University Research Centres on Central Sub-Saharan Africa: A Capacity Building Objective in Engineering and Technology

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Abstract

The combination of an urgent need for graduates to support the development of Central Sub-Saharan Africa and an explosion in demand for secondary and tertiary education demands a significant increase in postgraduate research training within the region. The need for engineering, technology and science graduates, essential for the management of the human and natural environment and commercial competitiveness in global markets, dictates that there has to be an increase in technology-based postgraduate training. These postgraduates are needed to teach the undergraduates of engineering and technology courses and to fill senior positions in government and industry. Along with the need for more technology-trained post-graduates is the need for appropriate technology to underpin the commercial and industrial growth and ensure that development is sustainable. The demand for post-graduates and technology development is best accommodated through research institutes/centres, thematically focused and concentrating on both postgraduate training (capacity building) and innovation for economic and social development. One such initiative at Uganda Christian University for the formation of an International Centre in Sustainable Engineering and Technology is briefly described.

Introduction

Globalisation, water quality and quantity deterioration (UNESCO, 2003), health (African Hunger 2002), population growth, and life-style expectations are some of the challenges facing Africa. Engineering, technology and science development has the potential to contribute to human and environmental health in the region, provided it is carefully managed and articulated in accepted socio-economic goals.

This paper reviews the state of technology training in Central Sub-Saharan Africa and reports a proposal for the development of a Research Centre for Sustainable Engineering and Technology. This paper, which draws on the work of Riley and Riley (2003) and Riley and Noll (2003), emphasises Central Sub-Saharan Africa, although reference will be made to countries outside of this region.

80% of the World's population lives in developing countries, yet accounts for only 2% of the global expenditure on scientific research (Szaro et al., 2002), a smaller proportion of the research output, and less than 20% of the working scientists (Nchinda, 2002). In a world where human capital is considered the most important component of any enterprise, this inequity is wastefull. UNESCO (2002) cites only one scientist or engineer per 10,000 for sub-Saharan Africa compared to one per 200-500 for Japan, Europe and the US. Table 1 (Riley and Riley, 2003) shows the present status of Universities and Research Centres in the various countries of Sub-Saharan Africa.

Central Sub Saharan Africa runs the risk of being marginalised and excluded from the benefits of global research (Szaro et al., 2002, Genthner, 2001). Globalisation impacts on research in industry, agriculture and the environment (Gaillard and Thulstrup, 1994).

While the weakness in research in developing areas of Africa is largely historical, it is also due in part to the low or slow return on investment (Szaro et al., 2002), governments' preference to invest resources in projects that will ensure economic growth (BBC World Service, 2002), and the simple fact that much of the needed hardware and consumables for scientific research (instruments, materials, chemicals, communication) tend to be much more expensive in developing than in industrialised countries (Thulstrup, 1993 cited in Szaro et al., 2002). Internet publishing is likely to overcome the shortage of library resources, given that researchers have good internet access. Other resources are likely to remain in short supply. There are other factors which complicate and frustrate research initiatives, such as poor salaries, lack of incentives, and social status.

Research is vital for establishing a technology-based economy and encouraging value adding to primary commodities. Support is needed to build research capability (Nchinda, 2002). Research Centres that focus on innovation that leads to commercialisation, better environmental and community management, and improved health and job opportunities, will be valued by their communities and survive the viscitudes of government and donor funding.

Capacity Building To Promote Research

Capacity building, defined as "the ability of individuals, groups, institutions and organisations to identify and solve development problems over time." (Morgan cited in Hilderbrand and Grindle, 1994) focuses on institution building (UNESCO-IICBA, 2002) as the key strategy in ensuring sustainable development (Luijendijk et al., 1999).

There will be an exponential growth in demand for tertiary training within the next 5 to 15 years. Universal Primary education in Uganda, as in other countries, with flow-on to secondary and tertiary training is partly driving this growth. The growth is also driven by deliberate Government policies to improve economic competitiveness and social well-being (UGANDA PEAP, 2001), the increasing ability of the population to afford such training, and almost universal recognition of the value of secondary and tertiary training. Uganda, for instance, expects a threefold increase of University applicants from 60,000 in 2001-02 to 180,000 in 2008 (Kasozi, 2002).

In order to meet the need for technical training in the region there will have to be a significant expansion in tertiary training. Specifically, for degree-based engineering and technology training programmes, there has to be at least an order of magnitude increase in the number of places offered. The number of appropriately qualified academic staff required to maintain the engineering and technology programmes of the Universities will increase significantly. Hence the Ugandan Ministry of Education "Issues Paper" (p. 153) calls for the training of 1000 M.A. graduates and 250 Ph.D graduates in science and technology as an immediate priority (Kasozi, 2002). But the present in-country resources for such advanced training are sadly lacking.

