

# Accelerating Research in Africa through Sustainable Virtual Research Communities

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## Abstract

Despite the commendable efforts by African NRENs to interconnect universities and research institutions, research capacity in Africa is still a major challenge. In particular African universities and research institutions phases the challenges of training, retaining and attracting competent researchers due to limited resources. Other limitations include cultural barriers, insecurity, government bureaucracy and technological resource limitations among others. However the introduction of modern communications techniques resulting from innovative information and communication technological transformations will go a long way to address these challenges. It is expected that improved connectivity will influence a paradigm shift in research approach in Africa. In order to remain relevant in the current competitive knowledge economy, African researchers ought to take advantage of the improved connectivity to reengineer their research approach by embracing current information and communication technology innovations. This study investigates how modern collaborative tools can be exploited to ensure effective brain circulation within Africa and attract young talents into research careers so as to boost Africa's research capacity. In the context of the expected paradigm shift from traditional research methods to e-research, the study examines the role of virtual research communities in addressing Africa's research challenges and hence accelerating research in Africa. The study takes into account the expected transformations of the scientific communication and points out the virtual communities' role in the current social context. By scrutinizing existing collaborative research projects with specific emphasis on application of ICTs, the study identifies specific approaches that can be exploited to establish virtual organizations which can then form virtual research communities. Long term sustainability of Virtual research communities is also addressed to ensure that established VRCs remain viable. By conducting desktop/web review of grey and published literature and a systematic review of existing well established virtual research communities, the study examines the key drivers and the critical success factors of these communities relevant to the African continent. In particular the study presents a review of the model used to establish virtual research communities within the European grid infrastructure and attempts to propose one for Africa through the African NRENs. Taking into consideration the drivers and the critical success factors, the study further proposes an adoption conceptual model for the new ICT based research paradigm.

## Keywords

E-research, critical success factors, research capacity, sustainability, virtual research communities

## 1. Introduction

Increased visibility of NRENs and NREN activities in Africa indicate that African governments have recognized the importance of Science and Technology (S&T) and ICT in bridging the scientific divides, reducing poverty and ensuring socio-economic development so as to achieve the Millennium Development Goals (MDGs). The rate at which ICT infrastructure initiatives are taking off either through international funding or institutional initiatives is commendable and an indicator of readiness of African universities and research institutions to embrace ICTs in their work. The AfricaConnect Initiative for instance aims to support the establishment of the regional backbones facilitating connection of the ready African NRENs to the global resources. It will also support capacity building in the not yet ready communities and establish a few demonstrators illustrating the value of the investment. There are other initiatives supporting the establishment of NRENs. These initiatives have been catalyzed by the deployment of submarine cables along the African coast and the rapid development of mobile phone networks. The effects of the ICT infrastructure projects are quite visible one being the drastic change in the connectivity status of the African continent. This has resulted to increased adoption of internet technology as a communication and information dissemination tool. Dissemination of internet as a communications and information access system, and increased use of other computer-based communications and information technologies, transforms a society to a net society, generating a new culture referred to as cyberculture. cyberculture refers exclusively to social relationships that are placed in virtual reality, or cyberspace, using computers (Machando & Reis, 2007). As noted by Machando, 2002, cyberspace is an immense network composed of computers, telecommunications, programs, interfaces and data, forming an intricate base of dynamic and interactive information. It represents the maximum expression of new forms of human communication, generated by the development of computation technologies and data transmission (Machando, 2002, p.2). Cyberspace encourages a style of independent relationship from geographic places. The virtual environment presented by the cyberspace makes it possible for people to communicate simultaneously, independent of where they are. This renders the distance and time between the information sources useless. According to Santos (2004) people do not need to dislocate themselves because it is the data that travels. For the author, these changes bring new requirements, strategies and actions on the part of institutions facing the dissemination of information, opening up new possibilities for the performance of professionals and users of the sector.

## 2. Background : Research capacity Challenge in Africa

Factors that constitute research capacity includes: individual skills developed in research work quality of the research environment, funding, adequate infrastructure, research incentives and time available to the researcher among others (Akilagpa, 2004). With regard to funding, expenditure on research by African government remains relatively low compared to other parts of the world (Kiburi et al, 2012) although policy development and discussions have focused on ST&I in the recent times. As a result dependency on external donor funds for research activities is quite high. It is worth noting that African governments are waking up to the fact that Science and Technology (S&T) and ICTs are key drivers in bridging the scientific divides, reducing poverty and ensuring socio-economic development so as to achieve the Millennium Development Goals (MDGs) however, the little efforts they are making towards funding research in this direction are being outstripped by growth around the world, leaving African research poorly funded by comparison as depicted in table 1(Nordling 2010, Kiburi et al, 2012).

