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Challenges to Research, Science & Technology in Tanzania, Mozambique and South Africa

Chris MORRIS
Meraka Institute, Pretoria, 0001, South Africa
Tel: +27 12 841 2509, Fax: + 27 12 841 4720, Email: cmorris@csir.co.za

Abstract: A number of African initiatives and Africa/EU strategies aim to build science and technology capacity in Africa. This paper builds on IST-Africa EU FP6 work which reviews the status of current levels of ICT related R&D activity in target countries. Other regional initiatives such as NePAD, the AISI and ICSU are described. This paper reviews the status of current levels of ICT related R&D activity in the three study countries and reports on their current levels of participation in EU Framework programmes. Some of the barriers to research and development are identified and strategies to overcome these barriers are proposed. It is clear that research engagement with the study countries must be firmly focused on applied ICT, with a view to leverage existing research capacity but also to focus on exploitation of existing FP6 research results that can be adapted to meet national priorities in these key areas. It is also clear that a key challenge is to raise awareness in Europe of the skills and research capacity available across Africa, to ensure that there is meaningful participation from Africa generally in FP7. Research challenges in Africa where cooperation with Europe will be mutually beneficial include wireless and mobile networking, technologies harnessing indigenous knowledge, telemedicine, and cooperation in space-based technology, applications and health.

Keywords: science, technology, EUFP7, NePAD, infrastructure, capacity, policy, regulatory

1. Introduction

One of the main challenges confronting the Science & Technology community in Africa is how to increase the overall capacity of regional players in enhancing science and technology for development. Appropriate strategies are required to strengthen regional capacity and provide the necessary focus and co-ordination of research effort for economic development. Information and Communication Technologies (ICTs) are seen as one of the key technologies that can help leapfrog development in Africa and collaborative research in this domain is required in order to create innovative solutions that support the social economic goals of the continent.

Initiatives such as the New Partnership for African Development (NePAD), the EU/Africa strategic framework, the African Information Society Initiative (AISI) and the International Council for Science (ICSU) seek to strengthen the science base of Africa.

The New Partnership for African Development (NePAD) has a strong science and technology focus that seeks to harness the collective effort of research institutions on the continent to address the development challenges on the continent.

2. Objectives

This paper reviews the status of current levels of ICT related R&D activity in three African countries, Tanzania, South Africa and Mozambique. It highlights the innovative aspects of

research currently being undertaken in the target countries and reports on their current levels of participation in EU Framework programmes.

Some barriers to research and development are identified and strategies to overcome these barriers are proposed. The papers aim is to highlight the research challenges in Africa where cooperation with Europe will be mutually beneficial. This then increases the potential for successful involvement of regional research institutions in European research projects and intensifies the role of science and technology in economic development.

Important lessons can be learnt from the EU Framework Programme that seeks to enhance regions to strengthen their capacity for investing in and conducting research and technological development activities in a way that can contribute significantly to economic development.

3. Methodology Used

The methodology used is a review of the target country science and technology landscape including science & technology policies, national ICT strategies, an overview of current research activities, research organisations and EU Framework participation.
The methodology will:

- Review current levels of ICT related R&D activity in Africa
- Highlight the innovative aspects of research being undertaken in the target countries.
- To identify barriers to R&D in Africa
- Propose strategies to overcome these barriers
- To highlight research challenges in Africa where cooperation with Europe will be mutually beneficial

Such a review of R&D initiatives can help determine future research collaboration opportunities for European and African organisations in these domains.

This paper builds on IST-Africa EU FP6 work, which reviews the status of current levels of ICT related R&D activity in the target countries. Other regional initiatives such as NePAD, the AISI and ICSU will be described.

4. Country Profiles

The United Republic of Tanzania is bordered by Burundi, Democratic Republic of the Congo, Kenya, Malawi, Mozambique, Rwanda, Uganda and Zambia. 53.6% of the population of 37,445,392 is aged between 15 and 64 (median 17.7 years). Literacy is 78.2%. Swahili, English (business, government and higher education) and Arabic (spoken in Zanzibar) are national languages. Agriculture accounts for 48.1% of GDP and 80% employment. The EU accounts for 7% of imports and 15% of exports. Tanzania is a very poor country with per capita GNI of $330 (2004 devdata) [1].

