

# IMPLEMENTING NATIONAL RESEARCH AND EDUCATION NETWORKS (NRENS) IN LAND LOCKED AFRICAN COUNTRIES: CRITICAL SUCCESS FACTORS

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## Abstract

The introduction of National Research and Education Networks (NRENs) has provided opportunities for Universities and Research Institutions in Africa for increased research and publications through increased Internet bandwidth, collaborative research and availability of resources through e-libraries. However, some Universities in landlocked countries have not taken advantage of these opportunities because of the challenges of implementing NRENs. The economic and human development indicators for landlocked countries in Africa are generally much worse than those for maritime neighbours because of dependence on other countries transit routes for access to overseas markets and to the Internet. The challenge of landlocked African countries include lack of direct access to the sea cable thus making Internet cost high about US\$4500 per 1 Mbps and the need to negotiate with neighbouring countries for connectivity. This paper presents critical success factors that need to be implemented in order to address the challenges faced by land locked African Countries. This paper presents the critical success factors that were used by Zambia, a landlocked African country. It provides information of the initiatives Zambia took to set up the ZAMREN (the Zambian Educational and Research Network). The paper also presents the lessons learned that can be used to assist other landlocked countries to quickly set up an NREN. Once an NREN is set up it presents new problems especially the issue of sustainability. The paper outlines the financial sustainability strategy that NRENs can use during its operations.

## Keywords

Challenges of landlocked countries, implementing National Research and Education Networks (NRENs), Critical success factors, Financial sustainability strategy for NRENs

## 1. Introduction

A number of African Universities and Research Institutions have not yet been able to take advantage of the full potential of ICTs in the delivery of actual education and learning. Education institutions operate independently in terms of sharing academic resources. Each of them has small networks with low bandwidth capacity. Maintenance of the existing bandwidth is a major problem due to inadequate funding for public universities. Lack of interconnectivity among the existing institutions in Africa have further hindered collaborative research. Institutions have made little progress in terms of research outputs and receiving research grants because of expensive Internet bandwidth costs that makes it difficult to share teaching and research resources. Implementing National Research and Education Networks (NRENs) has proved to be the most promising option for African Universities and Research Institutions. However, setting up an NREN in a land locked African country has its own challenges. The challenge of landlocked African countries include lack of direct access to the sea cable thus making Internet cost high about US\$4500 per 1 Mbps; need to negotiate with neighbouring countries for connectivity; expensive rates charged by local service providers for local transit; expensive set up costs and unwillingness for local Universities and Research Institutions to participate and provide the seed funds.

There are critical success factors that need to be implemented in order to address the challenges faced by land locked African Countries. This paper presents the critical success factors that were implemented by Zambia, a landlocked African country. It provides information of the initiatives Zambia took to set up the ZAMREN (the Zambian Educational and Research Network). The paper provides the historical background and challenges faced to set up the NREN in Zambia. The critical success factors include availability of ICT infrastructure, funding for setting up NREN, Government policy framework, financial sustainability and successful operations of NRENs. In case of ZAMREN the initiatives implemented included: NICHE project financing; provision of resources by three public University to kick start the process; provision of free local transit from one of the providers; and negotiation of international transit. The paper also presents the lessons learned and discusses available options to quick start an NREN. For example, NREN can now take advantage of the Africa Connect Project. Once an NREN is set up it presents new problems especially the issue of financial sustainability. The paper outlines the financial sustainability analysis check list that NRENs can use to assess their financial sustainability.

## 2. Challenges of lock-locked countries

A landlocked country is a country that is completely surrounded by land and having no direct access to the sea or ocean. Economic and human development indicators for landlocked countries are generally much worse than those for maritime neighbours because of dependence on other countries transit routes for access to overseas markets. This dependence can take at least four forms (Faye, Arthura, Sachse and Snowd, 2004): (1) dependence on transit infrastructure; (2) dependence on political relations with neighbours; (3) dependence on peace and stability within transit neighbours; and (4) dependence on administrative processes in transit. There are currently 16 African landlocked countries (Botswana, Burkina Faso, Burundi, Chad, Central Africa Republic, Ethiopia, Lesotho, Malawi, Mali, Niger, Rwanda, Swaziland, South Sudan, Uganda, Zambia, and Zimbabwe)

The problem of being landlocked has been analyzed mostly at a macro-level with a focus on the dependence over transit countries and on land locked country's transport cost disadvantage. However, transportation costs only explain one part of the real impact of being landlocked (Arvis, Raballand and Jean-Marteau, 2007). Delays and even more importantly low degree of reliability and predictability of services create massive disincentives to invest and higher total logistics costs. Dependence over the transit state necessarily implies high transaction costs (notably transportation costs). High transaction costs are perceived as the result of (i) "transit charges" but also (ii) the difficulties to benefit from regional adequate infrastructure.