Many Universities in the region now require their staff to have Ph.Ds. While it is unlikely that 100% compliance will be achieved, the requirement will increase the demand for doctoral courses in-country. At present, however, only a trickle of Ph.Ds are home-grown. There will be a need for Master's and PhD's that are internationally competitive. Study costs at home are cheaper than overseas study. The cost of an African student undertaking a 3 year Ph.D programme in engineering at an Australian University (this varies slightly from

University to University) is approximately $US50,000 ($28,000 for tuition and fees; $20,000 for living expenses; and $3,000 for travel). It is not possible to judge the exact nature of the demand in Central Sub-Saharan Africa. There is ample evidence that even a 100 graduates per year will not meet the requirements of tertiary training, government and industry.

Universities As Centres For Capacity Building

Fincham et al. (2002) describe universities as being knowledge Centres in capacity building for the future. Tertiary institutions involved with scientific and technological research will be central to forming partnerships for sustainable development. The operating environments defines research Centres. Within the African context there is a need to ensure that practical and useful measures are delivered to the poor (Szaro, et al., 2002), in an applied problem orientated and socially responsive environment (Luijendijk, et al., 1999; AAAS, 2002). Capacity building has to accord with national planning and match the needs of the community (Cissé et al., 1998 cited in Szaro et al., 2002). Sustainability of the programmes is important (IFPRI, 2002) and it has to be accepted that developing a research culture takes a long time and is costly (Maya, 2002). Two main inter-related and inter-dependent activities form the basis of institutional development through research capability strengthening (Nchinda, 2002): 1) improving, through appropriate training, the capabilities of scientists, technologists and engineers to undertake quality research and 2) providing institutional support, supplies and other logistic support to the institution in which the trained scientists have to work (Rowley, 2002).

Overseas study has enormous benefits to an individual but often it represents a loss of human resources and inhibits the promotion of regionally relevant research. Approximately 30,000 Africans holding PhDs in Science and Technology are living outside of the continent (UNESCO, 2002). Technical expertise is often very specific for a given country and locale, and this expertise may not be obtainable in an overseas institution (Thulstrup 1993 cite in Szaro et al., 2002). Overseas training is also becoming increasingly expensive (IFPRI, 2002). Postgraduate training should ideally take place at home or in a neighbouring country.

In 1997, universities in Denmark discussed the concept of universities from disparate parts of the globe working together to develop their capacities around strategic environment and development concerns within urban and industrial settings. Under the umbrella of the Linked University Consortia for Environment and Development - Industry and Urban Areas (LUCED-I&UA), the Southern African Consortium of Universities for Development and Environment - Industry and Urban Areas (SACUDE-I&UA) was formed in 1998. The objective of this, and a number of other consortia worldwide, was to consolidate tertiary level expertise in an effort to enhance education, research capacity and continued education in environmental management in an urban context (Fincham et al., 2002).

The importance of long-term financial commitment to success in capacity building through research is an issue which has been strongly emphasised (Szaro et al., 2002). Encouraging sustainability may come about through the introduction of affordable fee structures for partial cost recovery (AAAS, 2002). Private funding is critical for sustainability and strengthening public-private partnerships is one way to mobilise such resources (UNCSD 1997 cited in Szaro et al., 2002). Linkages with new local, small scale industries may be the way forward as these partners are more likely and able to implement radical technology changes (Maya, 2002).

Technology Training

There is a clear and well-established link between economic development and education in science and technology, as indicated by initiatives like the UNESCO "Science-Led Development in Africa Programme" (UNESCO, 2002). The Africa Workshop Programme: Knowledge for Development, held at Makerere Institute of Social Research May 13-30 2002 with support of the World Bank Institute presented papers on three countries, Uganda (MISO, 2002), Ghana (Adei et al, 2002) and Tanzania (Economic and Social Research Foundation, 2002) all of which identified the weakness of technology and science training in the region and more particularly in the area of innovation. In Uganda, for instance, the three Universities with substantial technology programmes – Makerere, Mbale and Kyombogo – have a total student enrolment in four-year engineering degrees of approximately 1000, for a country of 23 million people. This is strikingly disproportionate to that of a country like Australia, which with a population of 19 million has 53,282 students undertaking four-year Bachelor of Engineering degrees (2001 – Australian Council of Engineering Deans, 2002).

