THE INTERNET IN TERTIARY EDUCATION IN AFRICA: RECENT TRENDS

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Poor Internet connectivity is one of the pertinent issues in the digital divide between developing and industrialized countries, hampering the transition to the global information society. Recent emergence of national and regional research and education data communication networks in parts of the developing world has shown large benefits arising from collaboration amongst tertiary education institutes. Africa is currently the most under-served continent in terms of the information and communication technologies. Hence the collaboration amongst tertiary education institutes in Africa is imperative to make them key players in the enhancement of information and communication technologies for society. An attempt is made in this article to delve the recent trends that emerged from the higher educational institutes in Africa. The paper also highlights the key role of tertiary education and Internet that can induce social and economic developments.

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1. INTRODUCTION

Technological advancements, global telecommunication and automation have greatly contributed to economic growth in the world over the past fifteen years. However, not all regions, countries and people in the world have benefited equally from the opportunities that Information and Communication Technologies (ICT) offer. Especially rich industrialized countries and several countries in transition have profited from the information age and attained high economic growth figures. The advantages of the information era have been less for developing countries, which often lack favourable conditions for deployment of new technologies. The difference in access to ICT between the poor and the rich is referred to as the digital divide [Rena 2007]. Further, ICT is considered one of the key factors for sustainable development, not only as a means for automation of work processes in business and industry, a tool for education and scientific collaboration, and a platform for technological innovation, but also for communication and access to information, thus contributing to democratic empowerment and poverty reduction [Potter et al. 1999].

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Poverty, poor access to education and lack of public investment capital are commonly believed to be the main causes for the digital divide, however, other causes may be of influence. A basic understanding of the mechanisms of the implementation and the role of ICT in society is necessary to reduce this digital divide, bearing in mind the local circumstances, differences and cultural context. This paper focuses on the most underserved African continent in terms of ICT.

In Africa, 29 countries have defined governmental policies to support ICT, in the past few years [Pehrson and Ngwira 2006]. Numerous ICT-initiatives and projects are taking place simultaneously in African countries, supported by the World Bank, the IDRC, the European Commission, the United Nations and many other donors [Hawkins 2005; Steiner 2005]. Further, 2007 was declared as the year for building up science and technology in Africa. African science ministers have backed a set of measures to promote science and technology across the continent. The ministers, who met in January 2007 in Cairo, Egypt, pledged the Heads of State create a Pan-African Intellectual Property Organisation, and to designate 2007 as a year for science, technology and innovation in Africa [CAIRO DECLARATION 2006].

To achieve this, Respective countries have to apportion at least one per cent of their GDP to promote research, development and innovation strategies in Africa. The African Union (AU) summit held in January 2007 in Cairo, Egypt asked to express support for South-South cooperation in science, technology and innovation, enhance the role of such cooperation in international partnerships, and move towards harmonizing national and regional regulations that promote the application and safe use of biotechnology [CAIRO DECLARATION 2006]. With Africa's population expected to increase from 923 million to 1.3 billion by 2020, agricultural technology development and transfer become crucial [Africa-Wikipedia 2007]. Farmers, who form the bulk of this population, will only be able to improve their productivity and livelihoods if they have access to technology [Olawo 2005; Rena 2007].

Indeed, many African countries lack explicit national science and innovation policies. Some policies were developed in the 1970s or 1980s and do not reflect the realities of a rapidly globalising world and national imperatives of the new millennium, notes Africa's Science and Technology Consolidated Plan of Action [2005]. In the developed and newly industrializing countries, there is ample evidence to suggest that economic advances are results of technological and organizational innovations. Globally, science and technology are recognized as drivers of increased wealth and improved standards of living [Pehrson and Ngwira 2006]. Information on market prices is critical for farmers to earn their bred. Indeed, the farmers have to reap the fruits of technological diffusion in Africa, thus they need to learn farming methods and crop protection techniques from the Internet. Although, farmers use cell phones in inquiring market prices where to buy or sell their produce but much has to be done to improve the situation in Africa [Olawo 2005; Muchanga 2005; Rena 2007]. It is to be noted that in Uganda, this kind of information gap is being bridged by Information Technology for African Rural Development (ICTARD) [Internet World Statistics 2007].