MacKellar, Wörgötter and Wörz (2000) discovered that landlocked countries experience a lower per capita economic growth on account of geographic disadvantage reducing average growth by as high as about 1.5 percentage points per year. This is because when goods cross a border, there will be transaction costs associated with customs and handling. If there is a switch in transport modes, there will be offloading and onloading costs, and perhaps storage costs as well. Therefore, landlockedness can be thought of as raising the price of imports, and reducing the price of exports net of transport costs (which must be absorbed by a price-taking seller in order to compete internationally). Thus, land locked countries suffer deterioration in their terms of trade and a resulting reduction in real income. The greater the share of primary commodities in the export basket, and of finished goods in the import basket, the greater the terms-of-trade loss, because transport costs are typically low per unit of value for primary goods and high per unit of value for manufactures. The income effect of the terms-of-trade loss is to reduce the volume of imports. The substitution effect is to cause consumers to switch from imports to domestic goods, reducing the exportable surplus as the opportunity cost of consuming at home instead of exporting falls. Both the import and substitution effects reduce the share of total trade (imports plus exports) in GDP.

A landlocked country in Africa also suffers extra transaction costs from the ICT point of view because most of the internet connectivity to Europe or USA is through the sea cable and therefore they have to pay transit costs to access the sea cable. Furthermore, there is dependence on peace and stability within transit countries, for example a riotous mob can cut the fibre cable in transit country and thus completely cut off the landlocked country's communication to the outside world. A landlocked country also depends of the ICT infrastructure of the transit country and therefore if there is new technology introduced on the market and the transit country does not invest in the new technology that means that the landlocked will not benefit from the new technology. This explains why the cost of ICT services in a landlocked country is much higher than its maritime neighbour, for example cost of internet in Zambia was high as US\$4500 per 1Mbps in 2008 while countries like Kenya was around US\$600.