Technology training can progress from two directions – from the bottom up or "low-end" Polytechnics or Technical Institutes, and from the top down through "high-end" research centres/institutes. Both are appropriate and both achieve different goals within the constraints of time and finance. Neither is in conflict with the other. They are complementary. The bottom-up approach concentrates on technical training at the level of certificates and diplomas. The top-down approach concentrates on postgraduate training. It is the premise of this paper that the quality of field engineers and technologists will depend to a large extent on the training that lecturers and technicians receive at University and are thus able to communicate in training schools and polytechnics.

Linkages between Universities, research Centres and industry will be crucial for the proper development of technological education in Africa. The UNESCO UNISPAR programme (UNiversity-Industry-Science PARtnership) is one of the initiatives to develop the links and is focused at the small-to medium scale enterprise (UNESCO, 2001). In a recent report by UNESCO it was noted that:

> Not only has regional or local intervention become more important to economic success, but there has been a qualitative shift in the form of local policy towards indigenous entrepreneurship and innovation, and to providing a more sophisticated environment for mobile capital so as to maximise local value added (R&D and other higher status jobs, successful and therefore growing firms). This leads to a greater concern to harness university education and research to specific economic and social objectives.
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> Nowhere is this demand for specificity more clear than in the field of regional development. While universities are located in regions, questions are being asked about what contribution they make to the development of those regions? Whilst it might be possible to identify passive impacts of universities in terms of direct and indirect employment, how can the resources of universities be mobilised to actively contribute to the development process?
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> This implies a better understanding of universities on the part of regional actors and agencies and of regional dynamics on the part of the universities. (UNESCO, 1998, vol IV, p. 7)

A small but truly "international" research Centre has the advantage of a focussed programme so that it can select the proper partner Universities and Centres to develop linkages with. At

the same time, it will seek partners in Government and the business community to employ its graduates and to apply and market its innovations.

Research Centre at Uganda Christian University

Uganda Christian University, one of the oldest tertiary institutions in Central Sub-Saharan Africa, has launched an initiative to develop a Research Centre for Sustainable Engineering and Technology. They are presently seeking funding for this proposal.

The Research Centre will have two core objectives:

a. to produce postgraduates to meet the increasing need for suitably qualified staff for tertiary institutions in the region, all of which are experiencing an exponential growth in the numbers of students enrolling in engineering and technology programmes; and
b. to undertake innovative research on appropriate technology using the resource of the research students and staff, working in an environment that will ensure that new knowledge is directed towards establishing industries through processes of licensing and franchising the new knowledge.

The Research Centre will be expected to have a postgraduate student population of 100, and in the first ten years graduate more than 250 students. The available data suggest that there is no facility similar to that proposed herein. Recommendations have been made to establish such Centres, but at present none exist in the area of engineering and technology (UNESCO, 2002) in Central Sub-Saharan Africa. Amongst the 20 UNESCO funded chairs at universities in sub-Saharan Africa are chairs in Renewable Engineering (Zimbabwe), Chemical Engineering (Angola and Zimbabwe), Science, Technology and Environment (Benin), and Applied Sciences and Engineering (South Africa). There is also the UNESCO established African Network of Scientific and Technical Institutions (ANSTI) established in 1980 (UNESCO, 2002).

The proposed IRCSET initiative should not be taken as a criticism of the research work already underway in the region and the research Centres that have operated for many years. There are well-known research Centres in Agriculture and other Sciences (e.g. Institute for Meteorological Training and Research – IMTR, Kenya). There is also research underway in technology and engineering in the long-established Universities. There are also long established collaborative relationships between overseas Universities and those in the region (e.g. Water, Engineering and Development Centre WEDC at Loughborough University in the U.K). However, the recent review of engineering and technology development in the region highlighted the lack of focused research Centres in this domain of knowledge and the significant of this to the economy of the region.

The proposed International Centre (IRCSET) is intended to benefit all of Central Sub-Saharan Africa. However, the location of the Centre in Uganda is not accidental. Uganda has been recognised in the past decade as one of the progressive nations of the region, with political stability, economic growth and the willingness to address impact issues like HIV/AIDS. Uganda has instituted Universal Primary Education (UPE), which is now burgeoning into the secondary and tertiary levels.

