Organizational Information Technology Infrastructure in Developing Countries: A Comparative Analysis of National versus International Research Organizations in Two Sub-Saharan African Countries

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ABSTRACT

This paper examines the imbalances in the availability and usage of information technology infrastructure between international and national research organizations in two sub-Saharan African countries. While national research organizations depend on the aid of the national government, international organizations have the resources to provide an adequate infrastructure sustaining their needs, without being greatly affected by operating environmental factors. Based on an empirical study, the imbalances can be broadly attributed to differences in funding, management and technical expertise, exposure to and awareness of available technologies, training, and other infrastructures like electricity, transportation, banking etc. To reduce these imbalances, we suggest that national governments provide adequate funds to build a sustainable IT infrastructure for their national organizations where it may not be feasible to build nationwide. For national organizations, we suggest that they study how international organizations have been able to provide and manage their own infrastructures despite the difficulties present in their environment.

Keywords: Information Technology Infrastructure, Research Organizations, Developing Countries, International Organizations, National Organizations, sub-Saharan Africa, Nigeria, The Gambia.

INTRODUCTION

The disparity in the availability of information technology (IT) infrastructure between Western industrialized countries of the North and the developing countries of the South has always been recognized by various agencies, like The World Bank; United Nation Development Programme (UNDP); Canadian International Development Agency (CIDA); Swedish International Development Agency (SIDA) etc. It has also been written about extensively (Crede and Mansell, 1998; Talero and Gaudette, 1996, Lynch, 2000; Braga and Alberto, 1998, Persaud, 2001; De Boer and Walbeek, 1999; Rodríguez and Wilson, 2000; GICTD, 2000). It is popularly tagged as the "digital divide". At the Kyushu-Okinawa Summit in July 2000, the leaders of the G8 major industrialized democracies focused attention on the impact of information technologies and the growing risks of this global "digital divide" (DOT Force, 2000). The problems of IT infrastructure in Africa, especially in sub-Saharan Africa, have also received attention in the literature (Odedra et al., 1993; Moyo, 1996; Sadare, 1998). However,

the disparity in IT infrastructure between the multinational and national organizations in developing countries has received less attention.

In this paper we assume that multinational, global, trans-national, and international organizations all represent international organization. Furthermore, national, local and domestic organizations will be assumed to share the same meaning. Multinational organizations are known to have better technology than most of the national local organizations (De Boer and Walbeek, 1999; McConnell, 2000; Dunning and Narula, 1999). They are taking the lead (alongside embassies, large relief and aid agencies) in providing infrastructure in developing countries. In most countries of the South, the developments in business sectors rely on the lead of these multinationals, and their infrastructures cannot be compared to national organizations.

In this paper, we present the findings from our study on IT infrastructure and knowledge management in six research organizations in sub-Saharan Africa - three international and three national organizations. We assessed and compared the availability and usage of IT infrastructure in the international and national organizations. While there are a few and sometimes no IT infrastructure services in national organizations; the infrastructure in international organizations is advanced and even comparable with the IT infrastructure in some similar organizations in western industrialized countries. The IT infrastructure services of the international organizations located in the south can be viewed like those in the North. The reasons for this could be differences in level of funding, managerial and technical skills, training, exposure to technology, and other infrastructure issues.

In the rest of this paper, we discuss the division of the world into North and South. We describe national information infrastructure, IT infrastructure and their relationship. We present the detail of our case organizations and their IT infrastructure. We then give a comparative analysis of international versus national organizations. We found that national organizations and perhaps governments have much to learn from international organizations in how they have been able to provide and sustain an infrastructure required to support the rapidly changing demands of their work activities.