## 3. Background to the Zambian NREN

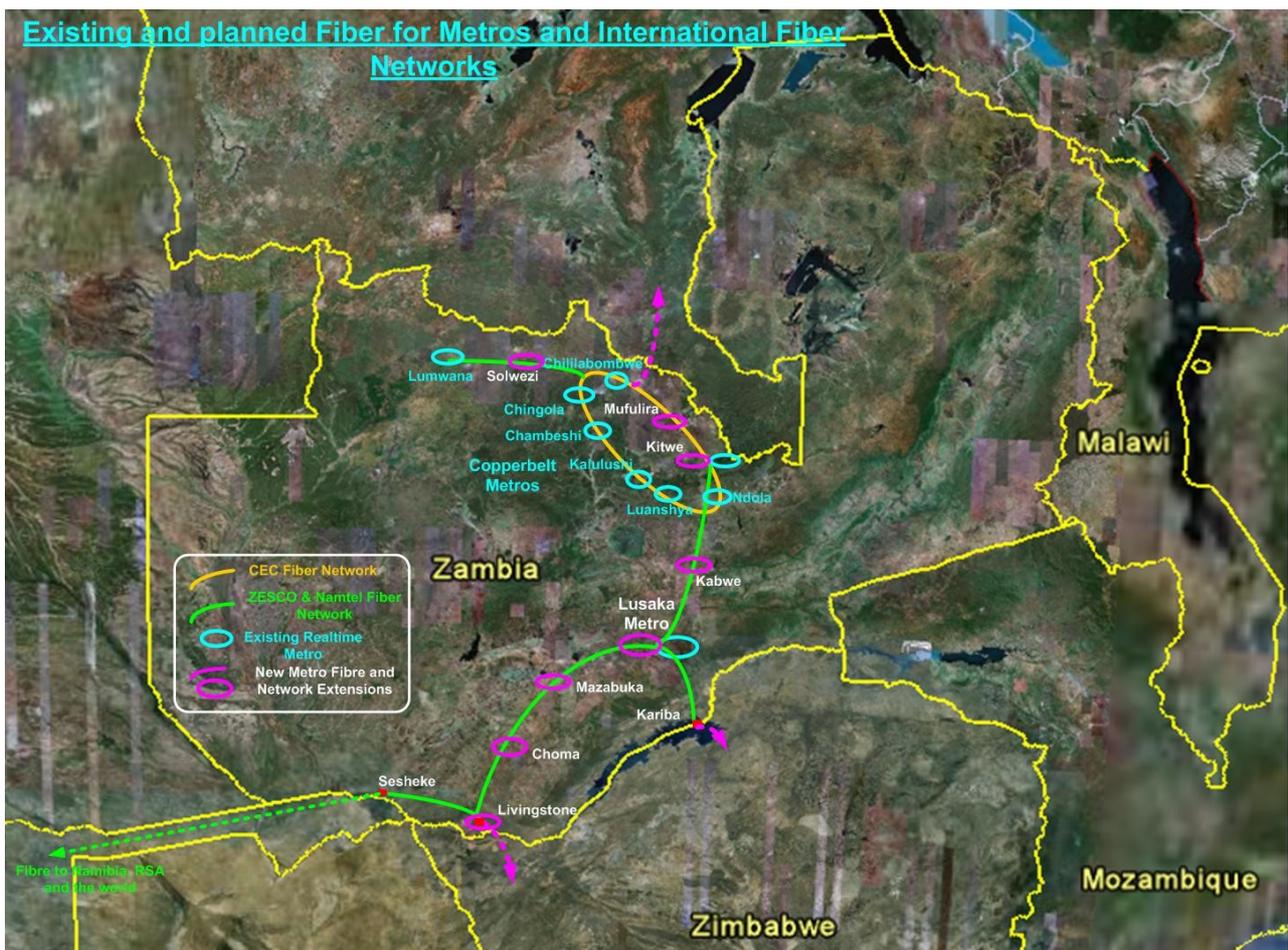
Zambia is a landlocked country and facing the challenges of landlocked countries highlighted above. The Zambian economy has historically been heavily dependent on copper mining (Shafika, 2007). Since the early 1970s the terms of international trade shifted towards a significant decline in copper prices. This led to the closure of mines and had a far-reaching effect on the economy. Slow progress in diversifying the economy and high levels of borrowing and debt relief are contributing factors to the country's economic malaise. Zambia is still one of the low income countries as it can be seen from the socio-economic indicators in the table below. According to the 2013 statistics, Zambia suffers a high rate of HIV/AIDS, with 12.5% of Zambians age 15 to 49 years being HIV positive (UNAIDS, 2015). This has a negative impact on the availability of national ICT skills because people with ICT expertise either die during the prime age or spend most of their time at the hospital thus robbing the country of the required technical skills.

Table 1. Zambia Economic Indicators (World Bank, 2015)

Indicators	
Population	14.54 million (2013)
Human Development Index (HDI)	0.561 (2013)
GDP	\$26.82 billion (2013) Annual GDP growth rate 6.4% (2014)

Poverty Headcount ratio (% of population)	60.5%
Per capita gross national income (GNI)	\$1,810 (2013)

At the time of setting up an NREN, Zambia did not have national fiber backbone, apart from those of the Zambian Electricity Supply Cooperation (ZESCO) and the Liquid Copperbelt Energy Cooperation (CEC) that just begun its implementation. Furthermore, the existing fibre were not connected to the sea cable along the African coasts. Higher Education Institutions (HEIs) in Zambia were working independently with small networks with low bandwidth capacity. Maintenance of the existing bandwidth was a major problem due to inadequate funding for public universities. Lack of interconnectivity among the existing institutions in Zambia hindered collaborative research. Institutions were unable to share the teaching-learning-research resources. The price of bandwidth of US\$4500 per Mbps per month was a prohibitive factor for HEIs towards attaining broadband connectivity in Gigabits (GB) per second. These costs were prohibitively expensive and thus the need for stakeholders to seek low-cost effective alternative as provided through the UbuntuNet Alliance.



Due to the above mentioned a large part of staff and students at Zambian HEIs did not have access to digital information sources. Neither did they use ICT-based facilities in the teaching and learning process. This was caused by a lack of ICT infrastructure and of competent teachers in this field. The culture of using ICT in the teaching and learning process was little developed. As a result, ICT literacy levels and knowledge of ICT applications, software and internet sources with a large added value for course and subject content among staff, technicians and students was low. The need for capacity building can only be achieved through intensive and diversified training programmes, and through curriculum reform in order to bring ICT to the classroom as part of the teaching methods.

