFund on how to improve on the intake of SET students. Table 4 gives the total enrolment for Arts and Sciences in the six public universities during the 2003/2004 academic year.

Table 4: Enrolment in Arts and Sciences in Public Universities 2003/2004

ACADEMIC YEAR	2003/2004						ART / SCIENCE RATIO
	ENROLMENT NORM: 40:60						
	ARTS			SCIENCE			
INSTITUTIONS	M	F	T	M	F	T	
University of Ghana	11960	7705	19665	2857	1376	4233	82:18
Kwame Nkrumah Univ. of Science & Technology	2504	1442	3946	7178	2267	9445	29:71
Univ. of Cape Coast	6480	3433	9913	2222	600	2822	78:22
Univ. of Education Winneba	5031	2430	7461	1802	652	2454	75:25
Univ. for Development Studies	881	369	1250	1207	308	1515	45:55
Western Univ. College (now U-MAT)	0	0	0	820	52	872	-
TOTAL	26856	15379	42235	16086	5255	21341	66:34

Source: NCTE, 2003.

3.3.1 *Size and structure of the R&D workforce*

The higher education sector comprising the 7 public universities and 10 polytechnics together with the researchers and technicians at the staff at CSIR and GAEC forms the core of the scientific workforce in Ghana. In 1998/99 academic year 1447 academic staff were working in the then five public universities in Ghana with a total student enrolment of 31501, excluding the polytechnics and other professional institutes (NCTE, 2002:18). Although the research and teaching staff at the universities has increased we estimated that that this will not be more than 4000 in 2005, but the research and teaching staff has almost doubled in each of the five universities between 1998/99 and 2005/2006. For example, from Table 5 below, the total number of research and teaching staff at UG, which is the biggest and the first university to be established was 767 staff in January 2006, whilst KNUST the second biggest had 751 which included 85 part-time staff members. Also, the CSIR which is one of two biggest public research organisation had a total staff strength of about 4,800 of which 390 were research staff and 400 senior technical support staff in 1999 (CSIR, 1999:5). With increasing brain drain and internal mobility of researchers from the research institutes, this number may be smaller now. Based on CSIR's website information, Table 6 below gives the number research staff at selected CSIR institutes and CRIG as at November 2006, The number of researchers working in industry and the growing number of private universities is not readily known but this will be a small number. Moreover, industry undertakes very little research and development activities and most scientists are more likely to be administrators rather than engage in active basic and applied research and innovation at the industry level.

Table 5: Academic Staff in Public Universities in Ghana, 1999/2000 – 2005/2006

Institution	1998/99	2000	2001	2002	2003	2004	2005	2006
University of Ghana	498	--	702	721	720	830	830	767
Kwame Nkrumah Univ. of Science & Technology	473	--	--	--	--	--	--	751
Univ. of Cape Coast	227	--	--	295	304	317	--	381
Univ. of Education Winneba	182	--	--	--	251	--	--	291
Univ. for Development Studies	67	--	--	--	--	--	141	--
Western Univ. College (now U-MAT)	--	--	--	--	--	--	--	--
TOTAL	1447						3933	

*Academic and administrative staff based on the January staff figures for year each; **Staff was part of KNUST before it became an independent university in 2004; -- Data not available.

Source: Own compilation from NCTE, 2001 for 1999; Universities Basic Statistics and Vice-Chancellors' Annual Reports, various years; Global Education Digest 2006 for 2005 grand total.

Table 6: Research staff at CSIR Institutes and CRIG

Institution	Total staff	Researchers (Snr members)	Senior staff	Junior staff	Others
CSIR	2088				
INSTI	79	22	36	31	
SARI	535	42	35	458	
OPRI	447	23	36	179	209m
FRI	170	35	51		
CRI		83	100		700
ARI	295	27	44	96	95d
IIR	135	38	44	53	
BRRRI	211	53	56	83	19m
SRI			32	257	
WRI 2003	249	68	65	116	
PGRC	127	10	12	54	51m
FORIG	278	47	61	74	96d
CRIG	210	35		175	

*others are monthly rated staff (m) or daily rated staff (d).

Source: Own compilation

3.3.2 Trends in Master's and doctoral enrolments

Master's and doctoral student enrolments are now part of the scientific workforce of a country and this makes the transition from undergraduate to postgraduate studies very important. At the 12th annual Delegates Congress of the Graduate Students Association of Ghana (GRASAG) on 19 June 2006 Professor Kwesi Andam, the former Vice-Chancellor of KNUST estimated that graduate admissions in the public universities stood as low as 10% of total admissions adding that it was necessary to increase this figure to at least 40%. In addition, Professor Clifford Nii Boi Tagoe, the Vice-Chancellor of the University of Ghana, said graduate intake in the public universities was increasing with about 8,000 admitted to pursue various programmes in the 2004/2005 academic year. According to Adam while undergraduates kept the economy of the nation going, graduate students' benefit to it. Hence, the country needed to address the problems faced by graduate students since they could push the economy to a middle-income level status. Adam announced that the University (KNUST) is to spend a total of seven billion cedis on students pursuing post-graduate studies for the next academic year. About 200 graduate students would receive 18 million cedis each a year as stipend and bench fees representing one-sixth of the University's

allocation from the Ghana Education Trust Fund (GETFund) for the 2006/2007 academic year. Andam said priority had been placed on students pursuing Doctor of Philosophy (PHD) programmes in the allocation. Current estimates by the President of GRASAG are that post-graduate students received thesis research grant of between 690,000 cedis and 1.7 million cedis for the number of years he /she studied (Quaye, 2006).

Andam (2006) argues that it was the responsibility of the major universities to produce graduate students, who would become lecturers for the new generation of universities and the private universities, as a future strategy. He said the country would have enormous benefit from investing into post- graduate studies, adding that proposals had been submitted by Vice-Chancellors of the various public universities to the Ministry of Education, Science and Sports to review funding for post-graduate studies. Indeed the Education White Paper states that "Government accepts the recommendation to expand post-graduate training and research in Ghana's tertiary institutions, especially as a source of recruitment of staff for their own faculties. Tertiary institutions will receive the required assistance to make post-graduate training and research more accessible and relevant to national development" (MEYS, 2004:39), the challenge here is how to carry out the implementation process forward in a sustainable manner.

At the matriculation ceremony for fresh students of various undergraduate and postgraduate programmes for the 2005/06 academic year, the acting Vice-Chancellor, Prof. Clifford Tagoe, announced the University of Ghana (UG) has reactivated its Scholarship Scheme in addition to the existing one to promote local postgraduate research and training with support from the GETFund. Under this scheme, the University of Ghana will be spending 18 million cedis per annum for a Master of Philosophy student and 28 million cedis per annum on a Doctor of Philosophy student (Teng-Zeng, 2005; UG, 2005:291).

During the 2003/2004 academic year, enrolment at the School of Research and Graduate Studies at UG stood at 1,545 representing 6.21 % of total UG enrolment figure of 24,876. Total postgraduate enrolment decreased to 1326 (890 males and 436 females) as against a total student enrolment figure of 26,162 representing 5.07% for the 2004/2005 academic year (UG, 2005:290). However, in the 2005/2006 academic year a total of 776 students made up of 527 males and 249 females enrolled for different post-graduate programmes Humanities, Sciences and Business Science increasing the graduate student enrolments for UG by 45% over the previous academic year and undergraduate science enrolments increased by 30% in the same period (UG, 2006). Of the total 776 graduate students, Science/Agriculture accounted for 196 comprising 135 males and 61 females. This brought the total graduate student enrolment to 1613 (5.66%) comprising 66.15% male and 33.85 female respectively in the 2005/2006 academic year. The overall student population is 28482.

Available statistics at KNUST indicate that 709 graduate students were admitted during the 2005/2006 academic year. Out of 45 PhD students admitted, the College of Arts and Social Sciences accounted 32 students. The total post graduate enrolment was 1351 of which female graduate students were 241 during the 2005/2006. The overall student population is 18303.

The University of Cape Coast (UCC), which is the third biggest university in the country, admitted 4,158 students made up of 27 PhDs, 220 Masters and 3,911 under-graduates for the 2006/2007 academic year. The total postgraduate student UCC is 488 out of total student population of 17072 for the 2006/2007 academic year.