**Table 1: Gross annual expenditure on research and development and proportionate number of researchers in selected regions and countries. (PPP\$: purchasing power parity in USD; SSA‡: Sub-Saharan countries excluding South Africa) (Nordling, op cit )**

	GERD per researcher (thousand PPP\$)		Researchers per million in habitants	
	2002	2007	2002	2007
North America	204.8	251	4527.30	4654.30
European Union	176.1	194.7	2,420.30	2,727.70
Japan	167.3	207.9	5,071.60	5,548.10
China	48.7	73.7	629.1	1,071.30
SSA	57.1	64.1	51.3	60.3

As can be seen from table 1 there is a relationship between resource allocation and number of researchers. It is clear from the table that Africa lags behind in resource allocation and consequently number of researchers. According to Nordling (op cit), majority of sub-Saharan African countries spend an average of just 0.3% of their GDP on science and technology. This is far below the 1% promised in 1980 and in 2005 by African governments. This scenario has resulted to African dependence on foreign funders and aid agencies. The donor-driven research landscape is quite fragmented and needs more domestic drivers.

As noted by Akilagpa (2004), every society needs to insure the existence of viable indigenous knowledge systems, i.e. local institutions, structures, and cadres which, in combination, are able to access knowledge from all sources including external and home-grown as well as traditional and modern. The knowledge systems should then be able to synthesize accessed knowledge, adapt it, and generally make it usable by local communities and agencies under local conditions. The inadequacy of such systems in Africa is both cause and effect of the continent's knowledge poverty and deepening material deprivation.

Other than limited funding, brain drain as a result of lack of research incentives has cost Africa valuable research personnel. Brain drain in the context of this paper refers to both internal and external. According to the Merriam-Webster online dictionary 'brain drain' is the departure of educated or professional people from one country, economic sector, or field for another usually for better pay or living conditions. Where the departure of skilled persons involve emigration from one country to another this is termed as external brain drain (Teferra, 2000) whereas departure of skilled persons from one economic sector or field to another is termed as internal brain drain. Both types of brain drain are quite prominent in Africa and have contributed to reduced research capacity in Africa as depicted in figure 1

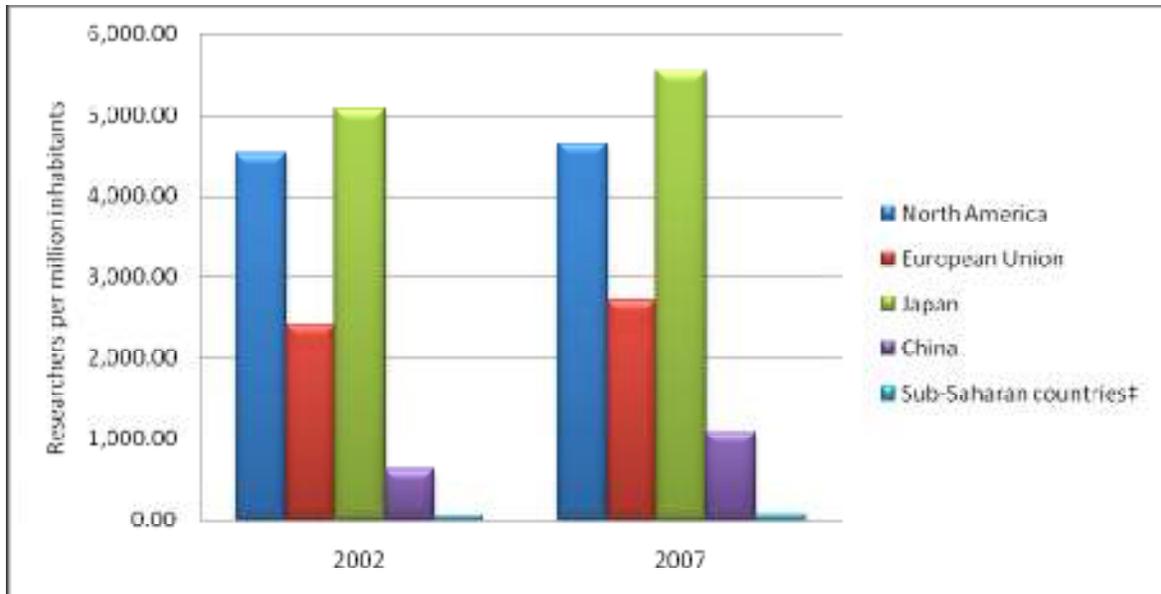


Figure 1 number of researchers across the population (Nordling 2010)

### 3. Addressing Research capacity Challenge in Africa

Efforts to address research capacity challenge in Africa include: raising the capacity of individual researchers so as to build a critical mass of competent researchers, improvements in the research environment and research capacity development (Akilagpa, 2004).

