

Global Access to Knowledge: Findings from Academic Research Organisations in sub-Saharan Africa

Adekunle Okunoye
University of Turku and TUCS
Lemminkaisenkatu 14 A, 2nd floor
20520 Turku
Finland

Email: adeokun@cs.utu.fi
(Corresponding author)

Helena Karsten
University of Turku and TUCS
Lemminkaisenkatu 14 A, 2nd floor
20520 Turku
Finland

Email: eija.karsten@cs.utu.fi

Global Access to Knowledge: Findings from Academic Research Organisations in sub-Saharan Africa

Abstract

A major area of global knowledge management is in the practice of academic research. We studied how the Internet was used to support knowledge management (KM) in six non-corporate research organisations in sub-Saharan Africa. For knowledge acquisition, abstract and article databases and field-specific web sites were considered the most important services. For knowledge transfer, email and especially email attachments were considered crucial in overcoming the slowness of other means of communication. For knowledge application, communication with collaborators and publishers helped bring African research communities more visibility. Despite limited availability and infrastructure problems, some researchers had made headway in using the Internet to improve acquisition and transfer of knowledge, but not knowledge storage. Researchers in other areas of the globe may benefit from a fuller understanding of the issues and challenges facing their sub-Saharan colleagues as an important step towards improving collaboration and knowledge sharing.

Keywords: Internet, sub-Saharan Africa, research institutes, development

1 Introduction

A major area of global knowledge management is in the practice of academic research, as most research communities, regardless of discipline, are international. Researchers need to access other scholars' findings, publish own results, and to collaborate (Swan *et al.*, 1999). Creating novel products and processes based on others' findings often requires the integration and synthesis of scientists' specialist knowledge in multi-disciplinary and multi-site projects. Research institutions can thus be seen as one kind of knowledge intensive organisation (Alvesson 1995, 1999) where creating and managing knowledge is of vital importance (Starbuck, 1992), and where a variety of spatial, social, discipline-related and temporal barriers (Walsham, 2001) must be overcome.

Western research communities have carried out most of these activities via computer networks for many years (Walsh and Bayma, 1996): electronic mail is used to communicate between known persons; documents and files can be transmitted, news sites and distribution

lists spread the news widely; web sites for conferences and journals maintain important information for contributors, and abstract and document databases provide access to publications. Widespread adoption of these services was slow until the arrival of the Internet (Thomas, 1996) but then grew rapidly throughout much of the globe.

The least-developed parts of the world, which includes most of sub-Saharan Africa, are often referred to as “information have-nots” (Arunachalam, 1998) and are considered as “the ‘lost continent’ of information technology” (Odedra *et al.*, 1993). A UNESCO report described the problems faced by researchers and scientists in developing countries:

“The field of scientific research is shrinking in many developing countries. Budgets are becoming tighter. As a result, scientists in developing countries lack proper facilities and equipment for conducting research. Developing country researchers and scientists also lack access to scientific research conducted in developing countries and in industrialized countries. Their work is under-represented in much of the documentation and databases that currently exist. They are also constrained in sharing and disseminating information with different institutions within their country as well as with other countries. The result is that researchers and scientists in developing countries are not able to collaborate on an equal footing with their peers around the world.” (UNESCO 1996)

Literature on the impact of information and communication technologies (ICTs) in developing countries (Bhatnagar, 2000; Jimba and Atinmo, 2000; Madon, 2000; Morales-Gomez and Melesse, 1998; Talero and Gaudette, 1996) portrays them as generally supportive of the development process by making information and knowledge more accessible, and more directly useful in applications such as distance learning, telemedicine, geographic information systems. The role of ICTs is considered crucial to the provision of people’s basic needs, such as healthcare, food, and shelter, both in emergency situations and in the longer term, directly in social economic terms and indirectly by enabling research activities (Avgerou, 1998; OECD, 1997)

ICTs are increasingly playing a crucial role in developing countries’ capacities to produce, access and apply information, and thereby to enhance the process of acquisition and sharing of knowledge (Morales-Gomez and Melesse, 1998). Although academic research institutions in developing countries may be using ICTs for these purposes, very few studies have explored this phenomenon. A rare exception is a study by Jimba and Atinmo (2000), which found that Internet accessibility had no positive impact on the number of publications in five Nigerian research institutions. Jimba and Atinmo list several reasons for this surprising result, such as low productivity in general, the content of the electronic databases not being relevant to the researchers in question, and that African knowledge was not integrated with the services.

With the rapid spread of the Internet, there is now a promise of overcoming some of the factors hindering researchers in sub-Saharan Africa and ending their isolation (Arunachalam, 1999; Detmar and Shortliffe, 1997). African research communities can enter the global scene in a much more visible way than before and their counterparts in other parts of the world can contact them more rapidly. This has important consequences for the continuity and stability of collaboration in research. In this paper, we illustrate the Internet as a form of knowledge management system (Jennex, 2002; Detmar and Shortliffe, 1997), which supports creation, transfer, storage and application of knowledge in organisations (Alavi and Leidner, 2001).

Within this context, this exploratory study develops a more detailed picture of African researchers' use of the Internet as a system for managing knowledge. How are African research institutes utilising the Internet to become members of the global knowledge community? What might prevent or slow down the realization of expected benefits? To answer these questions, we first establish our framework for analysing KM processes. Next, we trace the evolution of Internet use in sub-Saharan Africa. Then, we examine how the Internet is being used for each KM process in six research organisations in sub-Saharan Africa. We conclude with recommendations for improving Internet-based KM in these organizations, and suggestions for future research in this area.

2 Knowledge management processes: a framework for analysis of Internet use

The activities that characterise knowledge work have been termed knowledge management processes (Bukowitz and Williams, 1999; Lai and Chu, 2000; Shin *et al.*, 2001). This section gives examples of how each of the KM processes described by Shin *et al.* (2001) applies to academic research, with a summary provided in Table 1.