Overall, the President's Committee on Review of Education Reforms in Ghana Report recommended that the universities should introduce more flexibility into their programmes to allow for work-study, and credit transfers from one institution to the other. The Report call upon Ghanaian government to provide adequate funding for postgraduate studies to enable universities achieve the present target of 10% intake of postgraduate students in the short-term, and at least 20% in the long term. It also called on universities to ensure that there are qualified and motivated staffs in adequate numbers and improved facilities for the running of successful post-graduate programmes; and finally the report reiterated that the GETFUND should make substantial allocation for post-graduate studies (NCTE, 2002:115). Most postgraduate studies occur at the first generation universities in the country.

3.3.3 *Masters and doctoral graduate output*

Given the limited number of postgraduate students' enrolment, the output number is limited. Based on recent universities basic statistics none of three main universities in Ghana at present graduate more than 1000 students in any academic year. Available data for UG suggests that it awarded close to close 600 postgraduate degrees in 2004/2005 academic year as indicated in Table 7. This is by far the highest figures for any of the universities up to this period. Table 8 shows the output of students in health and medical sciences but this is not necessarily postgraduate degrees.

Table 7: Postgraduate output in three Ghanaian Universities, 1999/2000 – 2005/2006

Institution	1999/ 2000	2000/ 01	2001/ 02	2002/ 03	2003/ 04	2004/ 05	2005/ 06
University of Ghana	246	423 (12)	402		576(7)	593 (12)	
Kwame Nkrumah Univ. of Science & Technology						386 (7)	
Univ. of Cape Coast		276	185		123 (7)		86 (2)
UEW							44

(...) figures in brackets represent the total number of PhDs awarded)

Sources: Own compilation from the Universities Basic Statistics and VCs Annual Reports various years

Table 8: Selected health personnel trained in Ghana, 1999 – 2005

Category of personnel	1999	2000	2001	2002	2003	2004	2005
Doctors	139	145	140	159	159	246	220
Pharmacist	96	84	82	92	109	120	111
Allied Health workers	185	191	168	215	260	262	435
Nurses/Midwives	1,057	1,077	1,133	1,167	1,219	1,500	1,791

Source: ISSER 2006, p181 based on MOH

3.3.4 *Human and institutional capacity development Strategies*

3.3.4.1 *Promoting of science and technology education at all levels*

In the State-of-the- Nation address to Parliament on 23 January 2005, President J A Kufuor placed in number position "the development of Ghana's human resources" and therefore, education and training are core elements of the human resource development pillar of the Growth and Poverty Reduction Strategy II (GPRS II 2006-2009). In the Ghana GPRS II it has been decided to eventually make school attendance obligatory for all children for years- from 4 to 15 years. Since the implementation of Ghana's FCUBE programme is still a major challenge, the government has introduced a capitation grant to further expand access and retention rates to basic education with some donor assistance in 53 deprived districts in 2004. The capitation grant scheme has since been expanded to cover the entire country in the third quarter of 2005.¹⁴ In this regard, the government is expanding access and improving educational infrastructure at the both primary and JSS levels with nearly 4000 school blocks constructed in the past four years. Improvements in production techniques for more efficient production of large quantities and high quality goods and services in the growth sectors require workers with modern scientific knowledge and ICT culture. Strategies to achieve this objective include providing incentive schemes to attract more teachers into teaching of science and ICT; support science and research institutions; provide incentives to attract science students; increase funding for research and technology development including ICT; support private sector initiatives in science and technology (GPRS II 2005:44)

3.3.4.2 *Training and skills development*

There are proposals for training and skills development linked to entrepreneurial development outside the formal education system under GPRS II, guided by the following priorities:

- Provide skills and entrepreneurial training in gender responsive and equitable manner;
- Promote dialogue between industry and skills/professional training institutions to produce skilled labour required by industry- demand driven skilled labour;
- strengthen and support HR institutions-through assistance to develop new syllabi/curricula to meet industry and employees needs;
- Promote apprenticeship training

¹⁴ Ghana first instituted fee-free primary education in 1952 and then introduced compulsory primary education in 1961 after rapid expansion of educational facilities but the implementation was never enforced.

- Promote the adoption of the National Youth Policy and enactment of the Disability Bill (GPRSII 2005:44).

A new Department to train Telecom Engineers started at the KNUST last year. The Ghana Telecom Training School also commenced the process of conversion into a Telecom University to serve the sub-region. The University Council has been put in place to oversee the transformation process aimed at turning the University into a Centre of Excellence in Applied Telecom Studies. Already arrangements are far advanced to commence the study of Telecom related courses at Masters Level. In addition, the Ghana India Kofi Annan Centre of Excellence in ICT has emerged as the leading IT Training Institution in the sub-region providing high level IT skills training after barely two years of its operation. It now plans to add to its curriculum, development of modules for scientists wishing to optimize their use of ICT as well as the provision of specialized laboratories for software and IT Enabled Services.

The United Nations has selected Ghana for a project on "International Partnerships on New and Emerging Technologies for Sustainable Development". This project will establish a comprehensive Science and Technology Park at the KNUST to promote Research and Development. It will be collaborating with other universities and research institutions in the country.

To address the acute shortage of professional staff in the field of meteorology, GMA is collaborating with the University of Ghana to commence degree courses in meteorology and related fields in September 2006. The Ministry of Communication has continued to pursue the provision of affordable access to ICT to the citizenry particularly in the underserved areas through the construction of Community Information Centres (CIC's). Seventy-two of such Centres have been built under the HIPC initiative in the ten regions. There are plans to construct CICs in the remaining 158 constituencies.

To enhance to postgraduate studies in the health and medical sciences, the government has established the Ghana College of Health and Physicians in 2004.

The government has approved the idea of establishing a national Open University that will provide avenues for part-time studies in both undergraduate and postgraduate higher education programmes through distance learning. In fact, in July 2006, Shenzhen-based ZTE Corporation, a leading telecommunications equipment manufacturer, announced that it would construct Ghana's first distance-learning network in cooperation with Cape Coast University.

The Ministry of Education, Science and Sports has initiated a programme of equipping 15 selected Teacher Training Colleges specialising in the teaching and learning of science and mathematics in order to improve Mathematics, Science and Technology in basic schools (GoG, 2006:216).

Government has introduced a capitation grant to further expand access and retention rates in basic education with some donor assistance in 53 deprived districts in 2004. The capitation grant scheme has since been expanded to cover the entire country in the third quarter of 2005. The budget for the capitation grant for the 2006/07 school year was 129.5 billion

3.3.4.3 *Increasing Postgraduate and Staff Training and Research*

The Government has realised the importance of postgraduate studies in the country to promote the training of high-level work force and to help address the perennial problem of brain drain as well as develop research capacity. One such initiative is the establishment of the Ghana College of Health and Medical Sciences in 2004. During a panel discussion on brain drain and its effects on Ghana's socioeconomic development at KNUST in Kumasi (also see next section), Dr Kwame Addo-Kuffour, Ghana's Minister of Defence said that about 800 medical practitioners were retained in the country since the past two years, following the introduction of post-graduate programmes and specialisation in the medical field (Ghanaweb.com, 13 January 2007).

To expand scientific programmes and to train necessary human resources for the Ghana Atomic Energy Commission and other institutions within the country, GAEC in collaboration with the University of Ghana and with assistances from the International Atomic Energy Commission has established the School of Nuclear and Allied Sciences (SNAS). SNAS will also serve as a regional training for other African Member States in Africa.

President Kufuor mentioned that in order to train faculty members for the tertiary institutions, a scholarship scheme has been initiated under the GETFund Manpower Development Scholarship Scheme. During 2005/06 about 60 faculty members in tertiary institutions were awarded sponsorship for overseas training (Kufuor, 2007).