At the United Nations World Summit on the Information Society, held in Tunis, November 2005, goals were set for developing a "…people-centred, inclusive and development-oriented Information Society so that people everywhere can create, access, utilize and share information and knowledge… to attain the internationally agreed development goals and objectives, including the Millennium Development Goals " [AAU 2005].

The contribution of education in bridging the digital divide is crucial. In this paper an attempt is made to describe the key role of tertiary education in their quest for good Internet access and accordingly to information and communication, that can induce social and economic developments.

2. THE INTERNET IN AFRICA

The total African population consists of approximately 933.000.000 inhabitants, representing 14 per cent of the total world population [Africa - Wikipedia, the free encyclopedia]. The estimated number of Internet users in Africa in 2007, is 39.000.000, which represents 3 per cent of the Internet users in the world [Internet World Statistics 2007]. Excluding South-Africa (and the North African countries Morocco, Algeria, Tunisia and Egypt, who have much higher Internet usage figures), the penetration of Internet in Sub-Saharan African countries is an average of 0.2 per cent. Yet, Internet use is growing fast in Africa, for example, during the period 2000 to 2007, the Internet users increased by 638 per cent in the whole of Africa. The total world Internet usage growth in 2006 was 209 %, between 2000 and 2007 [Internet World Statistics 2007]. The number of Internet users in a country can be considered a "digital indicator" of the adoption of ICT in society.

Table 1: Population per country, number of Internet users and penetration: percentage of Internet users relative to the total population: (Internet World Statistics 2007)

Area coverage		Population	Internet users in 2007	Penetration
Total World		6.574.666.417	1.114.274.426	16.9%
USA		301.967.681	211.108.086	69.9%
China		1.317.431.495	137.000.000	10.4%
Netherlands		16.447.682	12.060.000	73.3%
Total North Africa		153.156.098	17.778.000	11.6%
South Africa		49.660.502	5.100.000	10.3%
SSA	729.1.27 629.4.400.2 334 0 %			

Source: Internet World Statistics (2007)
Note: SSA =Sub Saharan Africa

Causes for the digital divide

Indeed, poverty and lack of education are the main causes for the digital divide. In addition, low population density, and large distances between urban centres are unfavourable conditions for the expansion of a continent-spanning communication infrastructure as these require high investments. In such circumstances there is no promise of quick revenues for private investors in country-wide telecommunication infrastructures. Nevertheless, several studies have shown that lack of financial means for the investments in a regional Internet infrastructure are not the main reasons for the digital divide, as one might expect [Rena 2007].

A study of the availability of optical fibre connections on the African continent was carried out in 2004-2005, sponsored by the World Bank and the IDRC, for the south eastern countries, initiated by the Southern Africa Regional Universities Association [Muchanga 2005]. This revealed the existence of thousands of km of private high capacity transmission over optical fibre cabling, owned by power utility companies, and pipeline operators. However, closed governmental policies and regional regulations in many countries have until now prevented the use of this valuable infrastructure for public communication purposes [Pehrson and Ngwira 2006].

The real problem that holds back use of the Internet is the high cost for Internet connectivity for end-users in Africa. An African consumer pays on average 240 times as much for the same Internet connection as a person in the Netherlands [Internet World Statistics 2007]. The high pricing is the main obstacle for the deployment of Internet in Africa. The main challenge, therefore, is to bring the costs down.

Causes for the high price of the Internet

It is important to understand the market mechanisms that contribute to the excessive high prices for Internet connections in Africa. The Internet infrastructure in African countries is dominated by private telecommunication companies and some monopolistic state companies. In Sub-Saharan countries, the access to the rest of the global Internet is exclusively through wireless satellite connectivity called VSAT, or through submarine optical cable [Martin 2006]. The VSAT dishes connect via a satellite directly to dishes in the US or Europe, and subsequently with the large Internet exchanges in the world, located in Amsterdam, London, Paris or New York.