The Republic of Mozambique is one of the southern Africa countries, bordered by Malawi, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe. At the east it is bordered by the Indian Ocean. Mozambique has an area of 799.390 km² and eleven provinces: Cabo Delgado, Niassa, Nampula, Tete, Zambézia, Manica, Sofala, Inhambane, Gaza, Maputo Província and Maputo-Cidade. The total population is 19,888,701 and the literacy is 47.8%. Portuguese is the official language and there are several indigenous languages as national languages. English is widely used in business and in government. Agriculture accounts for 81% of all employment. The EU accounts for 5% of imports and 10% of exports. Mozambique is one of the poorest countries in the world with a per capita GNI of $210 in 2004(devdata) [1].

The Republic of South Africa is bordered by Botswana, Lesotho, Mozambique, Namibia and Zimbabwe. 65% of the population (46,888,200, Statistics South Africa 2005) is aged between 15 and 64 (median 24.5 years). Literacy is 86.4% with 11 official

languages including Afrikaans and English. Services account for 64.9% of GDP. The EU accounts for 45.8% of imports and 40% of exports. South Africa is a middle-income country with per capita GNI (Gross National Income) of $3,630(2004 devdata) [1].

5. Current Initiatives

Africa's Science and Technology Consolidated Plan of Action (ACP) [2] aims to consolidate science and technology programmes of the African Union (AU) Commission and the New Partnership for Africa's Development (NEPAD).

This plan of action puts emphasis on developing an African system of research and technological innovation by establishing networks of centres of excellence dedicated to specific R&D and capacity building programmes. It complements a series of other AU and NEPAD programmes for agriculture, environment, infrastructure, industrialization and education. International partnerships are a key part of the strategy e.g. UK-Canada-Africa workshop, France-NEPAD partnership on water sciences.

The ACP has three interrelated pillars, capacity building, knowledge production and technological innovation. The main objectives are to improve infrastructure for R&D, build and use Africa's scientists, technicians and engineers and improve quality of policies for science and innovation.

The Africa EU Strategic Partnership [3] is based on the AU Constitutive Act and Strategic Framework 2004-2007 and the EU Africa Strategy of 2005. The objectives are to strengthen and promote peace, security, democratic governance and human rights, fundamental freedoms, gender equality, sustainable economic development, including industrialisation, and regional and continental integration in Africa, and to ensure that all the Millennium Development Goals (MDGs) are met in all African countries by 2015.

Building upon the 2007 Addis Ababa Declaration on Science Technology and Scientific Research for Development, the Africa and EU partnership plans to strengthen cooperation in space-based technology, applications and health.

In the area of ICT, the partnership aims at bridging the digital divide that limits access to modern telephony and Internet services. It will address the harmonisation of policy and regulatory frameworks and investment in broadband infrastructure and support non-commercial e-services.

Similar efforts will be made to address the scientific divide and increase Africa's research capacities. Inadequate technical capacity of Africa will be upgraded through the establishment of specialised networks in regions and sub-regions, which need to focus on identified priorities so as to underpin economic growth and sustainable development of the African continent.

It is the intention that Africa and the EU will promote the strengthening of collaborative links between African regional and sub-regional partnerships and European partners, in order to contribute to the sustainability of established centres and networks of excellence.

The African Information Society Initiative (AISI) is a National ICT policy initiative co-ordinated by the Economic Commission of Africa whose vision is to build policy and research capacity in ICTs [4].

The International Council for Science (ICSU) is a non-governmental organization representing a global membership that includes both national scientific bodies (113 members) and international scientific unions (29 members) [5].

Through this extensive international network, ICSU provides a forum for discussion of issues relevant to policy for international science and the importance of international science for policy issues.

The main objectives of the IST-Africa Initiative are to establish a better understanding of current exploitation of applied ICT in Africa and opportunities for adaptation of European funded research results and international research collaboration, to establish a

collaboration framework for researchers and government officials in European and African States, and to create a sustainable community with strong pan-African and international participation, focused on the economic and social impact of Applied ICT in Africa [1].