3.3.5 *Scientific mobility*

The migration of skilled labour has long been a source of concern for most developing countries, but Africa in particular because it is regarded as a major impediment to national and regional development. For instance, although remittances to Ghana from non resident Ghanaians over the years have increased tremendously reaching \$4.25bn (with \$1.2billion from Ghanaians in the Diaspora) there are serious concerns about the impact on Ghana's human resources capacity development and sustainable development efforts. A recent World Bank report on census and population titled International Migration, Remittances and Brain Drain, indicated that 47% of Ghana's college-educated citizens live abroad. In fact, it has been estimated that about 90% of all Ghanaian graduates have attempted at one point or the other to travel overseas. Although remittances are growing, in the words of Kwesi Andam, "nations are built with brains, not with absentee dollar remittance" (quoted by Adomako, Appiah Kusi 2006 Ghanaweb Feature, 29 August 2006).

Also a new United Nations report on International Migration the presented before the 61st UN General Assembly in August 2006 points out that "Between 33 and 55% of the highly-educated people of Angola, Burundi, Kenya, Mauritius, Mozambique, Sierra Leone, Uganda and the United Republic of Tanzania live in the countries of the Organisation for Economic Co-operation and Development (OECD). The report notes that about 50% of the 'highly-educated' Ghanaians have migrated - mainly to more developed countries such as the United States, Britain and others within

the OECD. Although brain drain cuts across sectors of the Ghanaian economy, the health sector has received much attention in recent times. For example, Samuel Owusu-Agyei, Ghana's Deputy Minister of Health, expressed regret that out of the over 73 members of the Class of 1986 medical graduates, only 23 were currently working in Ghana with the rest working abroad. Table 9 shows the brain drain of medical and health personnel from Ghana in recent years with about 448 doctors leaving the country between 1999 and 2004.

Furthermore, an important aspect of scientific mobility in Ghana is internal, with more researchers at the public research institutes opting to join the higher education sector due to worsening conditions of service and poorer remuneration in the research institutes (Ayensu, 2005). For instance, the CSIR researchers went on strike in late 2004 upon failure to reach an agreement with government over salary and wage negotiations for better conditions of service.

Table 9: Brain Drain Health Personnel in Ghana, 1999 – 2005

Category of personnel	1999	2000	2001	2002	2003	2004*	Total
Doctors	72	52	62	105	117	40	448
Pharmacist	49	24	58	84	95	30	340
Allied Health workers	9	16	14	12	10	8	69
Nurses/Midwives	215	207	235	246	252	82	1,237

*Provisional

Source: ISSER 2006, p181 based on MOH

3.3.5.1 Policy Interventions to address Brain drain

On 20 November 2006 Hewlett Packard (HP) and UN Educational, Scientific and Cultural Organisation (UNESCO) launched a new project "Piloting Solutions for Reversing Brain Drain into Brain Gain for Africa", which aims to help to reduce brain drain in Africa by providing grid computing technology to universities in Algeria, Ghana, Nigeria, Senegal and Zimbabwe. The project aims to re-establish links between researchers, who have stayed in their native countries and those that have left, connecting scientists to international colleagues, research networks and funding opportunities. Faculties and students at beneficiary universities would also be able to work on major collaborative research projects with other institutions around the world (UNESCO, 2006).

Under this project, preference would be given to university departments with important information technology components. HP would provide equipment - including servers and grid-enabling technologies - and local human resources to the universities, as well as training and support, until the projects become self-sustainable. It would also donate PCs and monitors and fund research visits abroad and meetings between beneficiary universities. UNESCO would be in charge of overall coordination and monitoring of activities; as well as administrative management; evaluation and promotion of results. After its first two-year implementation phase, the project may be extended to cover other countries (UNESCO, 2006).

Furthermore, during a visit to Ghana in early January 2007, the German President Horst Kohler pledged that Germany would collaborate with Ghana to solve the perennial problem of brain drain that had impeded Ghana's socio-economic development. Addressing a panel discussion on brain drain and its effects at KNUST in Kumasi, President Kohler said that "The incessant exodus of Ghanaian professionals to Germany and other European countries to seek greener pastures should be a matter of concern to all of us. Germany is committed to fashion out a more comprehensive programme to redress the issue". President Kohler said as part of the collaborative efforts, Germany would ensure that Ghanaian professionals who had worked in Germany for more than five years returned to serve their motherland at least for a year under a mandatory and mutual arrangement between both countries (Ghanaweb.com, 13 January 2007).

In addition to the above, the Ghana Ministry of Health has initiated a Project to encourage Ghanaian health professionals residing in the Netherlands and the European Union countries to come home and work during their leave. The Project, "Migration for Development in Africa", carried out by International Organisation for Migration (IOM), would enable them to transfer their knowledge, skills and other resources through short assignments when they are on holidays. The Project, which would last for two-and-a-half years and subject to renewal, would facilitate the temporary and longer-term return of about 30 Ghanaians in the Diaspora; facilitate training of about 20 health professionals from Ghana in The Netherlands and help to build networks and cooperation between health organizations in Ghana and those in The Netherlands. Under this programme, the IOM would offer financial support to professionals from the Diaspora to cover the cost of travel, living allowance, travel insurance and visa

3.4 *Financial resources (funding)*

3.4.1 *National financial resources*

In a discussion of research and technological development funding in Ghana, Ayensu (2005:8) notes that the government of Ghana accounts for approximately 73% of national funding, international donors 25% and the private sector 2%. It is believed that a greater proportion of the government funds (about 97%) support administrative and personal emoluments leaving the international donor funding to support actual research activities. For example, Joseph Ofori, Deputy Director of the Forest Research Institute of Ghana (FORIG) recently stated that a major problem facing the Institute was lack of funding for research activities, adding that more than 95 percent of money received from the government went into payment of wages and salaries of staff leaving, only small amount for research work (Ghanaweb, 13 August 2006).

Excluding other important lines ministries whose activities also promote scientific and technological development, prior to the dismantling of the Ministry of Environment and Science (MES) in April 2006, during the presentation of the 2005 National Budget Statement, MES was awarded ₵157.7 billion to cover its programmes in the 2005 financial year. The same budget statement allocated the Ministry of Education and Sport (MOES) ₵4,295.28 billion of which GOG will provide ₵3,920.12 billion and ₵375.16 billion will be from donor sources (GOG, 2005). From Table 10 it seems to reason that budgets for both the two ministries more than doubled between 2000 and 2005 before the merger of the two ministries in early 2006. However, the general argument is that there are still not adequate financial resources coming from Ghana government to support research and innovation activities including human resource training (especially at the postgraduate level). There also a general concern, Government in an attempt to implement its Constitutional Mandate of providing Free Compulsory Basic education, may be neglecting higher education sector training and research, which will influence negatively in the medium to long-term

development of country. In addition, there is a snag or a precaution to bear in mind in discussion budgetary allocations because more often than not all approved allocations are transferred to the line ministry and or to research performing institutes. Table 11 gives the provisional budget for MES and selected research institutes falling under its jurisdiction in fiscal 2004.

Table 10: Ghana Estimates for Sectoral Budgetary allocations (Cedi billions)

Ministry*	2000	2001	2002	2003	2004	2005	2006	2007
MEST	72.5	85.08	124.3	133.5	172.3	157.7		
MoC	32.2	37.01	54.8	62.7	42.2	26.4		
MoA	174.9	453.75	349.9	419.3	394.4	642.9		
MOES (MOESS)	1032.9 (62.3 donor)	1420.22	1800.0	2,775.9	3466.0	4295.3		11,322,257m
MoH	320.1	422.22	699.4	1154.6	1449.5	2452.8		

* The change of government at the beginning of 2001 also led to reorganisation of ministries with the MEST becoming MES before being closed down completely in April 2006. The Ministry of Education and Sport now assumes the responsibility for Science and Sports. Sources: Own compilation from the Government of Ghana Annual Budget Statement, various years

Table 11: Provisional Budget Estimates for MES and Selected Research Institutes, 2004 (in Million Cedis)

Institute	Government	Donor	Total
Ministry of Environment & Science	37,913	2908	40822
CSIR	28,450	342	28,792
Secretariat (CSIR)	3,023	335	3,358
Crop Research Institute	2,167	0	2,167
Animal research Institute	1,652	3	1,656
Soil Research Institute	2,045	0	2,045
Soil Research Centre	383	0	383
Building & Road Research Institute	2,470	0	2,470
Food Research Institute	1,668	0	1,668
Water Research Institute	1,966	1	1,967