A submarine cabling system, called SAT-3/WASC/SAFE was completed in 2002, and has landing points at eight African countries mainly along the west coast (Senegal, Ivory Coast, Ghana, Benin, Nigeria, Cameroun, Gabon and South Africa), and it also connects to Spain, Portugal and to India and Malaysia. The landlocked countries in Africa and countries on the east coast are not connected to this submarine cabling system. The VSAT wireless Internet connection appears to be an adequate alternative for the Internet at places and countries that do not access the submarine system. A dish can be easily purchased and installed anywhere. Almost every university in Sub-Saharan Africa is already connected to the Internet via VSAT [Hawkins 2005].

The downside of VSAT connection is the high price, the inferior connectivity quality and lower bandwidth[1], as compared to optical cable, plus the fact that no local infrastructure is being built. It is estimated that Africa spends 400 million US $ per year on VSAT connections, that are exploited by international, not African companies [Drouot 2005]. Take the case for example, when two users at the Asmara University send an email to each other, using email addresses from American providers such as hotmail.com (Microsoft Corporation) or yahoo.com (Yahoo). While both persons are located

on the same campus, the email travels through the VSAT to the satellite and through the exchange point in Amsterdam, back to the satellite, and again to the campus. The whole travel of the email usually takes only a few seconds, but it represents a disinvestment in terms of local capital. The Internet providers and satellite owners are international companies. All the budgets spent on VSAT – connections flow away from Africa, instead of being reinvested in local infrastructure.
Glass (optical) fibre is the best medium for data transport, and is much more sustainable satellite wireless, but it requires high initial investments. One optical fibre pair (dark fibre) can nowadays carry 80 Gbps of data, which is 80.000 times the capacity of an Internet connection for an average university in Africa. In each glass fibre duct hundreds of fibre pairs are bundled together, giving a total connectivity of Terabits (1000 Gigabits) per second for one single duct. Still, the return on investment of optical cable infrastructure is often too risky for private investors.

One of the main goals of the SAT-3/WASC/SAFE cable was the reduction of connectivity costs to the Internet, for the participating nations. The lowering in price did not happen, because the connection was shared by a closed consortium of dominant telephone companies and telecom state monopolies [Gedye, 2006]. There was, unfortunately, no Open Access Model or governmental policy or enforcement regulation to break the monopolistic market position of the members, and thus lower the Internet prices [Drouot 2005].

The efforts are exerted to establish EASSY cable, the East African Submarine cable System, it and runs from Port Sudan (Sudan) in the north to Durban (South Africa). This will complete the fibre loop surrounding Africa, and will connect as well to Djibouti, Somalia, Eritrea, Ethiopia, Tanzania, Madagascar and Mozambique [Olawo 2005; Balancing Act, 2005; Steiner et al. 2005]. The submarine cabling systems are a good step forward in bringing Africa "on-line", but additional infrastructure is required to connect the inland regions and landlocked countries to the landing points. As shown by several studies, including the SARUA fiber study [Muchanga 2005], power utility companies commonly use optical fibre for the operation of their core business; so many investments in expensive infrastructure are already done. This electricity fibre infrastructure might easily be shared by other companies, such as Internet providers, or public user consortia, without affecting the electricity business, and without technical or market constraints. The use of the infrastructure by several competing business partners, is not only common in the rest of the world, it is even enforced by Open Access policies and regulations in many countries to prevent monopolies (e.g. the OPTA and the NMA in the Netherlands, Independent Regulators Group (IRG) and the European Regulators Group (ERG) for the European Union).

3. COMPUTERS AND THE INTERNET IN EDUCATION

The ICT and the Internet for tertiary education is imperative. The most effective way to increase the knowledge of ICT of a population is through education. To underline this statement, the following goal was set up by the Association of African Universities (AAU), at the Conference on African Research and Education Network Infrastructure, held in Tunis, in November 2005; Björn Pehrson, professor in Telecom Systems from the IT-University KTH in Sweden, stated that "No later than 2008, universities and research institutions in Southern Africa will have access to broadband services and the global Internet on the same level as peers in the developed parts of the world, with a quality of service in the Gbps rather than kbps"[2] [AAU 2005].