(1) *Knowledge creation/acquisition* involves knowledge addition, replacement, or correction of existing knowledge (Nonaka and Takeuchi, 1995). *In research*, knowledge creation includes analysis of data and syntheses of earlier studies. Some of the knowledge that can be acquired is found in existing literature. Research data from other projects can also inform knowledge creation. Knowledge can also be created in collaboration; for example, there are several free collaboration-supporting applications on the Internet (e.g., Webinarⁱⁱ, BSCWⁱⁱⁱ). The basic applications of the Internet, email and web pages, are also widely used means for knowledge acquisition (Davenport *et al.*, 1996; Junnarkar and Brown, 1997).

(2) *Knowledge transfer/sharing* involves conveying and diffusing knowledge throughout an organisation to leverage the ways it can be used to solve problems and strengthen performance. Communication is a crucial element of knowledge sharing (Nonaka and Takeuchi, 1995). *In research*, knowledge transfer and sharing in global perspective mainly involves communication between researchers. The Internet supports this through selective distribution of information, such as alerting and current awareness services, concerning (for example) publications, grants, or research facilities. Asynchronous Internet-based communication tools can also reduce problems associated with working at different times and in different places and thus enhance the transfer of knowledge among globally distributed researchers.

(3) *Knowledge application/utilization* relates to the deployment of knowledge for the benefit of the organization, enabling members to use the knowledge they possess in practice and to establish the need for more. *In research*, one area of knowledge application is naturally in the practice of research itself, in constructing new methods (to calculate need for fertilisers, for example), new products (such as grains), or new production methods (for spreading the fertilisers). In terms of global KM, knowledge application involves reporting research results and writing project proposals. The Internet supports these and other activities, such as patenting and licensing.

(4) *Knowledge storage, organisation, and retrieval* is the last KM process considered. *In research*, knowledge that needs to be stored includes datasets and bodies of researchers' own work, which are often stored locally. For example, collaboratories such as the Worm Community (Star and Ruhleder, 1996) provide centralised storage of data sets and publications. Such services could enhance access to data and documents after the completion of a project and serve as a project archive. Although the Internet is beginning to gain recognition for this purpose, such use is still nascent (Jennex, 2002)

Table 1 summarizes this KM processes typology along with examples from its application in the context of academic research.

KM process	In research work, for example:
Creation/acquisition	Analysis of data, synthesis of earlier studies – needs access to the data and to earlier literature, procurement of tools and materials
Transfer/sharing	Communication between researchers, publishing
Application/utilization	Constructing new inventions, reporting results, joint writing, preparing project proposals
Storage	Storage of data sets, article abstract databases, body of own work

Table 1. Knowledge management processes in research

3 The empirical study

One of the authors, Adekunle Okunoye, conducted the empirical study between January and March 2001 in six research organisations in sub-Saharan Africa, three in Nigeria and three in the Gambia (Table 2). In this multiple case study (Yin, 1994), we used a number of data gathering methods. Evidence about Internet use for knowledge management was primarily based on interviews, questionnaires about KM and the use of information technology (IT), observation of IT equipment including local set-ups and IT use, and on analysis of documents, especially IT related reports. The interviews focused on the means of acquiring and sharing knowledge before and after the introduction of the Internet and how this had influenced research activities. The two weeks spent in each organization also allowed non-participant observation and access to historical documents and presentations. In total, 48 research scientists, librarians and IT staff members participated in the study. A more detailed explanation of the data gathering and analysis is presented in an earlier article (Okunoye and Karsten, 2002).

Both authors read the written materials. The transcribed interviews on Internet use were independently coded by each author using keywords that related to each knowledge process and the results compared to arrive at the joint interpretation presented here. We illustrate our analysis with several interview quotes, but informants are not identified to protect confidentiality.

4 Internet development histories

The implementation of computer networks in sub-Saharan Africa has been slowed by various infrastructural issues, which also curtail the possible benefits of ICTs (see, e.g., Barata *et al.*, 2001; Darley, 2001). In sub-Saharan Africa, as of 2001, there were only 16 phone lines for every 1000 inhabitants, compared to 583 phone lines in high-income countries (ITU 1999). Telecommunication services were expensive in relation to the level of income, even though charges had started coming down (Jensen 1999, 2001). The services were also unreliable and often could not be used as expected (World Bank, 2001). Another major issue was electricity: while power lines existed, the daily amount of electricity available was often limited. Also, as a complex system, the electricity network was prone to failures.

Name of the Institute/Homepage	Location/Country	Staff / Expatriate	Sites	National/ International	Internet Use	Informants
International Trypanotolerance Center (ITC) www.itc.gm	Banjul/ The Gambia	122 / 22	3	International	Dial-up connections through a local ISP; some of the staff use	Researchers (3) Programme leaders (1)
Medical Research Council (MRC) www.mrc.gm	Banjul/ The Gambia	600 / 30	6	International	A non-commercial ISP; all staff have unlimited access	Researchers (2) Programme leaders (2) Library personnel (1) IT personnel (2) Management staff (3)
National Agricultural Research Institute (NARI) www.narigambia.org	Brikama/ The Gambia	211 / 0	3	National	Dial-up connections through a local ISP; some of the staff use	Researchers (5) Programme leaders (3) Library personnel (2) IT personnel (1) Management staff (2)
International Institute of Tropical Agriculture (IITA) www.iita.org	Ibadan/ Nigeria	1400 / 100	6	International	Own infrastructure for Internet provision; all senior scientific staff have access	Researchers (1) Library personnel (1) IT personnel (1) Management staff (1)
Nigeria Institute of Social Economic Research (NISER) www.niser.org	Ibadan/ Nigeria	500 / 0	1	National	Dial-up connection through a local ISP; research projects may have their own arrangements; senior staff may also have private home connections or they use an Internet café	Researchers (4) Programme leaders (2) Library personnel (1) IT personnel (1)
Nigeria Institute of Medical Research (NIMR) http://www.homestead.com/nimr_ng/	Lagos/ Nigeria	130 / 0	1	National	Dial-up connection through a local ISP; all senior scientific staff have access. Also use an Internet café.	Researchers (5) Programme leaders (2) Library personnel (1) IT personnel (1)

Table 2. The six organizations studied

As of 2001, all the organisations had Internet connectivity and 89% of the researchers reported that they personally had Internet access. One international organisation (MRC) operated as a non-commercial Internet Service Provider (ISP), providing unlimited access to the researchers, while all the national organisations connected through local ISPs with limited access. Centralising Internet access to a few workstations was common practice in most of the national organisations without a LAN and with a limited number of workstations. Generally, researchers all had used email and were aware of some other basic services on the Internet.