Improving the Research Environment: Introducing Virtual Research Environments to support e-Research

According to Carusi & Reimer (2010) a virtual research environment (VRE) is an electronic web-based environment for: a) access to data, tools, resources; b) collaboration with other researchers or institutions at intra- and inter-institutional levels as well as; c) preserving data and other outputs. Similarly Jansen W. (2006) defines a Virtual Research Environment as a set of online tools, systems and processes to enhance the research process. From both these definitions a VRE aims to provide researchers with the tools and services they need to do research efficiently and effectively as well as manage the increasingly complex range of tasks involved in doing research.

e-Research is the use of information and communication technologies to do better research and to do research collaboration better. e-Research enables researchers to draw on perspectives and resources from a range of participants, in order to develop new insights and new solutions to complex problems. It involves the use of technology to draw people together, where technology is the facilitator to researcher collaboration (Monash University, 2008).

To improve Africa's research environment, African NRENs have come out strongly to uplift connectivity of Universities and research institutions. This has facilitated connection of these institutions to off-site research centres internationally. Quite outstanding is UbuntuNet Alliance's effort to interconnect all NRENs in eastern and southern Africa with other regional RENs of the world. From these efforts the alliance is a notable participant in key EU FP7 e-infrastructure projects including: GLOBAL, ERINA4Africa and CHAIN (Banda, 2011). The latest engagement of the Alliance is the AfricaConnect project whose aim is to establish a high-capacity Internet network for

research and education in Southern and Eastern Africa to provide the region with a gateway to global research collaboration (AfricaConnect, 2012). By interconnection with its pan-European counterpart GÉANT as depicted in figure 2, AfricaConnect will allow researchers, educators and students across the region to collaborate among themselves and to engage in joint projects with their peers in Europe and other parts of the world (AfricaConnect, 2012).

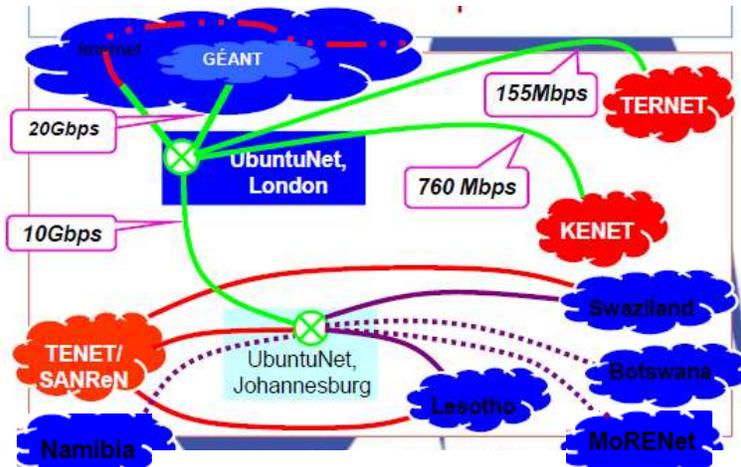


Figure 2: REN interconnection through UbuntuNet (Banda, 2011)

This approach to improving the research environment is gradually transforming the research community to a net community, generating a new research cyberculture. As noted by Machando & Reis (2007) cyber culture refers to social relationships that are placed in cyberspace, using computers. This transformation is expected to result to a paradigm shift in research approach in Africa.

#### 4. Research Collaborations Through ICT enhanced Research Environment

Never has international collaboration been more important in all disciplines than in the 21st century. The growth of Cyber-infrastructure projects reflects a trend towards scientific collaboration. Among the factors that motivate research collaboration are high cost of conducting scientific research as a result of expensive scientific equipment and the improved modes of communication. Collaboration enables researchers to conduct scientific research cost effectively by making use of a pool of resources from different organizations. Current e-Infrastructures activity efforts in Africa and globally aim to empower researchers with an easy and controlled online access to facilities, resources and collaboration tools, bringing to them the power of ICT for computing, connectivity, storage and instrumentation (European Commission, 2012). This allows for instant access to data and remote instruments for performing computer simulations. Access to online collaboration tools has enabled research collaborations across geographical, disciplinary and organizational boundaries necessitating formation of virtual research communities (VRC).