Indeed, the Internet originated in the domain of higher education. Although, the technology for interconnection of computer networks was developed for the American military network, important applications such as email and http (i.e. the World Wide Web), emerged within higher education [Stanton and Stöver 2005; SURFnet 2002]. The Internet and the World Wide Web, in fact the largest knowledge data base in the world [SURFnet 2002]. The information is accessible through powerful search engines. The Internet can substitute expensive hard-copy libraries, and provide access to resources of scientific publications and scholarly information.

Distance learning is already in use at many African universities, and fills a clear need for education of people who work during the day, and live in remote areas without access to transportation. Distance learning can be improved significantly by the use of the Internet and electronic learning environments, when sufficient bandwidth is available.

Universities are the place where the future scientists, teachers, politicians and entrepreneurs are being prepared for their tasks in society. It is also the place where technological innovation initiates, and where new ideas emerge. Students need to have daily access to computers and the Internet, and sufficient bandwidth is necessary for downloading and exchanging documents over the network. Collaboration and frequent interaction with other research groups in other institutes, regions or countries through the Internet contributes to the quality of research and education. The availability

of sufficient ICT equipment is indispensable as well as skilled teachers and ICT-support staff, and adequate and inexpensive broadband access to the Internet for students and researchers.

It is viable to bring the Internet to the African society via tertiary education, just like it happened in the rest of the world. The Association of African Universities (AAU) supports the need for the Internet connectivity by stating:" African universities and researchers are often working in a silo model, insulated from regional actors and drivers of funding and requirements. Through establishing low cost high quality networks a platform for generative discourse can be created leading to improved policy advice, more effective cross pollination of best practices and lessons …"[AAU 2007].

The Massachusetts Institute of Technology in Boston, USA (MIT) already made available through the Internet programmes like BSc. and MSc. level, curricula that can be accessed and downloaded through the Internet. Their statement on this is: "…While recognizing that people in the developing world—who may benefit most from the open sharing of knowledge—are hindered by a lack of Internet access and connectivity, we must not let this problem obscure our vision of the future, but rather, take it as a challenge: Can the decision-makers of the world's leading educational institutions use what we are doing on our campuses to improve the lives of people around the world? History has proved that education and discovery are best advanced when knowledge is shared openly. We believe the idea of opencourseware is an opportunity that we must seize during the next decade." [Massachusetts Institute of Technology 2001].

4. MAIN PROBLEMS IN THE DEPLOYMENT OF ICTs

Connectivity, capacity and content are the three basic conditions for the use of the Internet. In their need for ICT, universities in Africa are hampered by problems such as high prices for Internet connectivity, poor local and regional infrastructure, and lack of ICT-skilled human resource capacity to manage the scarce Internet resources and make them available to the end-user community. Low remuneration is one of the causes for the lack of ICT-skilled staff at tertiary education. Moreover, lack of experience with ICT organization at management level can also lead to inefficiency in operational and management structures of ICT departments, and of poor ICT deployment at an institutional level. Additionally, high licence fees for software and other expensive resources can hinder the use of ICT. Connectivity is usually obtained through expensive VSAT connections, because of the lack of a regional optical backbone. The capacity of this VSAT is acceptable, but it is not comparable to an optical connection, and it is unsuitable for broadband document downloading, and data exchange and other bandwidth consuming applications. This capacity is narrowed by inadequate management of campus networks, causing frequent power outages, service denial, poor security, virus spread and lack of prioritising of usage, leading to even lower capacity of the Internet to the end-users. First the basic conditions of connectivity and capacity have to be improved to allow content exchange. Content provisioning through the Internet will enable African researchers to contribute and share their studies with the global communities. Hence, the collaboration amongst local, regional and international institutes can improve the ICT situation at every level.