In the Gambia, the Internet has been available since the commissioning of the Internet gateway in 1998, through the UNDP and Government of the Gambia Internet Initiative for Africa (IIA) project. The Gambia is a relatively stable society, with reliable electricity and telephone networks. A major player in the Gambia was Gambia Telecommunications (GAMTEL), whose aim was to make connectivity cheaper for subscribers. The spread of telecommunication services and high tele-density of the Gambia enabled users to have a connection even from the remotest part of the country without any extra cost. This became important as several researchers were located in remote field stations.

Most of the senior scientists at MRC came from or were educated in western countries and as a result engaged in significantly more ICT use. Internet use started at MRC in the early 1990's with a connection to HealthNet nodes for email services. This was later improved through a connection to a server at Environmental Development Action in the Third World in Senegal for store and forward services. In 1998, MRC registered as a non-commercial ISP, thereby giving all staff members unlimited access to Internet services.

NARI and ITC have similar histories. Prior to 1998, everything that was happening in these organisations concerning Internet services was on an individual basis, with some scientists using the GAMTEL/Compuserve and later the GAMTEL/Delphi Internet connection, or COMMIT, a Norwegian ISP that provided a store and forward connection. Since 1998, these organisations have subscribed to dial-up connections through the local ISP, and researchers could also use various other facilities available within the country to access the Internet.

The history of the Internet in Nigeria is more complex than in the Gambia due to its larger size, bigger population and higher level of direct foreign investment. NITEL, the national telecom monopoly, had not been able provide reliable Internet gateway services in the way that GAMTEL did in the Gambia. Therefore, each ISP was responsible for a direct connection to the Internet.

As an international organization, IITA was influenced by the presence of highly-educated scientific staff in a similar way to MRC. Before the institute and the nation began to take advantage of the Internet, individual researchers were utilising it in a variety of ways due to their international exposure. More recently, IITA had invested in its own infrastructure for Internet service provision. All senior scientific staff members had access to Internet services.

NISER and NIMR are national research centres. They were not able to afford the kind of investment required to have unlimited access to Internet services but they maintained a dial-up connection through a local ISP. NIMR had a subscription to MEDLINE for online access to journal abstracts. Research projects were complementing the organisation's efforts by making their own arrangements. Most of the senior scientific staff members had a connection in their private homes and when necessary some also used a commercial Internet café.

5 Internet use in knowledge processes

This section describes informants' use of the Internet to support knowledge processes. Overall, we found that these research organisations were already making use of the Internet in their KM efforts, even when the services at their disposal were not state-of-the-art. Of the four knowledge processes described, informants used the Internet for knowledge creation and acquisition, transfer/sharing, and application. However, we found no evidence of the Internet being used for knowledge storage. The first three uses are discussed in detail below.

5.1 Knowledge creation and acquisition

Here we expected informants to describe how data sets were shared and maintained, their literature searches and acquisition, and collaboration in joint projects. Many of their comments had to do with intellectual isolation, the effort needed to acquire the needed knowledge, and the ease of Internet use. Very few critical voices were raised.

Research libraries in all organizations studied except IITA were often poorly stocked with printed publications, making literature searches difficult.

".....Getting references have always been difficult. As you know, the library here is not well stocked; the types of journals we have here are limited. And it means that when you need references, you have to fill out a request through a librarian to be forwarded to London. That is still done for old journals." (ED, MRC)

Due to poor funding and the rising cost of journals, organisations in sub-Saharan Africa had to reduce the number of subscribed journals. For example, as of 2001, NIMR was subscribing to fewer than 25 titles (30 titles including African journals).

African journals would appear the obvious publishing outlet for African research institutes. However, they are considered local, and many informants' goal was to publish in internationally-recognized journals. Some international institutes such as MRC mostly published in such international journals. Thus it appears that studies conducted in sub-Saharan Africa were more available to scientists elsewhere than to researchers in sub-Saharan Africa.

"...So you do your research study and publish your result in the best journals like Lancet, Nature and then that's all from your end. And of course those journals are not readily accessible within Africa and therefore the research findings might not be available to those who seek them and they have little impact where it is needed." (SA, MRC)

Due to the unavailability of many publications, many African researchers relied on personal colleagues abroad, CD-ROMs of abstracts, or interlibrary loans. In some organisations, researchers took time each year to conduct a literature review abroad.

"That used to be quite a difficult thing, it was a problem, the only way you could get access to journals would be either to go to Europe in person and then do your literature search." (YA, ITC)

"Those days, we assigned a scientist to travel around the sub-region to do a literature review, you see how much that means." (LJ, NARI)

For many years, researchers in sub-Saharan Africa coped with this situation even though it took a long time and resulted in delays in reporting the studies. Since the Internet became available in 1998, the situation seems to have improved. With many of the journals online, organisations or even individuals could subscribe to those most needed. They were kept aware of the recent publications in their field and found ways of ordering those not subscribed to online. Both medical research institutes, MRC and NIMR, subscribed to Medline for medical abstracts and journals (see also Detmar and Shortliffe, 1997). Researchers also used free subject – or research area – specific information sites on the Internet, some of which contained high quality material.