For a long time, researchers in Africa have not been well integrated into the social network of scientists. Research networks are important for receiving criticism of one's work, having access to the most recent, unpublished work of other scientists in one's field as well as having access to resources and funding Wray(2002). To integrate the African researcher into the social network of scientists, In the recent times there have been deliberate efforts to establish ICT supported research collaboration. For instance the brain gain project and the HP catalyst projects put specific emphasis on research projects utilizing distributed computing environment to collaborate. The HP catalyst

project global collaborator consortium of the year 2011 aimed to enable students to participate in collaborative problem-solving to address urgent social challenges using the power of collaborative grid computing. The brain gain project purposed to promote experts collaboration in Africa and the Arab with the help of advanced information and distributed computing technologies (grid and cloud computing). Participating institutions from Africa in the two projects are summarized in Table 2 (Karume & Omieno, 2011).

**Table 1: summary of number of higher education institutions and the number of e-research projects involved in the UNESCO-HP brain gain and HP catalyst initiatives source: (Karume & Omieno 2011).**

Country/Region	No of HEIs	No of projects	
		Brain Gain	HP- Catalyst
<b>West Africa</b>			
Ghana	1	1	
Nigeria	1	1	1
Senegal	1	1	
Burkina Faso	1	2	0
Côte d'Ivoire	1	1	
<i>Sub total</i>	<i>5</i>	<i>6</i>	<i>1</i>
<b>North Africa</b>			
Morocco	1	1	
Tunisia	1	1	
Egypt	1	0	1
Algeria	1	1	
<i>Sub total</i>	<i>4</i>	<i>3</i>	<i>1</i>
<b>Central Africa</b>			
Cameroon	2	2	0
<i>Sub total</i>	<i>2</i>	<i>2</i>	<i>0</i>
<b>East Africa</b>			
Ethiopia	1	1	
Kenya	3	2	2
Uganda	2	2	0
<i>Sub total</i>	<i>6</i>	<i>5</i>	<i>2</i>
<b>South Africa</b>			
Zimbabwe	1	1	
South Africa	3	0	3
<i>Sub total</i>	<i>4</i>	<i>2</i>	<i>3</i>
<b>Total</b>	<b>21</b>	<b>17</b>	<b>7</b>

Collaboration analyses carried out by Adams et al (2010) using Research Performance Profiles data in InCite reveals clusters of countries with the strongest partnerships. There is a Striking relationship between Table 2 by Karume & Omieno (2011) and the Visual interpretation of collaboration diagram by papers published (figure 3) in that all the participating countries in the Brain Gain and HP distributed computing projects are represented in the collaboration profile by papers published.

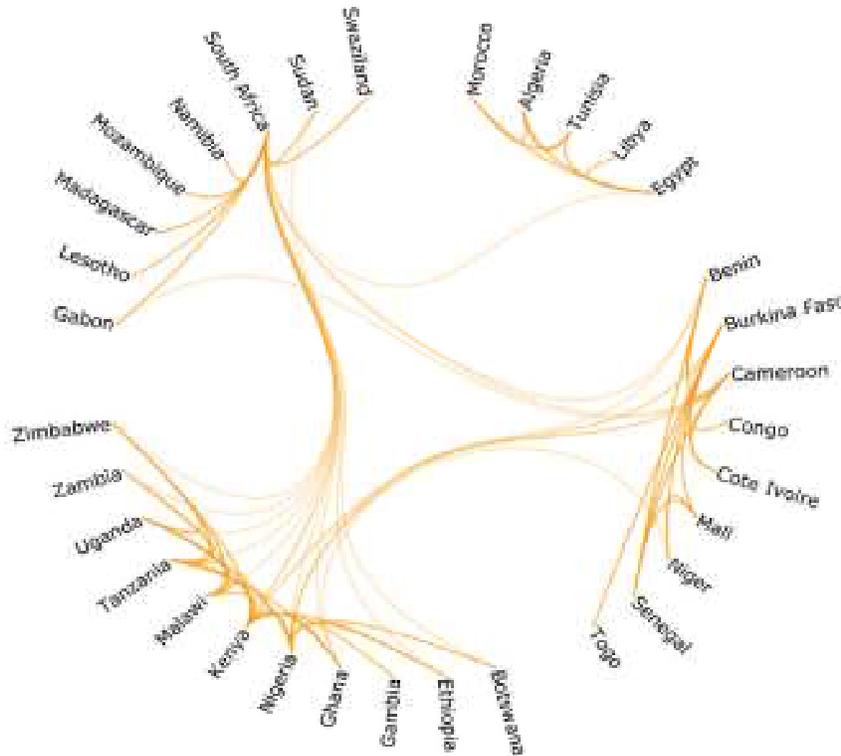


Figure 3: Visual interpretation of collaboration, by papers published: Source Adams et al (2010)