Table 11 Continued

Institute	Government	Donor	Total
Institute of Industrial Research	1,368		1,368
INSTI	1,095	0	1,095
Oil Palm Research Institute	1,866	2	1868
Savanna Agricultural Research Institute	3,302	0	3,302
Ghana Grains Development Project	1,549	0	1,549
STEPRI	311	0	311
Forest Research Institute of Ghana	2,074	0	2,074
Plant Genetic Resource Centre	846	0	846
Root & Tuber Crops Project	661	0	661
ICMST	2	0	2
GAEC	4,449	2,558	7,007
NNRI	1,373	525	1,898
BNARI	707	826	1,532
RPB	335	0	335
Total	103,710	5,118	111,419

Source: GOG Provisional Budget Estimates for 2004

3.4.1.1 *The Ghana Education Trust Fund*

During 2000 Ghana passed legislation establishing the Ghana Education Trust Fund (GETFund) whereby the government can devote the necessary financial resources to support educational infrastructure development, including universities and polytechnics. While government and other donors may contribute to the fund, the core funding of GETFund is based on 2.5% of the prevailing rate of the national Value Added Tax (VAT) deductions or such percentage not being less than 2.5% of the Value Added Tax rate, which Ghana's Parliament may determine. In 2003 the GETFund was allocated ₵224 billion to continue with the construction of library blocks, lecture theatres, administration blocks, etc. It was given an additional amount of ₵28 billion for faculty research and development, and ₵32 billion to support the national student loan scheme. This support for projects enabled admissions into universities to increase from 40673 in 2002 to 53895 in 2003, which represented a rise of 30.5%. Furthermore, student intake at the country's polytechnics also increased from 18459 in 2002 to 23717 in 2003, up by 26.5% (Teng-Zeng, 2004 & 2005).

According to Fosuaba Mensah Banahene, Administrator of the GETFUND, since the establishment of the GETFUND, it has spent about four trillion cedis on projects in educational institutions in the past five years. About 2.5 trillion cedis out of the amount was spent on projects in 18 tertiary institutions. For example, since 2001 about 157 billion cedis from the GETFUND had been provided to authorities of KNUST to upgrade most of its old structures including lecture theatres for Engineering, Pharmacy and Institute for Mining and Mineral Engineering (MME) (Ghanaweb General News, 20 September 2006). Table 12 shows the budgetary allocations and actual government transfers to the GETFund since it became operational in 2001.

Table 12: Budgetary Allocations and Transfers to GETFund 2001-2006 (cedis billion)

	2001	2002	2003	2004	2005	2006*	2007*
Budget estimate	-	-	284	810.5	1124.2	-	1775.2

*Provisional

Source: Own compilation from Ghana Budget Statements, various years

3.4.1.2 Research Grant and Teaching and Learning Innovation Fund (TALIF)

Prior to the GETFUND, the first attempt at creating a national fund for research in the higher education sector was the introduction of Research Grant as part of the World Bank's Tertiary Education Project 1 (TEPI) in 1993. The World Bank provided \$1.0 million in support of this project to be managed under the Universities Research Fund Manage Committee (URMC) (NCTE, 1998:22). However, the implementation of project was not smooth due to long lags in between meetings of the URMC and delays from the Ministry of Education in disbursement of monies for the approved projects. According to the NCTE (1998:23), the Ministry of Education began to release funds in 1996 and by the time a change of Secretariat for the Fund's management was moved to the University of Ghana for the programme implementation, the Ministry of Education indicated in the terms of reference that the fund to administered had been reduced to \$600,000.00 without providing any reason. Meanwhile between 1996 and 2000, the Universities did not properly define research funding and the allocation of financial resources to that activity was ad hoc. Within this period, the percentage of total expenditure attributed to research in the universities was said to average 2.7% and occurred under the General Expenditure Expenses of these institutions. No research activity was undertaken in the polytechnics during this period as well (NCTE, 2002:22).

As part of Ghana's Ministry of Education's *Education Strategic Plan (ESP) 2003-2015* and the Education Sector Project (EdSep), a Teaching and Learning Innovation Fund (TALIF) has been launched for tertiary institutions aimed at improving teaching and learning facilities and programmes as well as postgraduate training. TALIF is financed with credit facility from the International Development Association (IDA) of the World Bank Group and counterpart funds from Ghana's national budget. The level of counterpart country will be 10% of each project's total budget. However, some projects may be supported with additional resources from other institutions and agencies. TALIF July 2005 results indicate that a total amount of US\$6,361,863.55 has been approved for allocations in the second proposal call (<http://www.ncteghana.org>; Teng-Zeng 2005).

3.4.1.3 *The Venture Capital Trust Fund*

In 2004 Ghana's Parliament passed the Venture Capital Fund Bill and the Long Term Savings Bill. The Venture Capital fund is intended to address inadequate capital problems of the private sector especially in the Micro, Small and Medium Enterprises (MSMEs). Nana Osei-Bonsu, Chief Executive Officer (CEO) of VCTF announced that the Fund had managed to raise 33 million dollars which the Fund had matched up to make with 11 million dollars (from its original capitalisation of 25 million dollars by government) making up 44 million dollars for onward lending to SMEs (Ghanaweb.com business 8 November 2006).

The government has announced further tax incentives to encourage more venture capital finance companies to participate in the scheme. The enhanced tax measures, which build on those of the 2006 budget, include:

- The 5-Year full exemption from corporate income tax, dividend tax and capital gains tax for eligible venture capital finance companies, extended to 10 years.
- The 100% chargeable income deduction granted to financial institutions investing in venture capital finance companies, expanded to include all corporate and individual investors who invest in venture capital financing companies.
- Distributions of interest, dividends and capital gains to investors in venture capital finance companies shall be tax exempt
- Losses from disposal of the shares of a venture investment may be carried forward for a period of up to 5 years after disposal (GoG, 2006:435)

Currently, the Fund is focusing on four areas including pharmaceuticals, ICT, tourism and agriculture. According to Osei-Bonsu (2006), these priority areas may benefit from about 55% of the total funds available, while the remainder will be spread to cover other viable business opportunities (Ghanaweb.com business 8 November 2006).

3.4.1.4 *Ghana Investment Fund for Telecommunication Service*

In addition, given the importance of ICT in socio-economic development and transformation the government announced the planned establishment of Ghana Investment Fund for Telecommunication Service (GIFTEL)¹⁵.

3.4.1.5 *Endowment Fund for Science and technology Research*

In the 2007, National Budget Statement the government announced the establishment of an Endowment Fund for Science and Technology Research with initial allocation of 5.0 billion cedis. The private sector and other institutions are encouraged to contribute to this Endowment Fund to create a regular flow of resources for basic research. The CSIR will co-ordinate this Fund (GoG, 2006b).

3.4.2 *International donor funding*

In a recent discussion of research and technological development funding in Ghana, Ayensu (2005:8) notes that the government of Ghana accounts for approximately 73% of national funding, international donors 25% and the private sector 2%. It is believed that a greater proportion of the government funds (about 97%) support administrative and personal emoluments leaving

¹⁵ Ghana National Budget 2005.

the international donor funding to support actual research activities. Excluding other important lines ministries whose activities also promote scientific and technological development, prior to the dismantling of the Ministry of Environment and Science (MES) in April 2006, during the presentation of the 2005 National Budget Statement, the MES was awarded 157.7 billion cedis (¢) of which Government of Ghana will account for ¢138.9 billion (including retained internally generated fund (IGF) of 11.1 billion) and 18.8 billion from donor sources to cover its programmes in the 2005 financial year. The same budget statement the Ministry of Education and Sport was granted ¢4,295.28 billion of which GOG will provide ¢3,920.12 billion and ¢375.16 billion will be from donor sources. This is in addition to an IGF amounting to ¢678 billion for Education Ministry that was to be retained.

Some of the donor agencies that have provided technical assistance and funding for specific research and industry projects in Ghana include: the Japanese International Co-operation Agency (JICA); European Union (EU); the Canadian International Development Agency (CIDA) and International Development Research Centre (IDRC), the British Voluntary Service Overseas (VSO), the UK Department for International Development (DFID), United States Agency for International Development (USAID); the German Agency for Technical Cooperation (GTZ), the German Development Service (GDS), the Netherlands Development Organisation (SNV) and the Canadian University Service Overseas (CUSO); DANIDA.