"..... But now I can liaise with the Royal Tropical Institute in Amsterdam. I only send keywords of a research topic and they do the relevant search and send back to me the abstracts and then I will request for the document I am interested in and they will send it to me...I get tables of contents of recent journals and if something is of interest to me I send for them by email and they send it back to me. So I have a good link with Amsterdam and I have a good link with the International Livestock Research Institute, headquartered in Nairobi in Kenya but the documentation centre is in Addis Ababa and from there, I get tables of contents of recent journals and if something is of interest to me I send for them by email and they send it back to me." (YA, ITC)

Some researchers, however, carried out searches without this kind of help. Undirected searching was not only time-consuming and tedious, but it sometimes produced low-quality

material that had not passed any kind of review process. Thus, when subject-specific databases were too expensive to access, researchers were forced to settle with reviews of sub-standard literature. However, informants' enthusiasm over the new possibilities appeared to obscure the possibility that they are only accessing low-quality research content on the Internet.

"...Because if you don't have information available within the country, you can search the Internet and get as much information as you want, the literature, everything. You can do it in your office without going out. ... You can get in touch with people and get information." (LJ, NARI)

Finally, informants did not mention maintaining data sets on the Internet or accessing shared communication spaces for joint projects. Thus, researchers' most pressing knowledge acquisition need fulfilled by the Internet was improved access to current literature, which overshadowed other knowledge creation and acquisition issues.

5.2 Knowledge transfer/sharing

Amongst our informants, knowledge transfer and knowledge sharing were the main areas of KM where the Internet was being used extensively. Here the global aspect of KM was very obvious: due to long distances, communication was often slow and tedious. With telephones, faxes and email, communication was much quicker and easier. We expected informants to describe how they communicated with colleagues abroad and at home, regardless of time and location, and accessed selective content distribution mechanisms, and also online shops.

Postal services in most of the countries in sub-Saharan Africa were unreliable. As a result, some research organisations maintained a foreign post address from which mail was forwarded through more reliable but expensive private courier companies. Fax and telephone were used extensively when available.

"The communication system within the Gambia is okay but reaching overseas is a problem. Posting takes 34 months to reach Nigeria. Communication is quite frustrating. It is a constraint to effectively carrying out one's job." (GE, MRC).

The use of email changed the way researchers communicated with each other. Sending email was cheaper and was considered to be more efficient than letters. The asynchronous nature of email also appeared very useful to informants: where a telephone call required the availability of the recipient, an email message could wait in the mailbox. Email was also superior to telephone use as it supported one-to-one and one-to-many communication. However, email did not always work.

".....Because when you want to disseminate information, you have to do it in the hard way, like having to call people by phone instead of sending one mail to many people at once, you

have to do it one after the other, they may not even be on seat. Email will always be there waiting for them.....”(ED, MRC)

“..... So I would say the main problem is communication, breakdown of email services, the phone is not working, people not having access to phone.... (MS, MRC)

When email was working, it became easier to communicate with other scientists who shared a common interest and who could provide input into a research project. Virtual networks of expertise emerged via the Internet, which corresponds to findings on the usefulness of weak ties (Constant *et al.*, 1996; Pickering and King, 1992).

“I have got information sitting on my table from as far as Canada and people have been enthusiastic in answering questions. Access to the Internet can open all those things for you, that is one of the things I have found out” (ED, MRC)

“..... When I was involved in a project and one [project member] of us was in Europe, we get in touch and we can exchange views, because on individual level [I have an email account] and even NISER permits us to have email account, too. So it is not as if the person is gone completely.” (FA, NISER)

Conference, workshop and seminar notifications were not easily obtainable in the pre-Internet era; such notifications often arrived either late or not at all. There were also problems associated with registration and obtaining detailed information. Online registration for conferences and workshops greatly reduced these problems. With the availability of various mailing lists, scientists were also kept updated on events and other useful news. For example, the Programme for Monitoring Emerging Diseases mailing list circulated information to control the spread of Ebola Virus (Press, 1996; Madon, 2000). Similarly, a modified copy of a proposal could be sent easily to multiple donors without the cost and burden of copying it several times.

“..... Now that we have the Internet in place, what we try to do is to search for information on grants, sponsorship, copy the information into the system, paste it on the notice board or send it to the people it concerns.”(SA, NIMR)

Internal communication before the Internet required a manual distribution list and voluminous photocopying. These still existed and served their own purpose, but with the Internet documents could be shared easily within the organisation through email distribution lists. These were particularly useful as some of the organisations did not even have a LAN, but rather relied solely on the Internet for internal connectivity.

Some informants had procured books and equipment via online stores (cf. Darley, 2001; Klepper and Carrington, 2002). For urgent requirements, some international staff members made purchases online without following the usual protocols and delays, using their personal credit cards. Gradually, credit cards were becoming available for local residents, too. Beyond online procurement, free software available online was also downloaded and shared among researchers.

“He sent the software via the Internet and I just downloaded it and plugged in my data and completed my analysis.....” (JA, NIMR)

In summary, informants’ primary knowledge transfer via the Internet involved communicating with colleagues using email and attached files. Email distribution lists were much faster for communicating with groups of colleagues as compared to telephone calls or posted letters. However, the problems with constant availability of email slowed its integration into researchers’ daily work practices.

5.3 Knowledge application

Here we expected to find mention of carrying out the research itself, coordinating efforts, writing proposals, patenting and licensing. We found that informants’ key concerns focused on reporting results and publishing their findings. As with their global counterparts, the productivity and usefulness of researchers in this study was judged by their success in publishing their findings and in producing reports that demonstrated the application of their research. The process of producing these publications sometimes required joint efforts among researchers.

The attachment capability of email changed how documents were shared between researchers. Publications could be submitted electronically and the process of reviewing and updating became much easier. Prior to the availability of the Internet, the process of joint editing and writing research reports relied on exchanging a hard copy through post or fax. This often extended the time-to-publication of research findings that involved scientists from various locations.