To address this situation HEIs came together in 2006 to form the Zambia Research and Education Network (ZAMREN) whose main objectives are to offer secure broadband connectivity to each other, to the dedicated global research and education resources and to the internet. ZAMREN is a non-profit association for tertiary level research and education institutions, which collectively intend to:

- Secure broadband connectivity to each other, to the dedicated global research and education resources and to the internet
- Share their education resources via this dedicated infrastructure of ZAMREN

- Provide Advanced ICT services to its member institutions.

The purpose of ZAMREN is to provide the inter-institutional connectivity in terms of a National Research and Education Network (NREN), and to connect it to the Regional Research and Education Network (RREN) in Eastern and Southern Africa, UbuntuNet ([www.ubuntunet.net](http://www.ubuntunet.net)), thereby extending ZAMREN to other National Research and Education Networks in Africa and in the rest of the World.

#### **4. Critical success factors in implementing NREN in Zambia**

In order to successfully set up an NREN there is need for internal champions who understand the local environment and more importantly can tap into personal, informal and formal or official networks to raise awareness and convince people to collaborate towards a common good (Twinomugisha, 2007). Such champions include highly respected academics, researchers and heads of academic and research institutions. The internal champion should sensitise all stakeholders on the need for an NREN. However, in Zambia the problem was lack of local associations of universities, colleges, teacher training colleges and the National Council for Higher Education and Research. Five public universities, thirty private Universities and the more than forty Colleges of Education were operating independently in terms of sharing academic resources. And Zambia being a land locked country, for example in 2008 the cost of bandwidth was US\$4500 per 1Mbps because of additional transaction cost of national and trans-national connection.

To address these challenges, three public Universities (University of Zambia, Copperbelt University and Mulungushi University) came together set up the Zambian Educational and Research Network. ZAMREN was registered in the year 2007 as a not for profit association and was operationalised in June 2012 when ZAMREN was connected to UbuntuNet Alliance PoP in South Africa (Mkandawire, 2013). ZAMREN is the first and until now, it remains the only NREN land locked/linked to operate a cross border network connecting to UbuntuNet Alliance PoP via Mtunzini U-HUB (Martin, 2012). To operationalise ZAMREN the following critical success factors were used: initiate HEI and Researchers collaboration; setting up seed funding and registration of ZAMREN; request for donor funding; provision of an enabling Government policy framework; and initiate regional and international collaboration

##### **4.1 Initiate HEI and Researchers collaboration**

Three public Universities (University of Zambia, Copperbelt University and Mulungushi University) came together to collaborate and set up a team of ICT Directors to spearhead the formation of the ZAMREN (the Zambian Educational and Research Network). The Vice Chancellors from the three public University met several times to provide policy direction and to provide resources necessary to initiate the setting of ZAMREN Office. The Committee of ICT Directors from three public Universities were responsible for technical and administrative tasks of setting up ZAMREN. In order for an NREN to be set up in a landlocked country you need two or more Universities and Research institutions to come together to spearhead the formation of an NREN. Alternatively if the country has National Council for Higher Education and Research, the National Council can be used to initiate the process of setting up an NREN.

##### **4.2 Setting up seed funding and registration of ZAMREN**

The three public University provided seed funding, provided an Office at University of Zambia, seconded staff and a vehicle to the ZAMREN secretariat. ZAMREN was officially registered with the Registrar of Societies and the office became operational with full time staff. A memorandum of understanding was signed between ZAMREN and ZESCO to use their fibre for free as long it was used for education and research purposes. The seed funding and full time staff is in an important catalyst to kick start the operations of an NREN.

##### **4.3 Request for donor funding**

In 2010 the three public universities submitted a project proposal to the Netherlands Government through NUFFIC. The Government of the Netherlands approved a total budget of Euro 2,249,767 for the ZAMREN/NICHE Project. The main objective of the project is “To improve the quality of Higher Education and to enhance research and resource sharing among research and education institutes in Zambia through ICT capacity building and strengthening of the Zambia Research and Education Network”. The specific objectives of the project are: a) Implement needs assessments and create conditions for increased use of ICT to improve quality and efficiency of teaching and learning at Zambian Higher Education Institutions. b) Develop organisation, administrative and technical capacity of ZAMREN to support member organisations in being connected and making full use of available education and research networks. c) Review and develop policy plans for ICT implementation strategies at the level of the Zambian Higher Education Institutions. d) Improve internet access and interconnectivity between local research and education institutions and regional institutions e) Improve the provision of ICT facilities and the delivery of ICT services and training for Academic, Administrative and Management staff and students in support of teaching, learning and research at the ZAMREN member organisations. f) Contribute to a better use of internet, intranet and other ICT-based content applications in higher education programmes at the ZAMREN member organisations through development and adaptation of curricula with ICT-based and E-learning modalities.