This observation reveals a trend towards research networking through ICT enhanced research environments. It can be construed that where research networks are strong research output is observable. ICT based collaborations result to emergence of research networks which are key to addressing Africa's research capacity. As noted by Akilagpa, 2004, collective or networked ongoing research provides an irreplaceable opportunity for the experience of each member of a team or network to complement and help raise the capacity of others. For young and mid-career researchers such participation, especially under the mentorship of senior colleagues, constitutes the most effective form of research capacity development.

## 5. From Informal Research Networks to Structured Virtual Research Communities

From the observation in the previous section the power of research networking in uplifting research capacity need not be overemphasized. It is clear from table 2 and figure 3 that active participants in research networks generate a fair amount of intellectual property goods. This is the reason why the author seeks to move the concept of research networks in Africa a notch higher to semi-structured research communities. Existing research networks in Africa are quite informal most of them arising out of opportunities. Often research networks spring from Calls for proposals by donors and the constitutions of members in the network is defined by the constraints in the Calls for proposal documents. Such networks evolve rather subconsciously and are likely to disintegrate once the donors pull out resulting to a decline in the observed intellectual property output. With the recent commitment by African governments to promote research in science and technology by increasing funding (Nording 2010), there is need to be more conscious and inject some structure in the formation of research networks. Donors attempt to put some structure in the emerging networks by

placing specific constraints in the call for proposal documents. These constraints then serves to bring together researchers with common interest.

## 6. Networks vs. Communities vs. Teams

The distinction between these types of social interactions between researchers can best be understood by looking at how communication in each is structured. As noted in section 3.2 improved modes of communication is one factor that have favoured research collaborations. Communication is a key factor in collaboration. Efimova (2009) notes that communication in distributed teams can be viewed in horizontal and vertical axis. The horizontal axis regards what triggers communication either a common goal or an opportunity. The vertical axis regards the pre-arrangeness of communication either informal or structured. Figure 4 illustrates how a distributed team communication differs from a co-located team communication based on these two axes.



Figure 4: Communication in co-located and distributed teams

This concept can be used to explain the distinction between the different types of social constructions in e-Research. As depicted in figure 5 (Efimova, 2010), social constructions in e-Research can be put into three categories team, community and network. A team is about working together closely and requires strong ties to get things done. It is goal oriented and structured. A community on the other hand constitutes of a mix of stronger and weaker ties that help to open up and share local practices is semi-structured but still has lots of connection where one uses an opportunity of being together with other experts to ask for solutions for a problem. There is enough commonality and trust to hold people together and enough diversity to support learning. A network is informal more opportunity-based and there is not much in terms of shared goals and recurrent conversations, the ties are weak or latent. However, there is enough connectivity and opportunities to communicate that result in cross-fertilization and emergent ideas and practices.



Figure 5: Core communication forms for teams, communities and networks source: (Efimova, op cit)

Many research networks in Africa are founded on donor fund opportunities and there is need to transform them to research communities which are not entirely opportunity driven but have other common factors that hold members together. As noted by Shih, J. L. et al. (2012), with appropriate technologies, informal communication and formal idea exchange can be transformed into collaborative knowledge creation. Collaborative activities such as sharing data and knowledge as well as having discussions around the content create valuable asset for research groups.

## 7. Building a virtual research community

Innovative online collaborative tools are helping researchers work in harmony and learn together at a distance (Krishna & Singh, 2008). Due to convenience, more and more researchers are choosing virtual forms of collaboration. Collaborative tools range from text-based e-mail to complex online meeting tools.

Virtual Research Communities (VRCs) are widely dispersed groups of researchers that potentially span different disciplines in different organizations working together in “collaboratory”. The Dutch SURF foundation, defines a “collaboratory” as a virtual research environment that enables researchers based in different locations to work together and share their knowledge and facilities, thus enriching and speeding up both national and international research.