Exploitation of ICT has enormous potential for impact in Developing Countries, to meet societal demands, more efficient delivery of public services and supporting economic development. IST-Africa supports the adaptation and exploitation of European ICT research results from the IST Programme of FP6, support regional impact by facilitating skills transfer through training workshops, and provide a framework for European and African researchers to explore opportunities for cooperation under FP7 [1].

At the country level, South Africa, Mozambique, and Tanzania have a Science and Technology policy or White paper detailing the vision and goals for creating an innovation policy for the country.

6. Challenges

There are a number of challenges facing the growth of African Science and Technology. Many African countries are challenged by inadequate telecommunication infrastructure, a lack of funding, a high incidence of poverty, lower levels of education, lack of effective policies and regulatory institutions and economic mismanagement.

In order to quantify these issues the Africa e-Readiness assessment [6] was commissioned by the Commonwealth Secretariat on behalf of the New Partnership for Africa's Development (NEPAD), e-Africa Commission.

6.1 Infrastructure

In terms of fixed line communications both Tanzania and Mozambique have very low rates of four lines per 1000 people and 105 in South Africa [7]. This compares poorly with the average of 498 per 1000 households for lower-middle-income households internationally [8]. Research by the South Africa Foundation, shows that the incumbent Telco's fees are up to 400% higher than the cost of similar services in 13 comparable countries. This has resulted in the disconnection of over 850,000 telephone lines in the past few years [9]. This low penetration has serious consequences not only in terms of voice communication but also for Internet access.

Tanzania's telecoms regulator the Tanzania Communications Regulatory Authority (TCRA) has published data showing a significant reduction in the cost of both national and international calls in the country over the last six years for both fixed and mobile networks. In Tanzania international call rates have dropped to USD3.17 [7] compared to USD1.17 for Mozambique and USD0.79 for South Africa.

One of the underlying causes of the high costs of telecommunications in Africa has been and continues to be the charges made for international connections between countries and especially to other continents. The cost of making telephone calls and of accessing the Internet remains disproportionately more expensive when compared to countries in the northern hemisphere. In part this is because the high charges are unaffordable for the majority of consumers and thus demand is low, so that the fixed costs must be borne by a small number of customers [10].

In Tanzania and Mozambique, the telecommunications landscape is dominated by the Telco monopoly. In South Africa government through a process of managed liberalisation has introduced competition through the Second Network Operator (SNO) and a fourth cellular operator was licensed in 2006. Despite this, broadband access is low and according to the ITU 2003 comparative study, all African countries, including South Africa perform poorly in this vital indicator of preparedness for e-commerce.

Mobile communication, GSM, has overtaken fixed line usage in most African countries and outside of Europe, Africa is the fastest growing mobile market. South Africa has a population cell phone coverage of 96%, compared to a rapidly rising 25% in Tanzania and 35% in Mozambique. This bodes well for the world's least wired continent [11].

In South Africa the market for Asymmetric Digital Subscriber Line (ADSL) and Integrated Services Digital Network (ISDN) fixed lines is slowly growing and new technologies such as WiFi, WiMax and 3G cellular services create new opportunities for broadband connectivity. Satellite connectivity, although expensive, is becoming more commercially available and Very Small Aperture Terminals (VSATs) are used in deep rural areas where fixed lines cannot reach.

While access to ICT infrastructure is a major constraint in Mozambique, several measures have been put in place to extend the basic infrastructure needed to expand ICT use. Of particular importance are the construction projects for the National Transmission Network backbone and the submarine fibre optic link between Maputo and Beira.

The Mozambiquan Ministry of Energy aims to electrify all district capitals by 2009. In rural areas electrification of rural hospitals and secondary schools using solar power systems or other alternative sources of energy such as diesel generators has been prioritised.

The South African Department of Science and Technology (DST) have initiated the procurement of the South African Research Network SANReN's for broadband connectivity. SANREN's will connect to the European Commission's Géant network in Europe, and to other research networks such as Internet2's Abilene network in the USA, the Australian AARNet and the TEIN2 network in the Far East, as well as to networks and/or institutions in neighbouring countries [12].