#### 4.4 Provision of an enabling Government policy framework

In March 2007, the Zambian government launched its national ICT policy. The policy identifies three goals for ICT: a) To enable a diversified and export-oriented economy b) To improve livelihoods and protect the vulnerable through service delivery c) To provide an efficient and effective public sector. The policy resulted in the creation of the Zambia Information Communication Technology Authority (ZICTA) in 2009 whose objective was to regulate the information communication technology. ZICTA funded the last mile connectivity for University of Zambia, Copperbelt University and Mulungushi University to ZESCO fiber grid backbone. ZICTA also assisted other colleges and secondary schools to be connected to ZAMREN fiber network.

#### 4.5 Initiate Regional and International Collaboration

ZAMREN joined the UbuntuNet Alliance as part of regional and international collaboration. The UbuntuNet Alliance exists to provide regional and international connectivity and Internet services to its member NRENs in Eastern and Southern Africa (“the Region”), on a non-profit basis. The Alliance provides specialised interconnections with other research and education networks worldwide – interconnections that are available only to bona-fide NRENs – and also connectivity to the general “commodity” Internet worldwide. The Alliance is in the process of designing a high-speed backbone network that will inter-connect the NRENs and provide them all with connectivity to major research and education networking gateways and general Internet gateways operated by the Alliance. The Association of African Universities paid for 16000 IP addresses for ZAMREN and also gave ZAMREN the ASN. The ASN helps to identify ZAMREN that it will transit data for education and research purposes and not for commercial purposes. ZAMREN negotiated with CEC Liquid Telecom for transnational transits cost from Lusaka to UbuntuNet Alliance PoP via Mtunzini U-HUB. ZAMREN was able to connect to GEANT hub through the UbuntuNet Alliance backbone thus reducing the cost of bandwidth for ZAMREN members.

### 5. Sustainability strategy

Although an African landlocked country can be set up an NREN using the critical success factors discussed above, there are still problems associated with sustainable operations of NRENs. Since the formation and operationalisation of ZAMREN, Zambia has seen an increase in the uptake of Internet among education and research institutions (Mkandawire, 2013). Local Internet Service Provider have seen this an opportunity for business and most of them have reduced their prices and will reduce their prices in future. The reduction of internet and bandwidth costs puts a lot of pressure on ZAMREN to either reduce their prices and operate at financial loss or simply lose customers. Therefore the challenge of financial sustainability must be addressed by new NRENs. In order to address challenges associated with the operations of an NREN, ZAMREN developed some financial sustainability strategy. These strategies include:

- **Negotiate prices with transit carriers.** ZAMREN negotiated international transit costs with CEC Liquid Telecom fiber to connect to South Africa from Lusaka through Zimbabwe.
- **Membership to UbuntuNet Alliance.** ZAMREN membership to UbuntuNet Alliance means enjoying concessional prices and use of the UbuntuNet Alliance (UA) backbone network. The Alliance provides specialised interconnections with other research and education networks worldwide – interconnections that are available only to bona-fide NRENs – and also connectivity to the general “commodity” Internet worldwide.
- **Participation in the Africa Connect Project.** ZAMREN has linkages with the African Union Commission and European Commission that is working on a project known as the Africa Connect with a budget of Euro14.2million, which will undertake the initial deployment of the UbuntuNet Alliance Network backbone whose overall vision is a dedicated research and education network interconnecting the entire continent and to the rest of the global research and education networking community. ZAMREN is a full member of UbuntuNet Alliance and participated in the Africa Connect Project. ZAMREN has made its contribution of Euro (€) 250,000 towards the Africa Connect project. ZAMREN has already started benefiting from the Africa Connect Project.
- **Provision of value added Services.** ZAMREN has been providing special value added services rather traditional services such as webhosting that commercial ISP provide. For example ZAMREN provides EDUROAM to its members. This service provides connectivity to Internet based services wherever the service was deployed within the country and outside the country at no cost to the user of the network (Mkandawire, 2013). This service distinguishes ZAMREN from other ISPs. Other services that ZAMREN has been providing is capacity building through trainings and technical support to its member institutions at shared cost. In future ZAMREN will offer federated identity services, Cloud Computing (CC) and High Performance Computing (HPC).
- **Charging Membership fees.** Annual Members Fees will be charged to all member institutions. This will be determined and revised at Annual General Meeting. The membership has increased from three (3) in 2008 to thirty nine (39) members by end of 2014. The rapid increase in membership suggests financial sustainability of ZAMREN.