“..... What we do is that we can send the documents as email attachments to the person who asked for them. Then, if the file is large, we can put the documents on IITA’s ftp site and ask the person to download it from there. It has been working fine.”(YA, IITA)

In putting together proposals and in planning projects and events, researchers used the Internet to coordinate efforts. For example, a training programme for physicians and fellows of the West African College of Physicians by MRC was planned and delivered via the Internet; according to a senior training officer, it went very well and efficiently.

As we expected, the actual carrying out of the research itself, be it raising a new breed of cows or surveying the population of an area, was mainly done outside the Internet. However, whenever informants discussed coordinating efforts, distributing, findings, or anything else that involved long distances, the Internet entered the conversation.

6 Limitations on Internet use

Several factors restricted Internet use by respondents in our study, including insufficient funding for access, low IT literacy, problems with organisational IT infrastructures and problems with national infrastructures. While many of these can be found also in the West, the scale of the problems was often much greater in sub-Saharan Africa.

Most of the national research organisations relied primarily on government funding, which generally was quite limited. This in turn restricted the resources they could commit to Internet connectivity and online subscriptions. Access was made more prohibitive in most organizations where individual researchers were expected to bear some of the costs.

“..... We have [the Internet], but it is not widely available to everybody, if you understand, it is not widely available for several reasons, ... cost of access is high, even though it has been opened to everybody, the cost is scaring them off and they are not using it. You have to pay N200 (\$2) for 15 minutes of browsing. Some of them use it only when it is very important and critical.”(IB, NISER)

Although using email and browsing the web are simple applications on the Internet, most of the researchers lacked the requisite skills to do so. Even when they had received training, they often lacked access to computers to practice their skills.

“.....Most of them are locally trained and have not been exposed to the use of IT equipment when in school. Often, it is very difficult, if NISER does not have a very serious training programme that would sort of expose the new entrant to the use of the system.....Some of them insist on having training but after you have trained them, and there is no computer to practice with what they have learned, what happens? They forget it.”(IB, NISER)
“I think there are three things. First, we need to improve the level of our IT. Second, we actually need to train people in using IT as an information tool and as a research tool, as well, to have improved performance. Then, we need to store more information on them. The level of knowledge and awareness and potential of what IT could do is still pretty limited” (KH, MRC)

Scientists in all national organisations also described how infrastructure problems indirectly affected their efforts in obtaining the required knowledge to do their work and hence their productivity. The infrastructure in this context included telecommunications, electricity, transportation and banking.

“.....You cannot rely on these gadgets. Suppose you are here now, you want certain information and there is no electricity supply, how do I open my computer to let you have access to information? That is one hindrance. Suppose I want to telephone, the telephone is

not functioning. Even if you write, the postal system is very deficient, what supposed to take a day can take a week.” (AA, NISER)

Although the Internet enabled researchers to register for conferences online, book hotels online and make purchases online, the payment system often required possession of a credit card – something that was not common in the banking system in sub-Saharan Africa in 2001. This limited researchers’ opportunities to benefit from these facilities.

The issue of infrastructure extended to the organisational IT infrastructure required to connect to the Internet; most of the national organisations could not acquire the minimum hardware and software required for the connection. Other significant problems appeared to be in maintaining the infrastructure and updating the software and hardware to such a level that the services on the Internet could be used. This problem of IT infrastructure was not limited to national research organisations alone. Most of the organisations lacked individuals with the technical and managerial expertise required to support the efficient running of the IT departments responsible for providing access to the Internet. Although international organisations had the resources to hire expatriates, the general shortage of local experts affected them, too.

7 Discussion

We have described a variety of benefits and issues associated with informants’ use of the Internet for supporting knowledge processes, as summarised in Table 3. Even though their Internet use was still in experimental stages during our study, the informants were able to obtain considerable benefits by acquiring, sharing and applying knowledge via the Internet. Research communities were much more accessible as a result. Further, even though the contents of some electronic databases might not be relevant to sub-Saharan researchers (Jimba and Atinmo, 2000), our informants had developed ways of finding and accessing at least some of the knowledge they needed.

In terms of knowledge creation/acquisition, the main benefit appeared to be in supplementing the local institute library collections. With limited access to fee-charging article databases, researchers risked exploring the Internet in an indiscriminate way, enthusiastic but not certain of the value of the publications or reports they found. While literature searches remained tedious, the volume of material available far exceeded anything that their libraries could afford. The literature they found on the Internet was also generally more current, which increased their awareness of the latest discussions in their field.

KM process	Benefits	Issues
Creation/acquisition	More materials are available than in institute libraries (references, abstracts, whole articles). Cheaper and faster than travelling to do literature reviews. Can use libraries abroad to do searches. Overall, access to literature is considerably faster than without the Internet.	Internet searching is used instead of specific databases, because of cost. Undirected searching of the Internet may produce sub-quality references. Mainly shared computers are used for literature searches. Not all computers are connected.
Transfer/sharing	Email very much quicker than post. Email can be sent to several people at once: considerably easier compared to telephone or letter. Email is asynchronous, and therefore collaboration is easier. Email attachments enable exchanging of reports. Possibility to receive information from unknown scholars far away. Being on mailing lists enables keeping up to date in a certain field. Tools and materials can be procured from e-shops if credit card available.	Email might not work always. Alternative communication channels might not work on occasion. Network capacity may limit sending of attachments. Credit cards in limited use. Cultural readiness there, but resources to implement limited.
Application/utilization	Email attachments enable exchanging of reports. The whole publication process is faster. Coordinating efforts in organising events is easier. More visibility can be attained by electronic publishing and other web presence.	Email might not work always. Alternative communication channels might not work on occasion. Electronic publications lower ranking than traditional ones. Electronic publishing is lower in cost, but not free. IT skills still need improvement.
Storage	None as of 2001	

Table 3. Benefits and issues in global KM with the Internet for researchers in sub-Saharan Africa

In knowledge transfer/sharing, the benefits of the Internet were significant. Electronic mail seemed to be the 'killer application' for Internet use by researchers in sub-Saharan Africa, who often used email to eliminate communications delays that previously could have taken weeks or months. However, its usability was limited by the uncertainty of email access. Email was useful when it worked, but as of 2001 researchers could not yet rely only on email; as a result, messages were sometimes sent via several channels or not at all. Despite this, the ease of electronic communication, when compared to travel, was significant in a vast continent such as Africa.