The process of forming virtual research community has been investigated by various scholars. In their study to explore the factors that affect formation of an inter-professional Virtual Community of Practice (VCoP) from which to promote clinical education research, Butson et al, (2012) notes that members contribution during the initial phase of any pre-structured virtual community of practice is crucial so as to overcome the consumption-construction dilemma. Members decide on the community’s value during the initial phase. If the community cannot offer added value, members who engage are likely to consume for a time and then leave. This observation concurs with Duggan (2002) view of virtual community membership. According to Duggan, community membership is not an event, but a process, that entails members transformation from stranger to passer-by to lurker to participant and finally to regular. Since only a small percentage of people make the conversion from step to step, it is important to hold on to as many as possible.

Urquhart et al (2010) in their study to evaluate the development of virtual communities of practice that support evidence based practice, notes that development of a community of practice is characterized by the following four stages: (1) Building stage (Constructs communal memory and context: learning about one another; building a common vocabulary; creating roles; beginning repertoires); (2) Engaged stage (Promotes access and learning: building trust, loyalty, and commitment; providing outreach; telling community stories; encouraging contribution to the knowledge base); (3) Active stage (Supports collaboration: engaging members in work groups or collaborative working with others; using analytical and decision making tools) (4) Adaptive stage (Creates new products: founding of more communities; responding to environmental changes).

Boetcher et al (2002) while discussing the importance of a virtual community in the Full Circle Associates website outlined the following five steps of building a virtual community: (1) identify community purpose or goal; (2) identify the target audience; (3) think about the interaction tools to serve the purpose and audience and how to structure the space ; (4) think about how to facilitate the community; (5) build the community; (6) draw in the members; (7) nurture the community.

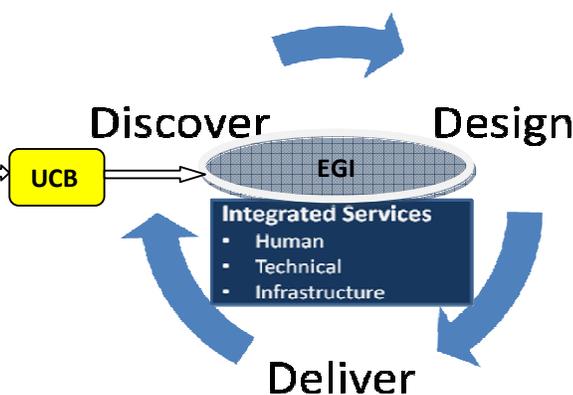
Butson et al, (2012), adopted the four stage cycle by Urquhart et al (2010) to investigate virtual community of practice for clinical research. They attributed poor uptake in the early stages of the project to lack of a clear purpose, incentives and benefits resulting to early-stage confusion. From this conclusion and findings it is clear that in the process of forming a virtual community steps one and two suggested by Boetcher et al (2002) are critical. It seems that in the clinical education virtual community research the investigators began by identifying the tool i.e step 3 and proceeded to build the community without clear purpose and some form of governance structure.

## **8. Lessons from EGI**

An investigation of the EGI model of forming and integrating VRCs in the EGI ecosystem reveals a blend of the four stage cycle by Urquhart et al (2010) and the seven steps by Boetcher et al (2002). According to EGI.eu (2012) VRCs are self-organised research communities which give individuals within their community a clear mandate to represent the interests of their research field within the EGI ecosystem. They can include one or more virtual organisations and act as the main communication channel between the researchers they represent and EGI. Virtual organizations (VOs) are groups of researchers with similar scientific interests and requirements, who are able to work collaboratively with other members and/or share geographically, dispersed computing resources and expertise. In this arrangement virtual organization represent a unit within which the issue of purpose and audience are addressed. This is a fundamental unit that understands the needs of the constituent members and generates requirements which are given to EGI to incorporate in the technology infrastructure. A clear governance structure is put in place through formation of user community boards (UCB) which links VRCs to EGI. Partnerships with individual VRCs are established through a Memorandum of Understanding (MoU). Following the accreditation process and final agreement, VRCs can access the computing resources and data storage provided by the EGI community through open source software solutions. VRC members can store, process and index large datasets and can interact with partners using the secured services of EGI's production infrastructure. Figure 6 summarizes the process of forming new user communities in EGI and integrating them in the system

### What makes up a Virtual Research Community?

- Virtual Organisations
- Mailing lists
- Workshops
- Forums
- Blogs
- Projects
- Shared stories
- Best practices
- Collaborations
- Laboratories



### VRCs provide EGI with:

- Requirements
- Applications and tools
- Data collections
- Training modules
- Success stories
- Experts