In June 2006 China and Ghana signed concessionary loan agreements worth 108 million dollars. Of that, 70 million dollar, provided through the Export-Import Bank of China, would be used to expand Ghana telecom's mobile and fixed networks, including 30 million dollar for a national telecommunications backbone. The United States Agency for International Development (USAID) has, for the past 10 years, supported the Adventist Development and Relief Agency (ADRA) with 11.8 billion cedis to cultivate cashew in Ghana. ADRA supported 15,000 farmers from 405 communities to grow the crop, cultivating 19,313 acres.

3.5 *Research outputs*

There are currently no ISI-indexed journals in Ghana; however, 12 local journals have been indexed in African Journals Online to give them visibility. In terms of research output, using the PASCAL Database, Arvanitis *et al* (2000) surveyed the scientific output in terms of publications of 49 African countries from 1991-1997. In this study, Ghana is ranked fifteenth with a total number of 460 articles, with Burkina Faso faring better than Ghana. Although Arvanitis *et al* considers this as an improvement given the decline of S&T production since the mid 1970s, it is quiet clear that Ghana has lost its role as one of the leading countries of intellectual life in Africa. More recent data by Tijssen (2006) indicate that Ghana produced 641 ISI-indexed journal articles between 2001 and 2004

3.6 *Technological innovation*

During the 1990s technological innovation especially linking research to industry became a concern for Government, which led to the Enactment of a new Act for the Council for Scientific and industrial Research (CSIR) given it a mandate to partially commercialise their research activities in 1996. In addition, the Act establishing the Ghana Atomic Energy Commission was repealed to enable the Commission to commercial its research activities in 2000. A third step has been the emphasis on linking higher education sector research and training to that of industry following the report of the Educational Review Committee of 2002 and the subsequent Ghana White Paper on Education Reform which states that "all tertiary institutions will be required to reinforce their links with the

private sector economy, including industry, agriculture and commerce". Underpinning this processes the government policy objective of agricultural sector modernisation and industrial transformation.

According to Baah Wiredu (2006) in taking the process of technological innovation forward, in the 2005, Budget Statement and Economic Policy government introduced a measure under policy initiatives to give special support to industries that would commercialize research findings. He emphasized that government re-introduced the measure in the 2006 Budget Statement and Economic Policy to ensure its implementation, adding that the "Ministry of Finance and Economic Planning, together with the Ministry of Education, Science and Sport and the National Council for Tertiary Education have been taking the necessary steps to support research commercialization." Hence the setting up of an eleven-member committee called the 'Task Force for Effective Utilization of Research Findings by Industry', to explore how research findings of research institutions could be integrated into local industries, especially to prepare a concrete action plan to commercialize Pozzolana, Glucose syrup and Activated Carbon.¹⁶ However, in the review of Ghana's Economy it is argued Ghana's use of conventional policy prescriptions seems to focus excessively on tinkering with market incentives and microeconomic framework conditions rather than building capacity in science and technology to respond to the challenges of technological change, liberalisation and shrinking economic distances. Because of the low level attention given to technological capabilities, Ghana's share of medium -or- high-technology production in MVA and products in manufactured exports has remained very low as compared to other countries like South Africa and Republic of Korea (ISSER, 2006:136).

The immediate challenge now is how to implement the findings of the Task Force that recommends amongst others that Ghana Government must immediately find 3 billion cedis to manufacture machines and promote the production of the three agro-based products identified from research findings for commercialization from 2006 to 2008. The Budget towards the implementation of the programme for 2006 is estimated at 2.4 billion cedis, 2007 is 8.7 billion cedis and 2008 is 2.7 billion cedis. Pozzolana is used to produce cement, activated carbon is used for the processing of precious mineral and in food processing to remove odour while glucose syrup is used in the confectionary and the pharmaceutical industries. The Finance Minister, Baah-Wiredu had suggested that funds be sourced from the Venture Capital Trust Fund (VCTF) and the micro-finance programme in addition to unused dividends.

3.6.1 Patents

Ghana recognizes the importance of intellectual property rights and value patenting activity. The country is a member of the World Intellectual Property Organisation (WIPO) and one of the founding members of the African Regional Industrial Property Organisation (ARIPO). Ghana joined the Paris Convention in 1976 and became a signatory to the Patent Co-operation Treaty of 1997. Ghana is also a member of the Universal Copyright Convention and signed the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPs) under the World Trade Organisation. The national Patent Law of 1992 deals with industrial property such as patents, trademarks and designs, while the Copyright Law of 1985 deals with the works of authors both as individuals and corporate bodies (Lall and Pietrobelli, 2002:157; UNCTAD, 2003). However, the level of international patenting activity is still very low in Ghana. For example, between 1965 and 2005 only 6 utility patent applications were

¹⁶ The Task Force was drawn mainly from the Association of Ghana Industries (AGI), National Council for Tertiary Education (NCTE), Ministry of Finance and Economic Planning (MOFEP) and the Centre for Scientific and Industrial Research (CSIR). Production of pozzolana (a highly active cementitious material) from bauxite waste. Pozzolana can replace 40% of Portland cement in sandcrete blocks and mortar for construction purposes.

filed in the United States, 5 of these in the last two years. Moreover, non-residents as shown in Table 13 file much of the patent and industrial designs applications.

Table 13: Ghana Utility Patent Applications filed in USPTO

Type of activity	2000	2001	2002	2002*	2003	2004	2005
Residents	-	1	-	0	-	1	4
Non-residents	-	-	-	177371	-	-	-

*data from WDI

Source: Own Compilation from World Bank's *WDI* various years

3.6.2 Manufacturing sector

In August 2006, Mr Allan Kyerematen, Ghana's Minister of Trade, Industry and President's Special Initiative (PSI) expressed worry about the uneven nature of product lines and countries exporting items to the United States under the African Growth and Opportunity Act (AGOA) and called for a broader product base in order to satisfy the demands of the US market. Addressing a workshop of business operators from 18 West African countries in Accra, Kyerematen argued that statistics derived from the West African Trade Hub (WATH) showed that 85% of all AGOA exports were from the petroleum and petroleum products sector. Besides, very few countries were participating in the programme from the non-petroleum product sector. However, statistics available indicate that Ghana has used AGOA's duty free advantage for manufactured apparel and is now Africa's third largest AGOA exporter after oil and gems. Introduced in 2000, AGOA waives duties on more than 6,000 products that Africans can take advantage of in the duty-free area. ("Africa countries urged to spread product base of AGOA" (Ghanaweb Business News, 9 August 2006). At the same time Ghana's own non traditional exports has not grown considerably due to the stagnation of the industrial sector performance especially in manufacturing activities. Non traditional exports value was \$777.6 million in 2005 (up from \$705.4 million in 2004) accounting for only 10.2% of total exports value in 2005 (ISSER, 2006:96).

For instance, a review of the Ghana's economy in 2005 has established that the industrial and manufacturing sub-sector has not responded to the overall government policy objective of agricultural modernization and industrial transformation in the past decade. This is evident from both the share of GDP and the growth rate of the industrial sector that has remained stagnant since 1995 (ISSER, 2006:22). The processing of cocoa at the domestic level remains at 30%. Mineral beneficiation is very low. Table 14 illustrates the manufacturing sector performance for 1990 and 2002 respectively.

Table 14: Selected Indicators of Technological Capability in Manufacturing

Country	Manufacturing value added (MVA) per capita (1995 US\$)		Manufactured exports per capita (US\$)		Share of medium- or high-technology production in MVA(%)		Share of medium- or high-technology production in manufactured exports (%)	
	1990	2002	1990	2002	1990	2002	1990	2002
Gabon	244.9	251.1	..	334.5	23.1	34.3	16.4	3.1
Ghana	35.4	39.2	15.2	25.6	26.0	27.2	10.1	6.1
Kenya	28.4	26.1	22.2	19.2	24.9	22.4	27.7	14.4
Korea, Rep.	2237.6	4858.7	1455.4	3591.1	55.1	64.1	52.9	70.6
Senegal	73.7	91.1	65.1	32.8	18.8	34.9	..	0.1
South Africa	788.7	753.7	287.7	336.7	46.4	51.0	28.8	47.2
Tunisia	313.9	492.5	329.7	603.7	13.4	22.0	24.0	26.8

Source: Own compilation from UNIDO Industrial Development Report 2005, p159-160.