In knowledge application, the main benefit was improved visibility of researchers and their research through their web presence and through their ability to publish results quicker on the web and in e-journals. Even though African knowledge was not yet integrated into services on the Internet (Jimba and Atinmo, 2000), the possibilities were there and were already being

exploited. Coordinating events became much more efficient with email and web sites; as a result, collaboration between researchers in sub-Saharan Africa may increase, despite the difficulties in travel. Again, key problems stemmed from the unreliability of technology and users' patchy skills. Over time, African scholars may become more familiar to other scholars, both in developing and industrialised countries, which could lead to stronger collaboration, continuity in research, and better exploitation of earlier studies in current work. What remains is the challenge in building and maintaining Africa-specific knowledge.

We found many problems with ICT use. Insufficient funding, low IT literacy among staff, problems with the IT function, problems with organisational IT infrastructure, and problems with national infrastructure (electricity, telecommunications, banking system) put major limitations on the Internet becoming a reliable, dependable service, constantly available for all researchers. There was also only limited government support for research. Despite researchers' enthusiasm and significant efforts to use ICT in academic research, these problems present very strong constraints to effective use.

A possible reason that made the Internet useful in these organisations, despite the odds, was the level of education and exposure of the researchers themselves (Straub, Loch and Hill, 2001). If researchers did not come from, or were educated in a high-income country, they occasionally attended conferences and received visitors from these countries. Through these experiences they became aware of the use of these technologies for academic purposes.

Despite all these problems, the use of ICTs has become a natural part of knowledge work in research institutes in the sub-Saharan Africa. Taking into the account the potential benefits, the future can be expected to show deeper and wider use of the Internet and gradual solving of these problems, even though many cannot be removed fully. Based on our observations and interpretation of the study data, we next discuss what could be done to alleviate these problems.

7.1 What needs to be done

Critical knowledge work activities depend on reliable services. Unreliable IT infrastructure is necessarily ineffectively utilised, as it can only be used for non-critical functions. For research organisations to build and effectively use an IT infrastructure, especially the Internet, they need to find ways to address the limitations found in our study. Although finding solutions to

numerous interwoven problems requires a multi-dimensional approach, we suggest some solutions to each of the limitations we observed.

In the face of insufficient funding, it becomes important for research organisations to find the best ways to utilize the available funds. Even with Internet access, there remains the problem that better sources of literature are more costly. Cheap, or preferably free, high-quality article databases would appear to be the most useful alternative, a finding not unrelated to what is needed in universities in high-income countries as well. However, the scale of the problems in sub-Saharan Africa was quite different from the West, perhaps best illustrated by the interviewees' overwhelming enthusiasm regarding the ease of literature acquisition via the Internet; for our informants, almost anything available online was better than what they had.

One way to address this problem would be by forging alliances with other research organisations within the country (and possibly elsewhere in sub-Saharan Africa) to collectively subscribe to electronic journals and databases, thereby reducing the burden on each individual organisation. Such agreements could extend to discussing what kind of services should be duplicated or shared among research organisations within the same country.

Research organisations could also form their own Internet provision network, perhaps with governmental support, and thereby reduce the cost of connection and improve the reliability of the services. These would make Internet access more appealing to the funding bodies of the research organisations. Further, increases to research institutes' IT budgets could shift the burden of paying for Internet services off individual research fellows and onto institutes, which in turn would increase individuals' willingness to use it.

To elevate the visibility of such issues and serve as a target for funding efforts, organisations could develop long-term IT strategies. In situations where managing IT within the organisation might not seem realistic, organisations should explore the option of outsourcing (Okunoye, 2002). However, even though they may be ready and willing to follow these suggestions, many research organizations are still at the mercy of the national governments. Some innovative solutions have emerged to infrastructural issues; for example, one ISP in the Gambia has circumvented the unreliable electrical system by running their servers on solar power.

With the dependency of the Internet on the telecommunication infrastructure, countries in sub-Saharan Africa could explore advances in wireless technologies, which could be easier to

deploy and thus eliminate some geographical barriers and costs associated with wired telecommunication systems. This still depends, however, on investment in the basic transmission infrastructure, which is currently gaining more attention in the countries in sub-Saharan Africa (for example, GSM is available in almost all countries in the sub-region).

Although major credit cards have begun to be issued in most countries in sub-Saharan Africa, the problems of online payments could still be addressed locally. The local banking industry could explore other payment systems more appropriate for Internet users in the region, to make online purchases easier. Issues such as trustworthiness, legality and security need to be addressed locally before these systems can be beneficial in sub-Saharan Africa.

7.2 Future possibilities for Internet use

Many of the services on the Internet are already in use in the research organisations we studied. Other applications that are already proving useful elsewhere might also offer potential benefits - naturally with due consideration to local realities. Here we present some possibilities.

E-publishing. Publishing only in high-end international journals, as some of the institutes claimed to do, is slow and subscribing to these journals might be beyond the means of research institutions in sub-Saharan Africa. The paradoxical result is that local findings may not end in local use. Publishing in e-journals might be a feasible solution to this problem, which would also help avoid problems of increasing journal prices, reduced library budgets, increasing printing costs, and declining value of local currencies against the U.S. dollar. E-journals are easily accessible, easy to publish, time saving, and low cost. An example of this kind of initiative is the Electronic Journal of Information System in Developing Countries¹. The main problem with e-journals remains their low status in academic ranking systems; as a result, they tend to attract lower-quality articles. However, this could work to the benefit of developing countries, which could build their own research communities around these e-journals. Instead of having low-ranking global e-journals, it is possible to have high-quality e-journals specific to sub-Saharan Africa.