The DST envisages that SANReN will enter into inter-connection agreements with a number of research and education networks in neighbouring countries such as Africa's UbuntuNet, Mozambique's MoRENET and other parts of the world. For this purpose SANReN will require international gateways at Cape Town, Durban and in Gauteng.

6.2 Capacity and ICT Skills Initiatives

Universities and other institutions of higher education play a critical role in promoting and sustaining ICT growth and development. A country's proportion of tertiary education graduates is an indication of the overall ability of the population to fully develop and participate in the Information Society. Without an educated population, developments in ICT will be unsustainable and eventually become obsolete. For example, many countries implement modern ICT infrastructure, with no skilled workforce to adapt and maintain it.

Tertiary level academic societies around the world have also been known for their contribution to knowledge building activities. Similarly, in Africa, a well-educated populace can act as a catalyst for development by using their knowledge and expertise to initiate change in the public and private sectors and in the larger civil society as a whole.

African universities are crucial to the future development of the Internet on the continent in two ways. Firstly, they contain one of the largest groups of existing and potential users: today's student user is tomorrow's future decision-maker. Secondly, universities should be generators of content that will be used by the same students to increase their knowledge and skills. The Kenyan Government and Google have both said they want to provide free Internet connectivity to students.

The "World Universities' ranking on the Web" is an initiative of the Cybermetrics Lab, a research group of the Centro de Información y Documentación (CINDOC), part of the National Research Council (CSIC), the largest public research body in Spain [13]. It provides a raking of over 4,000 universities worldwide based upon four "content" metrics: the number of pages recovered from the four main search engines; the number of unique external links; the number of rich files to download (pdfs and .ppts, etc); and a Google

Scholar scoring of the number of papers and citations for each university domain. These scores are turned into a metric for ranking universities globally. Not surprisingly, the premier league globally (top 100) is almost entirely composed of US institutions, with only a sprinkling of European institutions. But the separate African Top 100 contains more surprises and questions.

Against fierce global competition, the top 5 South African universities (also top 5 in the Africa Top 100) achieve a particularly high ranking: University of Cape Town (349); Rhodes University (624), Stellenbosch (653), University of Pretoria (686) and University of Witwatersrand (703). This is not just a plus for South Africa in terms of its own ability to create knowledge through academic content but must be something that may attract students from across Africa in greater numbers in the future [14].

South Africa has an advanced and well-developed research community. There are a number of universities and research centres active in the areas of ICTs including eGovernment, eHealth, eLearning & ICT Skills Development in South Africa.

The general level of research capacity in Tanzanian organisations is good. The Open University of Tanzania, University of Dar-Es-Salaam and Tanzania Bureau of Standards each have more than 50 researchers, while the Tanzania Fisheries Research Institute, Public Service Management in the president's office, National Institute for Medical Research, National Construction Council, and Ministry of Education and Vocational Training each have between 11 – 49 researchers. The African Virtual University (AVU) is hosted at the University of Dar es Salaam. This was primarily related to the whole question of information exchange with other member countries.

Mozambique has good capacity in the University Eduardo Mondlane as well as a number of private universities, and institutions. Science and technology capacity initiatives include the Mozambiquan ICT Incubator, MICTI, and the construction of a science park.

One of the challenges facing engineers and scientists in Africa, as well as in the rest of the developing world, is the lack of the state of the art research tools. The cost of hardware and software needed for learning and research tends to be too expensive and thus leaving scientist and engineers in these countries behind their counterparts in the developed world.

6.3 Regulatory and Policy

Africa has recognized the need to develop legislation to support ICT development and address the security concerns, which have deterred businesses and individuals from embracing ICTs. Many African countries have a legal framework that has been modeled either after the British or French legal systems. The possibility exists for cooperation in the development of ICT related laws, since similarities exist among most legal systems.