5. OTHER TERTIARY EDUCATION NETWORKS IN THE WORLD

There are several successful examples of how countries improved the ICT situation at tertiary institutes. In the Europe, the National Research and Education Networks (NRENs) were established in the 80's and early 90's to interconnect universities, mainly for use of email. Networking technologies upgraded every year, gradually enabling larger data exchange and more enhanced applications. In 1993, a consortium of European NRENs was formed, called DANTE (Delivery of Advanced Network Technology to Europe) and its first international network of networks was formed, named GÉANT. GÉANT has recently been connected to the Asian university networks forming TEIN (Trans-Eurasia Information Network). GÉANT2 and TEIN2, as the second generation networks are named, operate at high data transmission rates, up to 80 Gbps [Internet World Statistics 2007].

In Latin America (LA), a collaboration initiative between several universities led to the formation of a continent wide research and education network in 2005, RedCLARA, through the interlinking of seven existing NRENs (Brazil, Argentina, Chile, Costa Rica, Mexico, Uruguay and Venezuela) and the formation of seven new NREN's (Colombia, Ecuador, Guatemala, Nicaragua, Panama, Peru, El Salvador). RedClara was then connected to GÉANT [Internet World Statistics 2007]. The project costs were € 12,5M and were financed by the European Commission (80%) and the governments of the participating countries (20%). The backbone is mainly composed of optical cable, and some copper wire [Stanton and Stover 2005; International Network of E-Communities 2006].

The RedClara network interconnects 600 universities in Latin America and 3500 universities across Europe. The first scientific collaboration projects between LA and EU which directly benefited form this new network were in the field of grid computing, astrophysics and life sciences. Six of the EUMEDCONNECT Mediterranean partners Algeria, Egypt, Jordan, Morocco, Palestine and Syria being have taken the first step towards forming an association of Mediterranean NRENS in 2006[EUMEDCONNECT 2007].

The EASSy cabling system that is currently being developed for the east coast of Africa was at risk of being a copy of the monopolistic system applied by the SAT-3 cable, in stead of an Open Access connectivity model [Zuckermann 2006]. With the aid of the Association of African Universities (AAU), a consortium was formed in 2006, called Ubuntunet Alliance, composed of 43 universities in south-eastern Africa, to negotiate with the EASSy operating companies to obtain a considerable bandwidth on this cable, against low price. This initiative is supported by the World Bank, who is willing to contribute financially to the EASSy project, on condition that the Open Access will be applied [Balancing Act 2005].

In West-Africa until present only a few consortia or NREN initiatives exist between universities, or countries. Yet, awareness is increasing, and this might happen in the very near future. Many countries were encouraged by the Ubuntunet Alliance initiative, and have expressed interest in contributing and subscribing to this consortium [Steiner et al. 2005]. These are currently Botswana, Burundi, Cote d'Ivoire, Democratic Republic of Congo, Egypt, Lesotho, Swaziland, Tanzania, Uganda, Zambia and Zimbabwe [UbuntuNet Alliance 2007].

6. DISCUSSION

The problems African universities are facing in their deployment of ICT seem to be aggravated by lack of communication and collaboration with peers and seem to become a vicious circle. The scientific field is a preferential ground to create a collaborative environment, ultimately promoting scientific and technological development.

Internet connectivity and pricing could be considerably improved by the formation of bandwidth consortia, which cooperate and emit tenders, insist on lower prices, and encourage competition between Internet providers. Consortia of tertiary education institutes consist of homogeneous user groups that can also lobby at governmental level. The high prices of Internet connectivity in Africa are a direct consequence of a producer dominated market, too few consumer organizations and lack of governmental policies and regulations enforcing competitiveness.

In many countries of the world, tertiary educational institutions have already organized themselves into consortia to obtain and share resources. These National Research and Education Networks consortia, (NRENs), are important organizations that can influence ICT policies on a national scale and benefit their member institutions [Dyer 2005]. The member institutions share the same need for good bandwidth and affordable Internet connectivity, forming a strong consumer group. Taking an example from the SARUA fibre study [Pehrson and Ngwira 2006], similar studies in other parts of Africa should be carried out, in order to map the available optical fibre connections that might be used as regional backbones.

The next step would be gaining access to these private closed infrastructures. This could be developed in public-private projects, where again consortia of tertiary education institutions can act as strong lobby groups to enforce Open Access, thus making these infrastructures also available for society. At remote sites where no optical backbone is available, consortia can negotiate for lower VSAT prices, through economics of scale. Moreover, tertiary education consortia can negotiate still other issues, such as favourable licence fees for software.