Since 1997, Uganda has focused its country plan for development around the theme of Poverty Reduction. This plan has recently been spelt out in its Poverty Eradication Action Plan (UGANDA PEAP, 2001). This plan works on the assumption that poverty reduction

cannot be addressed by mere infusions of relief funds. Rather it "must emanate from a stable macroeconomic environment which is conducive to increasing overall economic growth, savings, and investment, thus increasing production and trade" (p. 58). The achievement of this macroeconomic environment, the Report goes to say, depends heavily on "human capital," achieved through entrepreneurship and tertiary education" (p. 79). In particular, tertiary education must have a technological focus:

> Skills development and attraction of technology is critical for Uganda's investment drive. Presently, there is an urgent need to interface the education system (including vocational training) with the needs of the private sector. Establishing linkages with international/foreign technology Centres is vital for faster acquisition of modern technology to build competitiveness in the domestic economy. (p. 79)

The Report goes on to specify a certain model for this technological development:

> Other countries that have succeeded in developing their technical capacities in the private sector and attracted modern technology have used the concept of "Centres of Excellence", which can be applied to Uganda (for example, providing incentives for the establishment of high quality secondary and/or technical educational institutions by private sector investors). (p. 79)

Appropriate Technology

One of the primary objectives for the proposed Research Centre is to focus postgraduate research training on the development of appropriate technology. The reasons for this are:

- the benefits to the regional economy of relevant new knowledge;
- the opportunity to sustain the Centre through licensing and franchising of IP;
- the relevance of the postgraduate training to the conditions that the graduates will encounter in their workplaces; and
- the maximisation of returns for the limited resources.

For this proposal "appropriate technology" is taken to mean technology applied to the existing socio-economic structure of the region with a high probability of achieving the dual goals of rapid application and socio-economic benefit. The region has a rich variety of engineering and technology problems that stimulate proposals for a large number of research programmes that focus on them.

The economic imperatives facing the region in the area of engineering and technology, which will help define the research agenda of IRCSET, primarily lie in the following areas:

- water: the region has a chronic shortage of potable water, which is having an adverse effect on health and industry
- waste: the cities have waste management problems. There are also issues related to waste of energy and materials that may lead to more efficient industries, secondary or associated industries and new forms of energy production and materials
- energy: while there have been substantial improvements in the generation and distribution of energy, much remains to be done. Alternative energy systems that take advantage of some of the abundant resources of the region, such as ethanol as an alternative fuel, have not been fully researched or exploited (see initiatives such as the World Bank African Rural Renewable Energy Initiative).
- Materials: the substitution of locally derived materials for imported ones and the development of new materials using local resources

- Management: new systems and products can fail because of poor management systems and inappropriate methods of introduction to the economy

As part of its dramatic growth, the University has dedicated itself as a "Centre of Excellence in the Heart of Africa" and has founded a new Faculty of Technology, which will offer a Bachelor of Science in Information Technology, Bachelor of Science with Education, and (in the future) diplomas and degrees in medical and paramedical subjects. The International Centre will be the jewel in the crown of this new Faculty, as the principal doctoral-level course at the University. Another side of the "Centre of Excellence" is the founding of an Honours College for high achievers and for "semester abroad" students from the USA.

There is one additional potential in Uganda Christian University. According to its "Regional College Initiative," the University plans to develop three regional Constituent Colleges: in the West (Bishop Barham College, Kabale), in the East (Mbale) and in the North (Gulu and/or Arua). These colleges will be networked electronically with the main campus, and students may "move up" from them to complete a particular programme.

The Regional College Initiative is in line with the Government's own priority of decentralisation through the Local Government Act (1997). It can also assist Government priorities for vocational education (UGANDA PEAP, 2001) and community polytechnics and paramedical institutes (Kasozi, 2002). These colleges can provide lower level technical education (diploma and Bachelor of Technology), making use of professors, postgraduate students and graduates of the Institute. The University can then partner with Government to oversee and strengthen polytechnical, technical, paramedical and vocational training schools in these areas.

IRCSET will focus on the region, but it will also have at least two contributing overseas Universities in the first stages of its development, partly to ensure overseas participation in the academic staffing of the Centre and partly to ensure that the Centre is linked to Universities with international reputations, during the first stage of its development.

Collaboration amongst contributing Universities is critical and will provide several opportunities:

1. the opportunity for African Universities to be involved in a Centre in Engineering and Technology and ensure that it achieves an international reputation;
2. the opportunity to share resources and reduce infrastructure costs;
3. the opportunity for staff to share in postgraduate supervision and undertake specific research projects within the Centre;
4. the opportunity for students to receive degrees from a variety of Universities, including joint degrees;
5. the opportunity for students to receive international degrees without leaving the region;
6. the opportunity to pool intellectual resources in problem solving and research development (innovation).