NORTH AND SOUTH, INTERNATIONAL AND NATIONAL

North and South

In this paper, we use the term, North and South to depict the Western industrialized countries and developing countries respectively. According to Korpela (1994), the division of the world into two large blocks is intuitively rather obvious, between the predominantly industrialized, rich North and the traditionally less developed, poor South. This distinction is gradually fading as more developing countries are joining the ranks of developed countries, and globalization is blurring the boundaries. According to Mazrui and Andrew (1991), the most obstinate line of demarcation between the North and South is not income (criteria of wealth), but technology (criteria of skill). Consequently, several reports have been written on the technology gap between the North and South. In spite of recommendations from various multilateral and bilateral organizations that the countries in the South should improve their technology infrastructure, the gap still continues to widen (Braga and Alberto, 1998; Crede and Mansell, 1998; The World Bank Group, 1999). With today's information revolution and knowledge based economy being driven by the underlying information technology, there is a vital need for countries in the South to provide adequate information infrastructures

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While the countries in the North are characterized by good infrastructures, advanced technology and adequate human resources, most developing countries are characterized by poor infrastructure, basic technology and insufficient IT workforce (Odedra et al., 1993; Moyo, 1996). Furthermore, most countries in the North have developed their national information infrastructure to meet the requirements of a wide sector of the population. Therefore, we consider the North as the leader in having addressed and solved information infrastructure problems and the South as the follower where things are still at developmental stage and where people have a lot to learn on the practice in the North with proper adaptation and consideration for the local factors.

International vs. National Research Organizations

International research organizations in this context are primarily sponsored by various bodies inside and outside their country of location. Their management is drawn from international experts and their senior staff comes from various countries. Some of the organizations have diplomatic status in their country of location. Usually, they are a part of a larger body or network. For example, International Institute of Tropical Agriculture (IITA) is an international organization based in Ibadan, Nigeria. It is a part of the Consultative Group for International Agricultural Research (CGIAR) which comprises of 16 separate organizations. National research organizations, on the other hand, are usually owned by a national government and they primarily depend on government sources for funding and support. Their management is drawn from local experts and the entire staff is usually made up of nationals. They are directly affected by the policies and programmes of the national government: e.g. a new government may stop funding a research programme or activities that is not on their manifesto. For example, Nigeria Institute of Social Economic Research (NISER) is a Nigerian national research organization, funded primarily through a ministry and directed by a Director General appointed by the government.

Most of the efforts to build information infrastructures in developing countries have been spearheaded by multinational organizations with business interests. However, international organizations and aid agencies that are not primarily profit oriented have also contributed to the development of information infrastructure, especially for developmental purposes. This has benefited many local organizations that have relationships with these international organizations in terms of physical infrastructure and managerial skills. (Kolodner, 1994; Nkereuwem, 1996; Dunning and Narula, 1999; McConnell, 2000).

NATIONAL INFORMATION INFRASTRUCTURE AND IT INFRASTRUCTURE.

National Information Infrastructure

At the beginning of the 1990s, the leading economies of the world began to realize the importance of information and knowledge as valuable resources, both nationally and within organizations. A national information infrastructure was formulated to provide foundation for an information economy. National Information Infrastructure (NII) was defined as a seamless web of communications networks, computers, databases, and consumer electronics that will put vast amounts of information at users' fingertips (IITF, 1993). The launching of the United States' plan for national information infrastructure in 1993 was followed by the European Union, with its Bangemann report in 1994 (Bangemann Commission, 1994). With this trend,

the shape and use of information infrastructure has been transformed into an issue of industrial policy (Hanseth and Monteiro, 1997). The United Nations' Economic Commission for Africa with the support of other development agencies also launched the African Information Society Initiative to build Africa's Information and Communication Infrastructure.

> *"In order to assist African countries to face the challenges of the information society and thus avoid their marginalization, the United Nations Economic Commission for Africa (ECA) has elaborated an African Information Society Initiative (AISI), as requested by member states. This initiative is an action framework to build Africa's information and communication infrastructure, and was adopted during the ECA's twenty-second meeting of African Ministers in charge of planning and development (held in May 1996) under resolution 812 (XXXI) entitled 'Implementation of the African Information Society Initiative'". (ECA, 1996)*

These efforts led to the development of the National Information and Communication Infrastructure (NICI), whose policies, plans and strategies could be used to enhance the role of information and communication technologies (ICTs) in facilitating the socio-economic development process. Full review of the national and global information infrastructure can be found in the national information infrastructure document (IITF, 1993). For full details of NICI, see ECA (1998) and for an example of African national government initiatives, see Miller and Day (2000). Although these efforts addressed the information infrastructure issue of several countries in Africa, they also revealed the low level of information infrastructure in African countries, and especially in sub-Saharan Africa (see Table 1). The national information infrastructure greatly influences the organizational information infrastructures which I describe here as information technology infrastructure.