Remote collaboration. Mobile IT could be useful in rural field stations and even in urban locations. One of the organisations we studied was already considering using wireless technology to build a virtual private network (VPN) between its headquarters and six different locations in remote areas. Voice over IP could be explored for communication with

counterparts abroad to bypass the problem-ridden and expensive telephone network. Travel costs often prevented researchers from participating physically in most conferences; collaboration applications such as Webinarⁱⁱ, BSCWⁱⁱⁱ and similar ones could be used for virtual seminars. Where the required hardware and software are available, a basic videoconferencing system such as NetMeeting could be used for face-to-face meetings. A simpler solution available to all with an Internet connection would involve the use of chat, a free, synchronous communication system.

For full benefit, the government and the organisation's leadership have to be committed to continuous provision and development of Internet services by improving other infrastructures, providing funds for training, and developing local capabilities to support ICTs in general and the Internet in particular. However, the opportunity remains for research organisations in sub-Saharan Africa to begin actively explore existing and evolving Internet applications to gain insight into future possibilities and in so doing shape how they support their own knowledge processes.

8 Conclusions

Most of the problems we found in sub-Saharan researchers' Internet use were tied to money and management, directly or indirectly. When a research institute operates in an environment that is not wealthy enough to provide a safe, reliable, and effective working environment, its ability to utilise even its own ICT funding effectively is quite constrained. Our findings also support those of Jimba and Atinmo (2000): there is low productivity in research in sub-Saharan Africa. This might be eased by efficient use of the ICTs; however, there is a risk of productivity becoming even lower if researchers become increasingly dependent on uncertain infrastructures.

Even though Western research institutions, especially universities, suffer from lack of funds, this is still on a very different scale when compared to the amounts available for African research institutions. This is especially true for national institutions, as international ones have traditionally been able to compete for larger grants and often have subsidies from a main research centre located in a Western country.

We can compare our findings to those in Western research institutions. Walsh and Bayma (1996) found substantial differences by field in computer network use in their study of US research institutes. Their claim was that the form of ICT use was dependent on the social

context into which new technology is embedded. Even though we can largely agree, we have focused here only on researchers' location and not on their field of study. A richer study on all ICT uses could be carried out by comparing research institutions within a field across different locations and socio-economic circumstances. To go beyond our results, more in-depth studies are needed in areas that are experienced as problematic in sub-Saharan Africa, such as the reliability of access to the Internet and its influence on work and communication practices.

The current phase of ICT exploitation appears to be about experimentation, limited use and uneven coverage in most institutes. The current experiments need to be reported to the research community and to funding bodies. Benefits and complications need to be clearly spelled out. Uneven coverage may lead to low efficiency and sub-optimal use of resources. Wider and more even coverage needs to be encouraged by managerial measures and by sufficient support for IT infrastructure. Over time, many other possibilities may emerge. As has been claimed (Talero and Gaudette, 1996; Avgerou, 1998), the Internet may indeed become a major tool in bringing sub-Saharan Africa into the economic community together with the industrialised countries and, we add, the African research community into the global community of researchers.

These experiences from research organisations in sub-Saharan Africa imply that more attention needs to be paid to funding, infrastructure, and management before the full benefit of Internet could be realised in countries and areas with similar infrastructural and environmental problems. A major lesson from this study, however, is that organisations do not necessarily have to wait until they acquire a state-of-the-art Internet connectivity and applications before they can start making use of it. As demonstrated in our cases, a little can go a long way.

9 Acknowledgements

We would like to thank Matthew Jones for helping with this paper. Furthermore, we would like to thank Peter Gray and Darren Meister, the editors of this special issue, and the three anonymous reviewers for their constructive suggestions.

10 References

- Alavi, M. and Leidner, D. (2001), "Knowledge Management and Knowledge Management Systems: Conceptual Foundations and Research Issues", *Management Information Systems Quarterly*, Vol. 25 No1, pp. 107-136.
- Alvesson, M. (1995), *Management of knowledge-intensive companies*. de Gruyter, Berlin/New York.
- Arunachalam, S. (1998), "Information Age Haves and Have-Nots", *Educom Review*, Vol 33 No 6, pp. 40-44.
- Arunachalam, S. (1999), "Information Technology: What Does It Mean for Scientists and Scholars in the Developing World", *Bulletin of the American Society for Information Sciences*, Vol 25, pp. 21-25.
- Avgerou, C. (1998), "How Can IT Enable Economic Growth in Developing Countries?" *Information Technology for Development*, Vol 8 No 1, pp. 15-29.
- Barata, K., Kutzner, F. and Wamukoya, J. (2001), "Records, Computers, Resources: A Difficult Equation for Sub-Saharan Africa", *Information Management Journal*, Vol 35 No 1, pp.34-42.
- Bhatnagar, S.(2000), "Social Implications of Information and Communication Technology in Developing Countries: Lessons from Asian Success Stories." *The Electronic Journal of Information Systems in Developing Countries*, Vol 1 No 4, pp.1-10.
- Borghoff, U. and Pareschi, R.(Eds), (1998),. *Information Technology for Knowledge Management*. Springer-Verlag, Berlin.
- Broadbent, M. and Weill, P. (1997), "Management by Maxim: How Business and IT Managers can create IT Infrastructures", *Sloan Management Review*, Vol 38 No 3, pp. 77-92.
- Bukowitz, W. R. and Williams, R. L. (1999), *The Knowledge Management Fieldbook*, Pearson Education Limited, London.
- Constant, D., Sproull, L. & Kiesler, S. (1997), "The kindness of strangers: On the usefulness of electronic weak ties for technical advice". In Kiesler, S. (Ed.), *Culture of the Internet*.; Lawrence Erlbaum Associates, Mahwah, NJ, pp. 303-321
- Davenport, T., Jarvenpaa, S. and Beers, M. (1996), "Improving Knowledge Work Processes." *Sloan Management Review*, Vol 37 No 4, pp. 53-65.
- Detmar, W. and Shortliffe, E. (1997) "Using the Internet to Improve Knowledge Diffusion in Medicine," *Communications of The ACM*, Vol40 No 1, pp. 101-108
- ITU. (1999), *World Telecommunication Development Report*. International Telecommunication Union, Geneva
- Jennex, M. (2002), "Using the Internet for Knowledge Management / Organisational Memory Systems. In Proceedings of IRMA Conference: *Information Technology and Organizations: Trends, Issues, Challenges and Solutions*, Idea Group Publishing, Hershey.
- Jensen, M. (1999), "The Status of African Information Infrastructure" Economic Commission for Africa, 1999. Available (UNECA, August 8th 2001) www.uneca.org/adf99/codipap1.htm
- Jensen, M. (2001), "The African Internet - A Status Report 2001." Available (African Internet Connectivity, June 29th, 2001) <http://www3.sn.apc.org/africa/afstat.htm>
- Jimba, S. and Atinmo, M. (2000), "The Influence of Information Technology Access on Agricultural Research in Nigeria," *Internet Research: Electronic Networking Applications and Policy*, Vol 10 No 1), pp. 63-71.
- Junnarkar, B. and Brown, C. (1997), "Re-assessing the Enabling Role of Information Technology in KM," *Journal of Knowledge Management*, Vol 1 No 2, pp.142-148.