3.6.3 *Innovation strategies*

3.6.3.1 *Commercialisation of Research*

In 2001, the Government announced that the current initiative for partial commercialisation of some institutes of the Council for Scientific and Industrial Research would be extended to all the other Institutes of the Council. The Programme will also be extended to the Ghana Atomic Energy Commission, to make it possible for the institution to engage in the commercialisation of some of its activities. Also in line with the White Paper on Educational Reform "all tertiary institutions will be required to reinforce their links with the private sector economy, including industry, agriculture and commerce", while the Government will encourage industry, to participate fully in technical, artisan and vocational education and training at the polytechnic level (MEYS, 2004:39). Meanwhile, NCTE submitted a proposal to MoFEP which led to the formation of a 'Task Force for Effective Utilization of Research Findings by Industry' to review and dialogue with the various research institutions to determine ways to catalogue their findings and prepare a concrete action plan to commercialize Pozzolana, Glucose syrup and Activated Carbon. However, the road map must still produce proposals that would detail the institutions that would take up the production of the three products and the cost of production.

3.6.3.2 *Financial incentives for companies*

Government intends to develop financial incentives for companies using locally generated technologies, as well as the importation of environmentally sound technologies to support the country's development efforts.

Effective co-ordination mechanisms will be developed to link the private sector, especially in the industrial sector, with science and technology institutions to promote demand-driven research and thus increase the income generating capacities of these institutions.

Government will also promote small-scale on-farm technologies through which farmers can process and thus add value to their agricultural produce to promote food security and stability in the price of produce.

3.6.3.3 Environmental Impact Assessment

Government will enforce Environmental Impact Assessment as a management tool to ensure that environmental concerns are mainstreamed into the country's development programmes so that the integrity of the environment is maintained. Public institutions will be encouraged to establish environmental desks to ensure that the environmental impact policies are incorporated into their development agenda.

3.6.3.4 Establishment of technology transfer centre

The Ghana 'Task Force for Effective Utilization of Research Findings by Industry', noted that there was no comprehensive data on research findings by research institutions and recommended that a technology transfer centre should be established and located at either the Association of Ghana Industries or the Ministry of Education, Science and Sports. The technology transfer centre should be established to serve as a secretariat and techno pool for collating, analyzing, facilitating and coordinating activities of commercializing research findings, including public sensitization programmes. According to the committee's report, a twelve-member technology transfer board comprising representatives of relevant stakeholders including research institutions and industry should be established to, among other things, formulate policies to reflect government and other stakeholders' interest in commercializing research findings.

Moreover, a technology incubator park that would house key commercial inventions including machinery for the purposes of demonstration, test runs and exhibitions of research outcomes should be established and managed under the auspices of the technology transfer centre.

In collaboration with the Ministry of Trade and Industries, the Ministry of Communications has set up incubator laboratories at the Ghana Multimedia Centre. The incubators are currently nurturing 10 Start-Up Firms made up of engineering and IT graduates from Ghanaian universities with product development potentialities. The Ministry will continue to nurture more "Start Up" companies at the Incubator in 2006 and attract a pool of professionals in the field of Accountancy, Law, and Finance and Banking to assist the nurturing process of these companies especially the development of a Venture Capital model for the companies.

3.6.3.5 Presidential Special Initiatives PSI for strategic exports

Under the Presidential Special Initiatives (PSI), the GoG has already identified strategic exports where it believes such a focused approach is needed. These sectors include oil palm, cassava starch, salt, as well as textiles and garments.

3.7 *International co-operation and networks*

Ghanaian institutions and researchers are involved in international science and technology co-operation activities within both bilateral and multilateral context. Some of the research co-operation initiatives has led to establishment of some research centres and provided much funding for research activities including the supply of basic and advanced laboratory equipments. We discuss some of the important collaborative research and infrastructure initiatives linkages.

3.7.1 *Bilateral Co-operation*

3.7.1.1 *Noguchi Memorial Institute for Medical Research*

The Noguchi Memorial Institute for Medical Research is a semi-autonomous Institute of the University of Ghana established in 1979; and a constituent member of the College of Health Sciences, University of Ghana. The Japanese Government built and donated the Institute. It is a biomedical research facility and conducts research mainly into communicable diseases and nutrition. It consists of nine Academic Departments and has several facilities. In addition, the facilities provide training both undergraduates and postgraduates from tertiary institutions in the country and abroad. It has strong links with the Ministry of Health and provides high-end laboratory support to public health programmes of the Ministry. The Institute also provides training in laboratory methods to technicians of the Ministry of Health. JICA was established on 24 November 1979 and is a partner of Noguchi Memorial Institute for Medical Research (NMIMR) (1979-1999). Since then JICA has contributed to the Institute by Project-type Technical Cooperation scheme.

For example, Ghanaian researchers participate in INDEPTH Network that oversees the Malaria Clinical Trial Alliance (MCTA), a project funded through a 17 million-dollar grant provided by the Bill and Melinda Gates Foundation to conduct trials into malaria vaccines and drug intervention in Ghana, Mozambique, Senegal, Gabon, Kenya, Malawi, Tanzania, Nigeria and the Gambia. Under this programme, the University of Ghana together with Noguchi Memorial Institute for Medical Research, (NMIMR) and a university in Burkina Faso are to lead the way in clinical research programme.

In May 2006 EMBRAPA, a major Brazilian Agricultural Institute selected Ghana as its regional base for technical co-operation with African countries. The focus of this co-operation would be in priority areas like food security, agribusiness and energy production. The technical and bilateral cooperation agreements were signed by presidents of the two countries in Brazil in July 2006. Ghana and Brazil have signed two to further strengthen their in Brazil). EMBRAPA would now open its Africa Regional Office in Accra, Ghana, a development likely to provide the needed impetus to the country's drive to modernise its agriculture.

3.7.1.2 *Ghana-India Kofi Anan Centre of Excellence in ICT*

One of the important South-South co-operation initiatives is the Ghana-India Kofi Annan Centre of Excellence in ICT (AITI-KACE), which is Ghana's first Advanced Information Technology Institute works to stimulate the growth of the ICT Sector in ECOWAS. Established in 2003, through a partnership between the Government of Ghana and the Government of India, this state-of-the-art facility provides a dynamic environment for innovation, teaching and learning as well as practical research on the application of ICT4D in Africa. The Centre houses West Africa's first supercomputer as well as top-of-the line desktops and laptops. The Centre has trained 24 personnel from 24 districts in the country in computer software skills, CIC concepts and how to successfully manage a CIC. The

Centre's research programme is building a West African network in supercomputing designed to help build bridges between specialist researchers within the sub-region. The primary focus of this work is climate modelling.

In addition to AITI-KACE, Ghana signed a Memorandum of Understanding (MOU) with the Telecommunications Consultants India LTD (TCIL) to "establish a VSAT based Tele-Medicine and Tele-Education Infrastructure for African Countries" in August 2005. The MOU is pursuant of an initiative by the Government of India to establish a VSAT based tele-medicine and tele-education infrastructure for Pan African Countries. TCIL is an Indian Government owned company mandated by the Indian Government to serve as the executing agents for the Project. Under the project, 53 African countries will be connected through Satellite and Fibre optic link for electronic data connectivity to the African nations on an announced budget of \$50 Million covering installation, initial operation and maintenance for 3 years.