Table 1.Sampled statistics of sub-Saharan Africa and High Income countries[1] based on Year 2000 estimates (The World Bank Group, 2003)

Series	Sub- Saharan Africa	High Income countries
Gross National Income *per capita*, Atlas method (current US$)	480.00	26,900.00
Export of goods and services, % of GDP	31.73	24.51
High-technology exports, % of manufactured exports	3.56	25.45
Fixed line and mobile Telephones, per 1,000 people	31.55	1121.10
Personal computers, per 1,000 people	9.01	345.8
Internet Users (millions)	3.58	379.26
Telephone, average cost of local call (US$ per three minutes)	0.06	0.11
Electric power consumption, KWh per capita (1998 est.)	431.64	8,617.17

Information Technology Infrastructure

IT infrastructure can be viewed as a term used to embrace the collection of computers, operating software, communication equipment and links, which collectively form the platform for assimilating and delivering information products and services to the organization, its suppliers and to its customers (Beranek, 1997). Information technology infrastructure is very

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[1] See http://www.worldbank.org/data/countryclass/classgroups.htm for detailed classifications

important to companies and particularly necessary to those in industries going through dynamic change, those reengineering their business processes, and those with widely dispersed operations (Broadbent and Weill, 1997).

Our characterization of IT infrastructure relates to the view of Lyytinen (1991), according to which information technology comprises computing and telecommunication infrastructure and associated know-how to apply them to different fields or organizational activity. Computing infrastructure consists of physical components of a computing set-up, the wiring, routers, switches, operating systems, middleware, mainframes, servers and sometime desktop machines. Computing infrastructures can be central to organizations. For example, Hildebrand (1998) emphasizes that a sound infrastructure can mean rapid access to online information, fewer system crashes, quicker email and personal computer systems that function with minimum trouble. Telecommunication infrastructure consists of fixed, wireless, and satellite telecommunication networks, telecommunication software and applications. A reliable IT infrastructure can also ensure the success of any future technological endeavors. During the 1990s, the focus was expanded from computing infrastructures to information infrastructures (see, e.g., Hanseth, 1996). Ciborra and Hanseth (1998) emphasize the role of infrastructure in allowing a firm to run interlinked applications to process and communicate information seamlessly; that is, IT infrastructure supports streamlined processes and enhances coordination.

THE EMPIRICAL INVESTIGATION

Selection of the case organizations

According to Stake (1998), the most unique aspect of a case study is the selection of cases to study. It was recognized that an understanding of the phenomena depends on the appropriate choice of cases. In alignment with the research design advice of Merriam (1988) and Yin (1994), six research organizations were selected according to the nature of their work which involves primary production and use of knowledge. Most of the organizational functions require the support of information technology. The study was conducted in two countries in West Africa – Nigeria and The Gambia. Nigeria has a range of problems found elsewhere in Africa, but also has research capacity and large indigenous industry (Korpela, 1994). Therefore, it is likely that findings in Nigerian organizations will be representative of the whole West Africa sub-region. The Gambia being a smaller country was also included as it gives a good comparison to Nigeria in terms of social, economic and political structures. The Gambia has a population of less than 1.5 million with reasonable control of the basic infrastructures. The Gambia rates higher on teledensity than many other African countries in the sub-region. It has a conducive environment for organizations to operate and there is less bureaucracy in government offices. The Gambia is one of the most peaceful and stable countries in the sub-region.

Data collection

This study uses multiple data gathering methods: semi-structured interviews, on-site observations and surveys with quantified responses. A full discussion of the methods and data collection can be found in Okunoye and Karsten (2001). Between January and March 2001, visits were made to all six organizations. The visits lasted for about two weeks each, to interview staff, to observe, administer questionnaires and to collect other relevant information. Some research sites of each organization were visited and relevant people were interviewed (e.g., heads of sections, IT managers and librarians). A total of 48 people participated in the

research, 29 of whom were interviewed and completed the questionnaire, 8 only completed the questionnaire and 11 were only interviewed. Altogether, 40 people were interviewed and 37 questionnaires were administered. However, only 31 out of the 37 questionnaires were included in the final analysis, as six had to be eliminated due to incomplete response to the questions. The interviews were recorded on audiotape and later transcribed. IT infrastructure was assessed using the approach developed by Broadbent and Weill (1997). A list of ITI was completed with the head of computing and tabulated to compare the organizations.