It is one of the aims of the Centre to share resources, particularly for the more expensive items of equipment and laboratories. Reference material can be obtained through use of partner University libraries, and some software is likely to available through partner Universities ICT departments. The Centre will concentrate on accessing internet-based

reference material through the partner Universities. There is a worldwide move towards open access to scientific papers (http://www.soros.org/openaccess/read/shtml) along with the development of the World Virtual Engineering Library (World Federation of Engineering Organisations, WFEO), the Australasian Virtual Engineering Library and the Virtual Colombo Plan (cited in Civil Engineers Australia, Sept 2002, p.39).

Conclusion

The proposed centre for technology excellence at Uganda Christian University (IRCSET) will supply trained postgraduates to staff the new and growing undergraduate programmes in engineering and technology. It is proposed that local graduates will undertake postgraduate study and disseminate new knowledge to inform engineering practice. This flow of information will take place primarily as post graduates take up appointments in Universities, government or industry; in short-course and coursework masters programmes focussed on new knowledge; and in newly developed industries based on IRCSET-developed technology.

IRCSET should become a focus for research in sustainable engineering and innovation in the region. It will attract visitors from outside of the region as its reputation grows. Visiting staff will be encouraged to work collaboratively on research programmes with students and staff of the Centre. Collaboration will be a condition of involvement with the Centre.

There is a significant need for research capacity in the Sub-Saharan region. The models for developing capacity building through University research Centres is well established in developed countries and their application to developing economies well understood. The critical issues are ones of relevance, linking to the regional economies, reputation, and financial sustainability. Engineering and Technology Centres of excellence are not inexpensive, but the returns to the community can be significant.

The development of Research Centres is not elitist. It is a map for the future, linking economic development, reduction of poverty, and regional engagement with the global economy.

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Table 1. Universities and Institutions of Higher Education in Sub-Saharan Africa

Country	Number of Private University	Number of State University	Extra Campus	FACULTIES			School /College In Science, Technology And Engineering	Institute/ Centre In Science, Technology And Engineering
				Total Number Of Science Related Faculties	Engineering And Technology	Science		
Angola		1		3	1	2		1
Benin		1		2		2	1	
Botswana		1	1	2	1	1	3	
Burkina-Faso		4		7	5	2	1	2
Burundi		1		1		1		
Cameroon	1	6	3	10	2	8	8	5
Cape Verde	0	0	0					
Central African Republic		1		1		1		1
Chad		1	1	1		1		
Comoros	0	0	0					
Congo/Brazzaville		1		1		1	1	2
Congo/Zaire		9		6	2	4		
Djibouti	0	0	0					
Equatorial Guinea	0	0	0					
Eritrea		1		1	1		2	
Ethiopia		4		7	4	3	1	2
Gabon		2	6	1		1	4	
Gambia	0	0	0					
Ghana		5	6	12	2	10	4	8
Guinea		2		3		3		4
Guinea-Bissau								
Ivory Coast (Cote d'	1	4						

Country	Number of Private University	Number of State University	Extra Campus	FACULTIES			School /College In Science, Technology And Engineering	Institute/ Centre In Science, Technology And Engineering
				Total Number Of Science Related Faculties	Engineering And Technology	Science		
Ivoire)								
Kenya	4	6		20	4	16	2	8
Lesotho		1		2		2		
Liberia	1	1		2		2		
Madagascar		7	11	9	4	5	4	10
Malawi		2	5	8	2	6	1	
Mali		1		1		1	1	2
Mauritania		1		1		1		
Mauritius		1	1	3	1	2		3
Mozambique	2	4		10	2	8	4	4
Namibia		1		2		2		
Niger		2		1		1		
Nigeria		36		101	26	75	26	28
Reunion		1		1		1		
Rwanda		2		3		3		
Sao Tome and Principe	0	0	0					
Senegal		2	1	2		2	2	4
Seychelles	0	0	0					
Sierra Leone		1	3	5	1	4		1
Somalia		1		4	1	3		
South Africa		22	3	41	9	32	15	39
Sudan	4	26		59	15	44		17
Swaziland		1	3	2		2	6	
Tanzania	1	3	2	6	1	5	2	5
Togo		1		1		1	3	1
Uganda	6	2		9	2	7		3
Zambia		2	3	7	4	3	2	1

Country	Number of Private University	Number of State University	Extra Campus	FACULTIES			School /College In Science, Technology And Engineering	Institute/ Centre In Science, Technology And Engineering
				Total Number Of Science Related Faculties	Engineering And Technology	Science		
Zimbabwe		4	3	9	3	6		4
TOTAL	**20**	**175**	**52**	**367**	**93**	**274**	**93**	**155**

Source: Reproduced from Riley and Riley (2003).