The major regulatory rule that all small telecommunication service providers in the different countries see as a challenge is the issue of (lack of) self-provision. As most service providers are still heavily dependent on incumbent telecom providers, prices remain high and impede further market growth, both nationally and regionally. However, most countries are working on further liberalization in this respect. Further regional harmonization of regulatory frameworks would be ideal, but an increase in transparency of national frameworks at this point seems most imperative.

7. Research Cooperation between European and African Organisations

In all the study countries, FP7-ICT Challenge of common interest included Challenge 4 (Digital libraries and Content), followed by Challenge 1 (Pervasive and Trusted Network and Service Infrastructures). Other relevant ICT Challenges being addressed by IST-Africa include Challenge 5 (Towards sustainable and personalised healthcare), Challenge 6 (ICT

for Mobility, Environmental Sustainability and Energy Efficiency) and Challenge 7 (ICT for Independent Living and Inclusion) [1].

Tanzania has identified a range of different research preferences and interests including research on e-commerce and broadband connectivity; knowledge management; and eInclusion (impact on the poor). Other issues identified include: development of aquatic resources databases for marine and fresh water bodies; security of shared data across networks; digitalization of special libraries (e.g. construction industry); eHealth (including compilation and analysis of health data); eGovernment; and language processing [1].

Some examples of projects funded under FP6, which are focused on cooperation with Sub-Saharan Africa include:

- IST-AFRICA - Regional Impact of Information Society Technologies in Africa,
- 6DISS is a Specific Support Action (SSA), which aims to establish and operate an information exchange programme for the optimal transfer of knowledge on Internet deployment and evolution to other research network operators, Universities, commercial organisations, ISPs, governments and regulators,
- BEANISH - Building Europe - Africa collaborative Network for IST in the Health care sector
- C@R, "Collaboration@Rural: Collaborative Platform for Working & Living in Rural Areas"
- EMPRO - European Microbicides Project
- EPOCH - Excellence in Processing Open Cultural Heritage
- FLOSSWorld - Free/Libre/Open Source Software
- ESASTAP - European - South African Science and Technology Advancement Programme
- MOCCA is a European Coordination Action (CA) that aims to facilitate collaboration between projects addressing mobile and wireless issues.
- START IST Specific Support Action aims to define a strategic framework for the development of EU - South Africa cooperation and EU - Sub-Saharan African cooperation.

By examining the EU approach to incorporating developing regions in science and technology, important lessons can be learnt for the developing world. For example as one element of the Wider Europe policy, the Commission prepared a Communication focused on the possibility of creating a New Neighbourhood Instrument supporting cross-border and regional/transnational co-operation along the external borders of the Union. The “Paving the Way for a New Neighbourhood Instrument” introduced the concept of “Neighbourhood Programmes” for the external borders of the enlarged Union for 2004-2006 [16].

Three strands were established for the Neighbourhood Programmes; Strand A: cross-border cooperation - cross-border cooperation between adjacent regions aims to develop cross-border social and economic centres through common development strategies; Strand B: transnational cooperation - transnational cooperation involving national, regional and local authorities aims to promote better integration within the Union through the formation of large groups of European regions; and Strand C: interregional cooperation - interregional cooperation aims to improve the effectiveness of regional development policies and instruments through large-scale information exchange and sharing of experience (networks).

8. Recommendations

There are a number of challenges facing the growth of African Science and Technology including inadequate telecommunication infrastructure, lower levels of education, and lack of effective policies and regulatory institutions.

An underlying theme among all countries surveyed, even those relatively advanced, is the challenge of improving the quality of the telecommunications infrastructure. It is interesting that all countries in continental Africa ranked in the sixties or below in the WEFs rankings for quality of infrastructure with the only exception being Mauritius.

Telecommunication costs in the Africa are the highest in the world, partly due to the infrastructural limitations as well as the lack of effective liberalization and regulation of the telecommunications sector. This has contributed to low individual and business usage statistics in fixed line and Internet services.

The infrastructural limitations have had a direct impact on the level of ICT usage within the region. Planning and regulation of the radio frequency spectrum, is needed to encourage private sector activity and ensure coverage to rural areas.