The infrastructure that connects research and educational institutions with one another constitutes an indisputable public good, donor investments can be applied without disadvantage and false competitiveness to the private companies. The enforcement of Open Access by governmental legislation policies on the communication infrastructure could be obtained by the lobbying consortium as well, using the examples of many countries where this kind of legislation has already been adopted.

7. CONCLUSION

African countries need good and inexpensive Internet services, to become “information societies” in their search for more favourable social and economic conditions. Tertiary education institutions should be aware of their key role, as contributor to Open Connectivity and of their potential influence in market mechanisms. At this level, user awareness is important as well as knowledge of market mechanisms that control the telecommunication market. Examples from peer institutions in other

countries are very important. Some countries in Africa are already joining forces, but many are still missing!

The human resource capacity problem in ICT must be addressed both at management and at technical and operational level. Collaboration between institutes should therefore be encouraged at regional and international levels. Governments should apply their legislative authorities to enforce "low price/ high connectivity" business models and encourages competitiveness, as to prevent monopolistic telecommunication markets. This is essential both for the connection to the global Internet, and for the formation of a regional communication infrastructure, which is now owned by private or state companies.

Donors should be aware of the importance of ICT and Internet connectivity as a motor for economic and social development and should focus attention on it in their development programmes. The private telecommunication sector should be aware of the business opportunities that may emerge when Internet penetration increases by low price/high volume business models for connectivity. Last, but not least, all the above mentioned stakeholders should collaborate and focus on the issue that will bring benefit to all: how to bring Africa online.

NOTES

1. Bandwidth in kbps (kilobits per second), Mbps, or Gbps is the unity in which the amount of digital data transmission per time interval is expressed.

2. Professor Pehrson was referring to a difference of a factor 1000 in data transfer rate between African universities and other universities in the World.

REFERENCES

AFRICA - WIKIPEDIA, 2007. The free encyclopedia. Avaialbale: wikipedia.org/wiki/Africa [Accessed on 26 May 2007]

ASSOCIATION OF AFRICAN UNIVERSITIES. 2005, Report of the Conference on African Research and Education Network Infrastructure, Tunis. November 14 and 15, 2005, [Online] Available: http://www.aau.org/tunis/presentation/Tunis%20Final%20report.doc [Accessed on May 15, 2007].

ASSOCIATION OF AFRICAN UNIVERSITIES.2007, Research and Education Networking, Available from http://www.aau.org/renu/index.htm [Accessed on May13, 2007].

BALANCING ACT NEWS UPDATE. 2005. WSIS Special: World Bank offers East African Fibre Consortium Easy funding, issue no 282, November 28, 2005, Available: http://www.balancingact-africa.com/news/back/balancing-act_282.html [Accessed on May15, 2007].

CAIRO DECLARATION. 2006. The Extraordinary Conference of The African Ministerial Council On Science And Technology Adopted on 24TH November 2006 Cairo, Arab Republic of Egypt. Available: http://www.bamako2008.org/en/docs/cairo-declaration-24-nov-2006.pdf [Accessed on 21 February 2007].

DROUOT, P. 2005. VSAT et sans-fil, des chances pour l'Afrique ? - Connecté avec le monde mais pas avec son voisin. – Africa Computing. Available: http://www.africacomputing.org/article543.html [Accessed on May13, 2007].

DYER, J. 2005. Setting up an NREN, European Experiences. Conference on African Research & Education Networking Infrastructure, Tunis., Available: http://www.aau.org/tunis/presentation/wayforward/20051115-jd-african-REN-workshop-v1.pdf [Accessed on May15, 2007].

EUMEDCONNECT .2007. Mediterranean partners take the first step towards forming an association of Mediterranean NRENS. Available: http://www.eumedconnect.net/server/show/nav.118 [Accessed on May15, 2007].

GEDYE L.2006. Not so Easy, Mail Guardian Online, 19 March 2006., Available: http://www.mg.co.za/articlePage.aspx?articleid=267024&area=/insight/insight__economy__business/ [Accessed on May13, 2007].