### EGI offers VRCs:

- Easy to use infrastructure
- Grid-ready applications
- Training resources
- Help and support
- Involvement in open development processes

Figure 6: Forming new user communities: gathering new requirements adopted from Szabolcs (2011)

Further EGI user communities exist within an established operational policy framework. Policy development within EGI is coordinated by policy groups. A policy group is an internal EGI.eu body created to define policies and procedures within a specific functional area including: technology, operations, user community, policy and administration. They are responsible for developing EGI.eu's strategic and operational policy framework and, thus, for ensuring the stability and availability of a European generic e-Infrastructure (EGI.eu, 2012). The user community board constitutes of representatives from virtual research communities and steers the policy matters affecting the user community. Other policy groups focus on technology, security and management among others.

## 9. Building Sustainable Virtual Research Communities: Critical Success factors

The concern of sustainability is long term existence of a product, a service or an entity. Long term existence of virtual research communities is dependent on factors ranging from personal characteristics of constituent members to technology related factors. For their survival VRCs need to be founded on a firm technology base. As can be seen from the EGI case in section 4.3, the technology base constitutes of an expert team that takes up emerging VRCs technical requirements and integrates them in the existing infrastructure. EGI has established clear policy framework to steer the entire e-infrastructure. As noted in the previous section the policy forming process is organized into specific areas placed under policy groups. The user community policy is steered by the user community board and user services advisory group. Clear governance structure is visible with a Virtual organization being headed by a VO manager. VRC representatives form a user community board which links VRC to the wider EGI. As noted by the EGI strategy and policy officer Holsinger (2012) in the EGI blog there is no such thing as a free lunch - sustainability costs! Coordinating and maintaining a quality infrastructure costs time and money. The seed money to fund EGI came from the European Union but as the blogger puts it there is need to consider having the beneficiaries of the EGI resources chip in financially for the infrastructure survival.

From the above observations, the following key success factors for VRCs can be identified: (1) strong technology base; (2) Clear purpose and goals; (3) a clear policy framework; (4) a good governance structure; (6) a clear mechanism for forming new VRCs or joining existing ones; (5)

proper funding mechanisms. These factors other than funding are reflected in the empirical study of the emergence of the Open Philosophies for Associative Autopoietic digital ecosystems (OPAALS) as a virtual team and a community of practice by Bräuer et al (2009). The study highlights the following factors to ensure a sustainable community building: (1) usage common of language; (2) Choice of an effective media to facilitate the collaboration processes; (3) shared understanding regarding particular concepts;(4) a well elaborated communication etiquette; (5) a governance founded on a shared role understanding; (6) a concrete community enlargement strategy for research partners; (7) policies that concern the joining and leaving of the community and access to resources. The issue of language does not arise in the EGI since all participating countries use English as the common language media.

## 10. Establishing Sustainable Virtual Research Communities in Africa: A Conceptual Framework

Through the lessons learnt from EGI community and the OPAALS research, this study proposes a conceptual framework for: (1) upgrading existing research networks to virtual research communities and; (2) forming new virtual research communities. The proposed framework is summarized in figure 7. As depicted by the framework VRCs ought to be established on a strong technology base and supported by two key pillars namely a clear policy framework and funding strategy. The other supporting factors contribute to the establishment and the survival of the VRCs in the long run.