3.7.1.3 *Canada-Ghana Science and Research Council*

Canadian High Commissioner Donald Bobiash formally launched the Canada-Ghana Science and Research Council in Accra on 24 February 2005. The Council will provide a new focal point for Canadian agencies involved in development assistance, science, research and trade promotion with Ghana. The Council is interested in research in the areas of health, agriculture, food science, energy and appropriate building technologies, as well as new fields of scientific research, such as biotechnology. The Council will develop new linkages between the science and research communities of the two countries and, in promoting linkages and exchanges, help replace the brain drain with brain exchange. A CAD\$18000 grant was provided by IDRC to assist the Canadian High Commission in supporting the Canada-Ghana Science and Research Council in the first year of its inception. http://www.idrc.ca/en/ev-83046-201_103316-1-IDRC_ADM_INFO.html 2 Nov 2006)

The IDRC is also supporting a project on the "Strategies for Health Insurance Mechanisms to Address Health System Inequalities in Ghana, South Africa and Tanzania" involving researchers from the three countries. According to the project abstract, it will critically examine existing inequities in the health systems of Ghana, South Africa and Tanzania. The results of which will inform alternative approaches to health insurance as a mechanism for addressing health system inequities and achieving the Millennium Development Goals. The project will form the basis for a larger three-year project that has been short-listed for support by the European Union. http://www.idrc.ca/en/ev-83046-201_103457-1-IDRC_ADM_INFO.html. The recipient institutions include: the Health Economics Unit, School of Public Health, University of Cape Town, South Africa (CAD\$142,400); the Ghanaian Health Research Unit, Ghana Health Service, Ghana (CAD\$96,200); and the Ifakara Health Research and Development Centre in Tanzania (CAD\$96,200).

Meanwhile the Faculty of Forest Resource Technology at KNUST in Sunyani has secured a CAN\$3 million grant from the Canadian International Development Agency (CIDA) to undertake an agro-forestry project in the municipality. In addition, the faculty in collaboration with the Sunyani Polytechnic has received a grant of CAN\$500,000 from CIDA to undertake a five-year project in waste and bushfire management, awareness creation about HIV/AIDS and to encourage eco-tourism in Brong Ahafo with support from Malaspina University in British Columbia.

3.7.1.4 *Kumasi Centre for Collaborative Research*

The Kumasi Centre for Collaborative Research in Tropical Medicine (KCCR) is a joint venture between the Ministry of Health of the Republic of Ghana, the Kwame Nkrumah University of Science and Technology and the Bernhard-Nocht-Institute for Tropical Medicine (BNITM), Hamburg, Germany. The KCCR is committed to establishing a first class research institution in tropical medicine in Ghana, combining research with educational programmes. The concept behind this Centre is to act as an international platform for biomedical research based upon the close collaboration between KNUST (School of Medical Sciences (SMS), Faculty of Science), Ghana, and the Bernhard Nocht Institute for Tropical Medicine, BNITM, in Hamburg, Germany. Some of the current collaborating Institutions outside Ghana include the University of Bonn, Germany; University of Alabama at Birmingham (UAB), USA and the St. Georges Hospital Medical School, London. KCCR supports postgraduate training for masters and PhD students using the infrastructure at KCCR, BNITM and other institutions. Currently, KCCR has 3 Ph.D. students and 9 M.Phil students pursuing their thesis projects.

DANIDA is supporting the "Capacity Enhancement Project (CEP)-Ghana" a collaborative research by the Crops Research Institute (CRI) and the Danish Seed Health Centre (DSHC). Crop scientists and researchers are developing new varieties of cereals and grains that will contain high levels of iron and zinc in order to increase the intake of the two minerals in the country.

3.7.2 *Multilateral co-operation*

Ghana participates in a multilateral science and technology programmes that has benefited its science and innovation systems in the last five decades. For example through its member of International Atomic Energy Agency and participation in the Agency's programme, it has been able to build a sound foundation for nuclear research and technology applications in the country. It also has good relations with the World Bank, UNIDO, UNCTAD, UNDP, the European Union and CTA etc, which support various programmes in the country. Within Africa Ghana participates in regional and sub-regional S&T programmes and host the headquarters of the Forum for Agricultural Research in Africa (FARA) as well as the FAO African Regional Office. It participates in NEPAD S&T Programmes and currently serves as the co-ordinator for the West African Sub-region.

3.8 *Conclusion*

Although there has been political interest in creating scientific and technological institutions to promote socio-economic development most of these institutions were not and are still not been given adequate financial resources to enable them perform their prescribed mandates. Without external donor support, most of these research institutions can undertake functional and competitive research activities. Thus far, the GETFund has proved to be the most innovative approach in funding educational infrastructure development and research in post independent Ghana. Despite these initiatives total expenditure as percentage of GDP are less than 1% and the failure to establish an independent national Science and Innovation Fund up to date remains a major of weakness of the Ghana Science and Innovation System. The government announced the establishment of an Endowment Fund for Science and Technology Research with initial allocation of 5.0 billion cedis in the 2007 National Budget Statement, which is a bright start. The CSIR will co-ordinate this initiative but as research performing institution, the CSIR may compromise the Fund's independence.

Brain drain of the highly skilled professionals remains a serious human resource development challenge and without adequate policy mechanisms to address the net skills outflows, scientific and technological innovation will remain very weak. Nevertheless, the prospects for technological innovation are bright amid the enormous challenges some of which require strong bilateral co-operation agreements with effective programmes as well as regional approaches to address them, especially through the ECOWAS and AU/NEPAD programmes.

4. References

- Arvanitis, R., Waast, R. & Gaillard, J. 2000. *Science in Africa: a Bibliometric Panorama Using PASCAL Database (Paris)*.
- Calvillo, E., Huang, K. G. L., Lim, S. Y. & Mutuku, F. L. 2002. DHP P232/ESD. 127 *Telecommunications Modelling and Policy Analysis. Information Infrastructure Enhancement Initiatives: A Case Study of Ghana*, 6 May 2002.
- Frempong, G. 2005. "Ghana" in: A. Gillwald (Ed) *Towards an African e-Index: Household and Individual ICT Access and Usage across Ten African Countries*. Chapter 6, pp 94-105.
- Ghana Statistical Service (GSS) 2005a. *Ghana Population Data Analysis Report volume 1 Socio-Economic and Demographic Trends*. Accra: GSS, August 2005.
- Ghana Statistical Service (GSS) 2005b. *Ghana Population Data Analysis Report volume 2 Policy Implication of Population Trends*. Accra: GSS, August 2005.
- Institute of Statistical, Social and Economic Research (ISSER) 2006. *The State of the Ghanaian Economy in 2005*. Legon: ISSER, University of Ghana.
- National Council on Tertiary Education (NCTE) 1998. *Report on Funding Tertiary Education*. TRS Vol. 1 No. 1 August 1998.
- National Council on Tertiary Education (NCTE) 2002a. *Meeting the challenges of education in the Twenty First Century*. Report of the President's Committee on Review of Education Reforms in Ghana. October 2002. Accra: Publications (Gh) Ltd.
- National Council on Tertiary Education (NCTE) 2002b. *Annual Report 2002*.
- National development Planning Commission 2005. *Growth and Poverty Reduction Strategy (GPRS II) (2006-2009)*. Volume 1 Policy Framework. Accra: NDPC.
- National development Planning Commission 2003. *Ghana Poverty Reduction Strategy 2003-2005. An Agenda for Growth and Prosperity*. Volume, Analysis and Policy Statement. Accra: NDPC
- UNFPA and Population Reference Bureau 2006. *Country Profiles for Population and Reproductive Health, Policy Developments and Indicators 2005*, produced jointly by UNFPA and Population Reference Bureau. March 2006.
- University of Ghana (UG) 2006. *Annual Report 2005*. Legon: UG
-