HAWKINS, R. 2005. Enhancing Research and Education Connectivity in Africa- The findings of the African Tertiary Institution Connectivity Study (ATICS) and Lessons for the Future of Campus Networks. World Bank. Available: http://www.oecd.org/dataoecd/49/48/35765204.pdf [Accessed on May13, 2007].

INTERNATIONAL NETWORK OF E-COMMUNITIES .2006. INEC Declaration on Open Networks.

Retrieved May 15, 2007, Available: www.smartcommunity.nl/.../205771/file/Stockholm%20INEC%20Declaration%20on%20Open%20Networks.draft.6.0.pdf [Accessed on May 12, 2007].

INTERNET WORLD STATISTICS .2007. World Internet Users and Population Statistics, Internet usage statistics - The Big Picture. Available: http://www.Internetworldstats.com/stats.htm [Accessed on May15, 2007].

MARTIN, D. 2006. The emerging NREN's of Sub-Saharan Africa TERENA Networking Conference 2006 "FOLLOW THE USER" 15 – 18 May 2006, Catania, Sicily. Available: http://www.tenet.ac.za/Publications/Emerging_NRENs_of_sub-Saharan_Africa.pdf [Accessed on May15, 2007].

MASSACHUSETTS INSTITUTE OF TECHNOLOGY. 2001. MIT to make nearly all course materials available free on the World Wide Web., Available: http://web.mit.edu/newsoffice/2001/ocw.html . [Accessed on May 17, 2007].

MUCHANGA, A. 2005. SARUA Fiber Study, Centro de Informática da Universidade Eduardo Mondlane (CIUEM) Available: http://event-africa-networking.web.cern.ch/event-africa-networking/cdrom/Joint_Internet2_IEEAF_workshops/Progress_and_Challenges_in_building_an_African_Research_and_Education_Network/20050918-africa-muchanga.ppt [Accessed on May18, 2007].

PEHRSON, B. & NGWIRA, M. 2006. Optical fiber for Research and Education Networks in Eastern and Southern Africa. University of Malawi. Available: http://www.idrc.ca/uploads/user-S/11083295861PAREN_Reportv15.doc . Accessed on May17, 2007

POTTER R. B., BINNS, T., ELLIOTT, J.A., SMITH,D. 1999. Geographies of Development. Pearson Education Limited, London.

RENA, RAVINDER 2007. Information and Communication Technologies, Education and Development in Eritrea. In ALLAM AHMED (Ed.) Science, Technology and Sustainability in the Middle East and North Africa. Inderscience Publishers, Brighton, UK. Vol.1, 80-90.

STANTON, M.A.& STÖVER, C. 2005. RedCLARA: Integrating Latin America into global Research & Education networking. DANTE, UK. Available: www.terena.nl/events/tnc2006/core/getfile.php?file_id=763 [Accessed on May 17, 2007].

STEINER, R., TIRIVAYI, A. TIRIVAYI, N., JENSEN, M. HAMILTON & P. BUECHLER, J. 2005. PAREN, Promoting African Research and Education Networking. A study sponsored by IDRC. Available: http://www.idrc.ca/uploads/user-S/11083295861PAREN_Reportv15.doc [Retrieved May15, 2007].

SURFnet. 2002. Het Internet georganised. Available: https://www.surfnet.nl/publicaties/brochures/organisaties/ [Accessed on April 17, 2007].

OLAWO, S. 2005. Easy Project Summary, Easy Project Secretariat. Available: http://www.itu.int/ITU-D/partners/Events/2004/Kampala_Oct-Nov04/Presentations/1_EASSy.ppt [Accessed on May15, 2007].

UBUNTUNET ALLIANCE FOR RESEARCH & EDUCATION NETWORKING. 2007. Working for Excellent Internet Connectivity for the Tertiary Education and Research Sectors in Africa. Available: http://www.ubuntunet.net/ . [Accessed on May18, 2007].

ZUCKERMANN, E. 2006. A peaceful Easy feeling. Available: http://ethanzuckerman.com/blog/?p=856 [Accessed on May 15, 2007].