- Klepper, R. and Carrington, A. (2002), "Option for Business-to-Consumer in Developing Countries: An Online Store Prototype", In Burgess, S. (Ed), *Managing Information Technology in Small Business: Challenges and Solutions*, Idea Group Publishing, Hershey PA.
- Lai, H. and Chu, T. (2000), "Knowledge Management: Theoretical Frameworks and Industrial Cases," In Proceedings of the 33rd *Hawaii International Conference on System Sciences*, Hawaii.
- Madon, S. (2000), "The Internet and Socio-economic Development: Exploring the Interaction." *Information Technology & People*, Vol 13 No 2, pp. 85-101.
- Morales-Gomez, D. and Melesse, M. (1998), "Utilising Information and Communication Technologies for Development: The Social Dimensions." *Information Technology for Development*, Vol 8 No 1, pp. 3-14.
- Nonaka, I. and Takeuchi, H (1995), *The Knowledge Creating Company*, Oxford University Press. London.
- Odedra M., Lawrie M., Bennett M., and Goodman S., "International Perspectives: Sub-Saharan Africa: A Technological Desert." *Communications of the ACM*, (36:2), 1993, pp. 25-29.
- OECD (1997), *Information Technology Outlook*. OECD, Paris, Available (OECD Sept. 30th 2002) <http://www.oecd.org/pdf/M00002000/M00002670.pdf>
- Okunoye, A. and Karsten, H. (2002), "ITI as Enabler of Knowledge Management: Empirical Perspective from Research Organisations in sub-Saharan Africa." In Proceedings of the 35th *Hawaii International Conference on System Sciences*, Hawaii.
- Okunoye, A. (2002), "Outsourcing as an IT Management Strategy for Knowledge Management in sub-Saharan Africa," In Proceedings of the IRMA conference: *Information Technology and Organizations: Trends, Issues, Challenges and Solutions*, Idea Group Publishing, Hershey,.
- Pickering, J. and King, J. L. (1992), *Hardwiring weak ties: Individual and institutional issues in computer mediated communication*. CSCW'92, ACM Press, Toronto, Canada, 1992,.
- Press, L. (1996), "The Role of Computer Networks in Development." *Communications of the ACM*, Vol 39 No 2, pp. 23-30.
- Shin, M., Holden, T. and Schmidt, R. (2001), "From Knowledge Theory to Management Practice: Towards an Integrated Approach, " *Information Processing and Management*, Vol 37 No 2, pp. 335-355.
- Starbuck, W. (1992), "Learning by knowledge-intensive firms," *Journal of Management Studies*, Vol 29 No 6, pp. 713-740.
- Star, S. and Ruhleder, K. (1996), "Steps Toward an Ecology of Infrastructure: Design and Access for Large Information Spaces," *Information Systems Research*, Vol 7 No 1, pp. 111-134.
- Swan, J., Newell, S., Scarbrough, H. and Hislop, D. (1999), "Knowledge management and innovation: networks and networking." *Journal of Knowledge Management* Vol 3 No 3, pp. 262-275.
- Straub, D., Loch, K. and Hill, C. (2001), "Transfer of Information Technology to Developing Countries: A Test of Cultural Influence Modelling in the Arab World," *Journal of Global Information Technology Management*, Vol 9 No 4, pp. 6-28.
- Talero, E. and Gaudette, P. (1996), "Harnessing Information for Development: A Proposal for a World Bank Group Strategy," The World Bank, Telecommunication and Informatics Division, 1996. Available (Finance and Private Sector Development, April 13th, 2000) <http://www.worldbank.org/html/fpd/harnessing/>

Thomas, B. (1996), *The Internet for Scientists and Engineers*. The International Society for Optical Engineering, Washington.

UNESCO. (1996), *Information and Communication Technologies in Development: A UNESCO Perspective*, UNESCO Secretariat, Paris.

Available (UNESCO, July 10th 2001) <http://www.unesco.org/webworld/telematics/uncstd.htm>

Walsham, G. (2001) *Making a World of Difference: IT in a Global Context*, John Wiley and Sons, New York.

Walsh, J. P. and Bayma, T. (1996), "Computer networks and scientific work." *Social Studies of Science*, Vol 26 No 3, pp. 661-703.

World Bank Group. (2001) "World Development Indicator",

Available (World Bank, August 29th 2001) <http://devdata.worldbank.org/data-query/>

Yin, R. K. (1994), *Case Study Research: Design and Methods* 2nd ed. Sage: Newbury Park, CA, USA.

ⁱ <http://www.ejisdc.org>

ⁱⁱ <http://www.mongoosetech.com/events/events.html>

ⁱⁱⁱ <http://bscw.gmd.de>