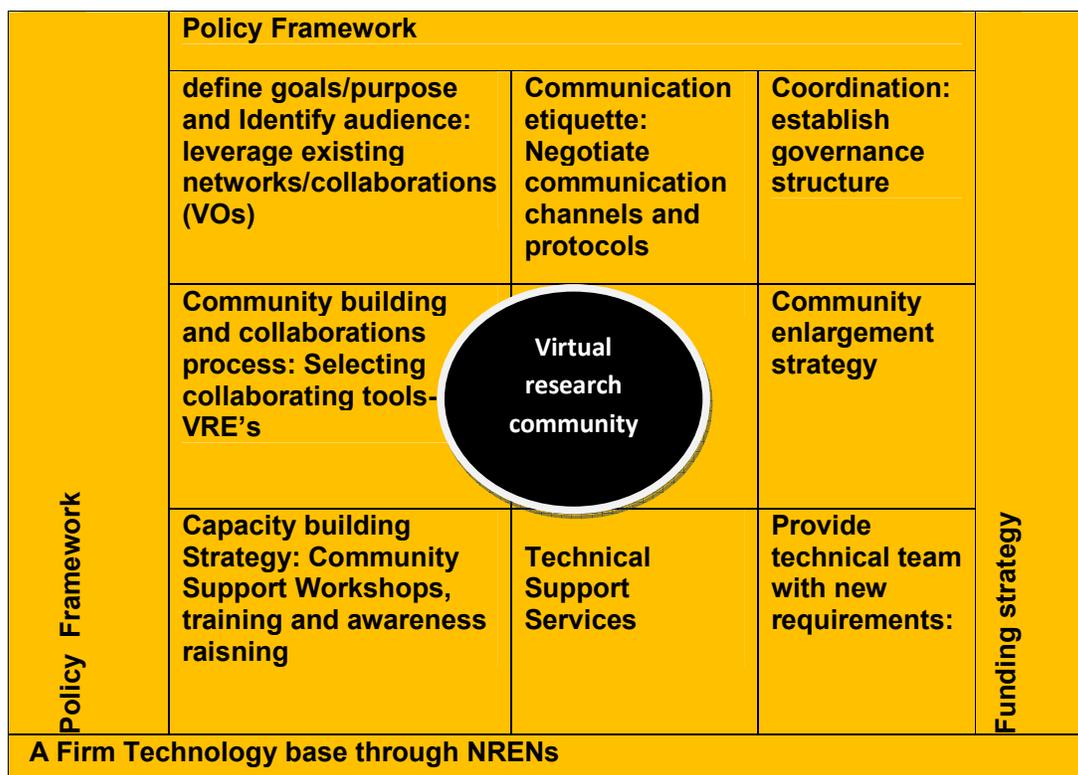


Figure 7: framework for VRC adoption

The policy frame work is critical as a pillar since it defines rules of engagement within and across VRCs. It addresses all the factors responsible for building and maintaining the VRC including

technology and the funding strategy. The funding strategy is vital particularly to sustain a quality infrastructure. A firm technology base is crucial to provide computational resources for virtual experiments, simulations and a means of communication and collaboration as noted by Bos et al (2008), the technical infrastructure has to be scalable enough to accommodate new technologies. Uniformity in the infrastructure is recommended. NRENs are doing a good job to this end though coordinating bodies like UbuntuNet. Having clear purpose and goal to guide the VRCs is important as it defines the reason for the existence of the VRC. A clear purpose/goal will help members to know why they are there, how they can contribute, and what they can expect from the community. A purpose helps to define the target audience of the community. Establishing communication etiquette upfront will help shape a culture of good interaction among members as noted by Preece (2000), participation policies in online communities vary from tacit assumptions and rituals to formal protocols, rules, and laws that guide people's interactions. The governance structure defines the decision making process in the virtual research community it also provides leadership and moderation mechanisms which are critical to the success of online communities (Gray, 2004). Once the structures and the rules of engagement are clear the process of building the community need be established. Wenger et al. (2009) suggest that for a community to be successful there is need to offer a variety of opportunities for sharing knowledge and resources, for collaborating, and for networking. The process of building the VRC will entail the choice of a suitable VRE that is rich enough to promote an effective social presence that will encourage members to become more engaged. This is very important in the early stages of community formation. A key enabler for knowledge sharing in online communities is usable community software (Ardichvili, 2008) thus usability should be taken into consideration when selecting a VRE. Once formed the community requires a clear strategy to retain members and expand it so as to remain afloat. To effectively utilize the technology infrastructure there is need to put in place proper training and awareness raising mechanisms. Survival of the VRCs is dependent on a well informed technical team to provide required technical services by the VRC members. User requirements for systems evolve over time and new ones emerge there is need to have a requirement gathering strategy that will help identify new user requirements and integrate them in the technology infrastructure.

## 11. Conclusion

The benefits of research networking have started to become visible on the African continent with collaborating countries generating a proportionate amount of intellectual property goods. However the sustainability of the collaborations hangs in the balance as most of them have arisen as a result of donor fund opportunities. It is likely that after the donors pull out these networks will collapse due to lack of strong ties. There is need to strengthen the research network ties and this can be achieved by applying a virtual research community adoption framework to transform the networks to research communities. Already groups of researchers working collaboratively on specific areas exist and these can be perceived as virtual organizations. NRENs are pulling resources together within and without countries through deployment of cloud services. To move VOs to VRC level there is need to map existing networks which constitute VOs and identify VREs that can support the VRCs.

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## **Biography**

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2. computational chemistry project co-author and IT lead administrator
3. sustainable ICT assessment model for low cost computers in developing nation