Appendix A: Evolution of selected research institutes in Ghana

1930s	In 1938 Cocoa Research Institute was established
1940s	In 1947 the Savanna Agricultural Research Institute (SARI) was established at Nyankpala, Tamale In 1948, the University College of Achimota was established
1950s	In 1952 the Building and Road Research Institute was established The promulgation of the Research Act of 1958 (No. 21) and the actual establishment of the National Research Council (NRC) which became effective from 14 February 1959. The NRC was to promote and co-ordinate all aspects of research including the application of research results in Ghana.
1960s	In 1960, under Legislative Instrument Number 72, a Research (Repeal) Act was brought into force simultaneously with Executive Instrument 214, which rescinded the 1958 Research Act thereby, abolishing the original Council. In 1963, the NRC formally ceased to exist, after it was merged with the Ghana Academy of Learning (a process that begun in 1959) under the new name Ghana Academy of Sciences (GAS). The NRC became the Research Division of GAS. The Ghana Atomic Energy Commission (GAEC) also established as a statutory body by an Act of Parliament (ACT 204, 1963). It is the national agency in Ghana responsible for all matters relating to the peaceful uses of nuclear and atomic energy. In 1964, the Animal Research Institute (ARI), Crop Research Institute (CRI), the Forestry Research Institute of Ghana (FORIG), and Plant Genetic Resources Research Institute were established. Also the Institute for Scientific and Technical information was created in the same year. In 1967 the Palm Oil Research Institute was created at Kade. The National Liberation Council (NLC) military regime appointed the Cockcroft Committee to advice on the future organisation of the Ghana Academy of Sciences. The Cockcroft Committee recommended that GAS be reconstituted into the Council for Scientific and Industrial Research (CSIR) and the Ghana Academy of Arts and Sciences (i.e., separating the Research Division from the Learned Society - Academic Division). These recommendations were accepted on 12 October 1968, and the CSIR was established under NLC Decree 293 and on the 7 th of February 1969 amended through CSIR (Amendment) Decree. The CSIR was to advise government on S&T policy.
1970s	In 1975 the Centre for Scientific Research into Plant Medicine was created at Mampong-Akuapem under Ministry of Health First establishment of the Ministry of Industries, Science and Technology (MIST) in September 1979. On 24 November, 1979 Noguchi Memorial Institute for Medical Research (NMIMR) was established as of the first medical research institute in Ghana. The Institute was built and donated to the people of Ghana by the Japanese Government and it is named after Dr Hideyo Noguchi, a Japanese scientist who died in Ghana in 1928 while researching into yellow fever. The Institute is a biomedical research facility and conducts research mainly into communicable diseases and nutrition. It is made up of nine Academic Departments and has several facilities. Since then JICA has contributed to the Institute by Project-type Technical Cooperation scheme. Noguchi research in snake venom was so remarkable that he got several awards and became a research fellow at the Rockefeller Medical Institute.
1980s	Science and Technology Policy research Institute was established 1981
1990s	University for Development Studies at Tamale (1992) University of Education at Winneba (1992) 1996 the Water Research Institute was created
2000 to present	University of Mines and Technology at Takwa (2004) Ghana Telecommunications University College, Accra (September 2006)

Source: Compiled by author

Appendix B: Summary of major policies driving research and institutional programmes

Policy/Act	Date
National Industrial Policy	To finalise 2007
Strategic Plan for Science and Technology Development	To finalise 2007
Draft National Health Policy	2006
Ghana Poverty Reduction Strategy II	2005
White Paper on the Report of the Education Reform Review Committee	2004
Draft Energy Sector Policy	2006
Draft Food and Agricultural Sector Development Policy (FASDEP)	2006
The Ghana ICT for Accelerated Development (ICT4AD) Policy	2003
National Science and Technology Policy Document	2000
Ghana Atomic Energy Commission Act	2000
Ghana Poverty Reduction Strategy I	2001
Ghana Vision 2020	1995
CSIR Act	1996
Telecommunications Policy for accelerated Development Programme 1994-2000	1994

Source: Compiled by author

Appendix C: Summary of functions of S&T agencies

Agency	Established	Key functions
Ghana Atomic Energy Commission (GAEC)	ACT 204, 1963 (Act 588 -2000)	<ul style="list-style-type: none"> • Co-ordinate and promote research into peaceful and safe applications of nuclear energy, science and technology, and biotechnology in sectors such as agriculture, energy, environment, geology, health and industry; • Advice Government on all matters relating to nuclear energy, science and technology; • Commercialize its research activities; • Make proposals to Government for the Legislature in the field of nuclear radiation and radioactive waste management.
National Council on Tertiary Education (NCTE)	1972(re-est. in 1993 by Act 454)	<ul style="list-style-type: none"> • co-ordinating body for the re-defined tertiary sector • Responsible for examining the budgets and programmes of tertiary institutions before submitting them to the Ministry of Education. • Seeks to promote a diversified, dynamic, high quality, cost effective teaching, and research and skills development within a financially healthy tertiary education sector, having regard to national needs. • promotion of access, quality, relevance and equity in tertiary education delivery.
National Development Planning Commission (NDPC)	Acts 479 and 480 (1994)	<ul style="list-style-type: none"> • mandate to advise the President on development planning policy and strategy • to advise the President of the Republic of Ghana (and Parliament upon request) on development policy and strategy, to prepare and ensure the effective implementation of approved national development plans and strategies and coordinate economic and social activities country wide in a manner that will ensure accelerated and sustainable development of the country and improvement in the standard of living for all Ghanaians.
Ghana Academy of Arts and Sciences	1959	<p>The Academy's objectives, partly reviewed over the years are:</p> <ul style="list-style-type: none"> • To promote the study, extension, and dissemination of knowledge of the arts and sciences. • To establish and maintain proper standards of endeavour in all fields of the arts and sciences. • To recognise outstanding contributions to the advancement of the arts and sciences in Ghana. • To contribute actively to the development of Ghana and Africa generally by examining and addressing crucial issues of development. • To do such other things as are conducive or incidental to the attainment of all or any of the foregoing objects.
Ghana Standards Board	NRCD 173, 1973	<ul style="list-style-type: none"> • National Statutory Body responsible for the quality infrastructure of the Nation embracing Metrology, Standards, Testing and Quality Assurance (MSTQ).

Source: Compiled by author

Appendix D: Public universities and key faculties in Ghana

Institution	Faculties/Colleges	Selected Research Centres
University of Ghana at Legon	<p>College of Health Sciences</p> <p>Faculty of Arts</p> <p>Faculty of Engineering Sciences</p> <p>Faculty of Law</p> <p>Faculty of Science</p> <p>Faculty of Social Studies</p> <p>Business School</p> <p>School for Research and Graduate Studies</p>	<ul style="list-style-type: none"> • Institute of Adult Education • Institute of African studies • ISSER • Legon Centre for International Affairs (LECIA) • Regional Institute for Population Studies (RIPS) • School of Communication Studies • Noguchi Memorial Institute for Medical Research
Kwame Nkrumah University of Science and Technology at Kumasi	<p>College of Agriculture and Natural Resources</p> <p>College of Architecture and Planning</p> <p>College of Arts and Social Sciences</p> <p>College of Engineering</p> <p>College of Health Science</p> <p>College of Science</p> <p>School for Research and Graduate Studies</p>	<ul style="list-style-type: none"> • Bureau of Integrated Rural Development • CBUD • Dairy/Beef Research Station • Centre for Human studies • Centre for Land Studies • Centre for Cultural and African studies • Centre for Energy Research and Development • Technology Consultancy Centre • Kumasi Centre for Collaborative Research In Tropical Medicine • National Centre for Mathematical Sciences
University of Cape Coast	<p>Faculty of Arts</p> <p>Faculty of Education</p> <p>Faculty of Science</p> <p>Faculty of Social Science</p> <p>School of Agriculture</p> <p>School of Biological Sciences</p> <p>School of Business</p>	<ul style="list-style-type: none"> • Centre for Development Studies • Laser and Fibre Optics Centre (LAFOC) • Institute of Educational Planning and Administration (I.E.P.A.) • Institute of Education • Centre for Continuing Education (CCE)
University for Development Studies at Tamale	<p>Faculty of Applied Sciences</p> <p>Faculty of Integrated Development Studies</p> <p>Faculty of Agriculture</p> <p>School of Medicine and Health Sciences</p>	

Institution	Faculties/Colleges	Selected Research Centres
University of Education at Winneba	Faculty of Applied Arts and Technology Faculty of Social Sciences Faculty of Language Education Faculty of Education Faculty of Science Education School for Research and Graduate Studies	Institute for Educational Development and extension <ul style="list-style-type: none"> • Centre for Distance Education • Centre for Teacher Development and Action Research • Centre for Continuing Education • Centre for Educational Policy Studies
University of Mines and Technology at Tarkwa	Faculty of Mineral Resources Technology Faculty of Engineering	
Ghana Telecom University College, Accra		

Source: Compiled by author