One of the underlying causes of the high costs of telecommunications in Africa has been and continues to be the charges made for international connections between countries and especially to other continents. African Networks (ISPs) must learn to grow and consolidate their traffic, both in size and reach in order to become attractive and qualify for peering arrangements with their counterparts in US/Europe.

EU – Africa cooperation is recommended to achieve inter-connectivity among regional IXPs in order to decrease the dependency on international hubs for intra-regional data transfer. The costs associated with data transfer outside the continent have contributed to the high costs of Internet access in the region.

Inter-connection agreements are also recommended between research and education networks in neighbouring countries in Africa as well as between UbuntuNet and the European Commission's Géant network in Europe.

Investment in human capacity has been an area that has been neglected in support of ICT for development. Developing a skilled, well-educated workforce is essential if a country is to fully exploit the potential of ICTs. Innovative thinking is needed to customize technology to meet the needs of a nation in the fields of e-Commerce, e-Health, e-Government and other spheres of socio-economic development. Adult literacy is also major a problem within the continent, with all the countries surveyed ranking below sixty in the WEFs adult literacy rankings. Some of the poorer countries had a literacy rate which was less than half of their population.

The high cost of tertiary education makes it inaccessible to the majority of Africans. Countries with a higher rate of tertiary level enrollment also showed increased availability of scientists and engineers. Some however, are battling the growing problem of "Brain Drain", and although the percentage of tertiary level graduates is relatively high, these graduates tend to migrate in search of higher wages and better living standards.

Performance in the overall quality of education, especially in mathematics and science subjects, highlights the need for greater focus on the "soft" aspects of ICT development. Tunisia is an African country that has excelled in this area and can prove to be a resource for best practices for other African nations.

Free/Libre Open Source Software - skills development and e-learning can address the lack of state of the art research tools. In the software front, many have turned toward Open Source Software (OSS) as a remedy. Even though OSS can be accessed for free, locating and downloading the software can be a challenge. New initiatives need to be designed to build Linux based scientific distributions targeted at scientists and engineers in various fields of scientific inquiry.

A regulatory climate favourable towards local and community network deployment would be applied in the areas identified. Licenses should be technology-neutral, so that services may use the most suitable license-exempt spectrum for wireless use should be free of costs and administrative burdens. An 'open access' policy for connections to the national backbone could be promoted.

9. Conclusions

This paper highlights the importance of science and technology in underpinning economic growth and sustainable development of the African continent and presents the strategic framework for developing science and technology in Africa. Africa has initiated its own strategies and developed strategic partnerships with the EU to tackle the challenges faced by the continent.

The key strategic issue identified is how to increase Africa's research capacity. Many challenges to this have been identified by various e-readiness assessments such as lack of infrastructure, high telecommunications costs, a restrictive regulatory environment and alack of skills and capacity. But where does one start, where should the focus of attack be?

This paper argues that the focus should be on building capacity at schools and universities. This can be achieved by providing the tools to the teachers who have the skills and resources to teach. This must begin with broadband access to all universities and by bringing down the cost of connectivity through peering arrangements with international backbone providers. Teacher training programmes in ICTs need to be developed and students need access to content through wireless and mobile technologies. There needs to be support for building and creating an African Indigenous Knowledge library that protects and makes accessible local content to all.

A key strategy would be to allow the stronger Universities to mentor the developing Universities. Other recommendations include reducing the cost of university education and providing incentives to graduates to promote retention and overcome the "brain drain". The use of Open Source software needs to be promoted throughout the continent particularly in the creation of scientific tools.

Other key strategies include the creation of regions of knowledge through the identification of pockets of excellence and prioritisation of research agendas according to local needs. Africa must engage with the EU Framework programmes in areas of common interest and harness technologies such as space technology for disaster management and applications in health.

Deliberate efforts are required for building a network through which European and African partners can identify each other for a common goal and work together on project proposals preparation. However, with low awareness level as to the skills available in Sub-Saharan Africa and the research activities currently being undertaken in particular thematic areas, the efforts and opportunity for collaboration and cooperation might not be realised. More EU support actions are required to promote the participation of willing and able African science institutions in EU Framework Programmes.

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