In addition to financial sustainability, ZAMREN has put in place a Governance Structure to ensure sustainability of the organisation. The ZAMREN Governance structure comprises of Council of Representatives, ZAMREN Board, Committees of Board (including Audit and Finance Sub committee), ZAMREN Organization Structure (with Chief Executive Officer). ZAMREN has developed a five year Strategic Plan.

## 6. Lessons Learnt

Implementing an NREN in a landlocked country like Zambia had a lot of challenges and required more work and finances compared to countries that has direct access to the sea cables. The following are the lessons learnt during the implementation of ZAMREN:

*Lesson 1. There is need for good national ICT policy to start an NREN in a land locked country.*

There is need for a national ICT policy and national regulator for information communication technology. The regulator will provide a level playing field for ICT vendors and ISP. The regulator can also initiate projects that promote the use of ICT in higher educational and research institutions. In Zambia, ZICTA (the ICT regulator) assisted the three public universities with last mile connectivity to fibre backbone as well as colleges and schools with ICT equipment.

*Lesson 2. There is need for two or more HEI to come together to kick start the setting up of an NREN*

There is need for two or more HEI or Research Institutions to come together to kick start the setting up of an NREN. In Zambia three public Universities came together to kick start the setting up of the NREN.

*Lesson 3. There is need for seed funding to start an NREN*

Starting an NREN always requires seed funding. The seed funding can be used to register the organisation, payment of membership fees to regional organisation, recruit staff and office administration. Implementing an NREN in a African landlocked country on part time basis will not work and if it does work may take a long time to operationalise it. In Zambia three public universities provided the seed funding, offices, seconded staff, provided a motor vehicle to ZAMREN secretariat to kick start the implementation process.

*Lesson 4. There is need for sustainability strategic plan for an NREN*

Setting up an NREN requires sustainability strategy because competition from Internet Service Providers. Furthermore service providers especially those that offers national and trans-border connectivity can collude and increase the prices and thus adversely affect the cash flow of an NREN. Collaboration with other regional NRENs eg UbuntuNet Alliance and international NRENs can minimize the impact of price changes in the market.

*Lesson 5. NREN opens doors for HEI and Research Institutions*

ZAMREN opened up the door for higher learning institutions to offer full scale Open and Distance Learning opportunities. Researchers now able to participate in collaborative research initiatives with their peers across the globe. Students can now access other educational materials such as MIT lectures on U-Tube and e-journals. Support for ICT capacity building has resulted in improved usage of ICT services in institutions e.g. Deployment of LMS such as of MOODLE, On-line registration, On-line financial transaction

*Lesson 6. NREN has an impact on the labour market*

The implementation of ZAMREN has directly impacted on the industry requirements. ICT literate graduate are preferred as they quickly adapt to systems found in industry. Furthermore, ICT literate graduate will demand for faster internet connectivity in the companies when they work because of the experience at HEI.

*Lesson 7. NREN is a game changer*

ZAMREN has been a Game Changer in reducing cost of Internet Bandwidth in the country, thereby reducing cost of education in the country. The internet bandwidth has been reduced from US\$4500 per 1 Mbps in 2008 to US\$422 per 1 Mbps in 2015.

## 7. Conclusion and future plans

The introduction of NRENs has provided opportunities for Universities in Africa for research through increased Internet bandwidth, collaborative research and availability of resources through e-libraries. However, some Universities in Africa have not taken advantage of these opportunities because of barriers for integrating ICT in research (Kunda, 2014). Therefore there is need for ZAMREN to introduce ICT services that will encourage lecturers and researchers to integrate ICT in their work. In future ZAMREN will provide the following ICT services i) Strengthen and scale up provision of EDUROAM services; ii) Develop and implement a programme for providing Cloud Computing (CC) & High; Performance Computing (HPC) resources; iii) Develop and implement a programme for providing FID Services; iv) Establish and operationalize a Computer incidence response mechanism; and v) Establish and operationalize Automated Standard Internet Services. ZAMREN will also foster collaboration among researchers, academics and other learners with national regional, international and other stakeholder institutions in order to facilitate exchange of

information and promotion of international best practice.

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## Biography

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Bonny Khunga is the Chief Executive Officer (CEO) of ZAMREN in Zambia. He holds an Master and Bachelor's degree in Computer Science. He has over 30 years experience in Information Communication Technology. He was Director of ICT at Copperbelt University before he became CEO for ZAMREN.