Results and discussion

We now present the outcome of the IT infrastructure analysis for each organization, starting with the three international organizations and followed by the three national organizations. Broadbent and Weill (1997) identify 23 maxims describing ten core ITI services and thirteen additional services. The IT infrastructure capability includes both the technical and managerial capabilities required to provide reliable services. The IT infrastructure list was completed with the heads of computer sections, where applicable, and supplemented by observations and interviews. Each of the services has equal weight and a high number of services in a firm indicate a high level of IT infrastructure capability. A list of the IT infrastructures and the results in each institute is presented in Appendix 1.

Case 1: International Institute of Tropical Agriculture (IITA)
IITA is an international organization in Nigeria. The infrastructure capability at IITA was very high, with 19 of the 23 services available. IITA has a well-developed computer section with highly qualified personnel. The organization had also invested considerable funds in IT infrastructure. The head of the computer section claimed that IITA spent about $1 million in the last five years (1996 - 2001) on information technology. IITA does not rely on national infrastructure for external data communication, but broadcast directly via their satellite. It provides training services and use local vendors for IT services when necessary. It does not have any problems in acquisition of required hardware and software. It is driven by the requirements of the well-trained scientists that come from all around the world.

> *"………There is no difficulty at all, because IITA funds are in dollars, so we can easily get whatever we want to get from abroad with hard currency. Then secondly, IITA has a center, which can assist in purchasing the best brand of any hardware and latest version of software. IITA has an effective purchasing unit, which also helps us to liaise with the vendors abroad. There are some efficient local suppliers of computers that IITA uses as well. But where a particular system is not available in the country, IITA can easily get it from abroad through its agent. So we have no problem in procuring whatever IT we need." (YA, IITA)*

IITA has a well-developed intranet and groupware system. Every senior scientist has an e-mail account and unrestricted access to the Internet. Even between the period of collecting data and the writing of this paper, the IITA website has been updated to improve navigation and interaction. The computer manager and the head of information services and training, confirmed their current efforts in designing an organization-wide research database management system. The scientists at IITA did not express any difficulty in using the system or getting the required support for information technology.

Case 2: Medical Research Council (MRC) Laboratories
MRC Laboratories is an international organization in The Gambia. The IT infrastructure capability showed a similar trend to that in IITA, with 16 of the 23 services available. They

have a well-developed computer unit, managed by a British expatriate. All the staff members at the computer unit are well-trained personnel recruited locally and from the West Africa sub-region. The head of the computer section estimated an annual expenditure of £100,000 on computer hardware and software. There are still problems with the information technology infrastructure in the organization, mostly in terms of technical support and local staff training.

> *"………the computer support services here are weak, if you have problems they [support personnel] either don't come or they come and don't know how to solve the problems. I think the computer staff needs proper training before they can provide adequate support services………" (SL, MRC)*

They have full connection to the Internet, which gives all the staff members unlimited access to e-mail and other services on the Internet. During the visit to the organization, there was a problem with their local area network (LAN) and Internet access. This greatly affected their communication and work process. The situation, however, was temporary. Things were satisfactory earlier when there was adequate support for the network. There is a current effort to improve the support services. While LAN is functioning, they use a Groupware system (GroupWise), though only a few of the features (like the e-mail client) are being utilized by the staff. The internal telecommunication system is functioning very well. There are also plans to further standardize all the hardware and software in future and to implement a good IT policy in the organization.

Case 3: International Trypanotolerance Center (ITC)
ITC is an international organization in The Gambia. ITC had a low IT infrastructure capability, with 8 of the 23 services available, compared to the other international organizations in the study. ITC ranked behind one national organization and came fourth in the overall assessment. The IT infrastructure is entirely managed by an outside vendor, in contrast to other organizations that have an internal information technology group. The reasons for this decision include the size of the organization and the volume of IT service usage. The person responsible for the relationship management with the vendor is of the opinion that having a whole computer section could be a waste, in view of the limited needs of their services.

> *"………We have IT support from ITS [a local IT consulting company] and another Internet service provider. That is better for us, because of critical mass, there is no point hiring a permanent staff, if no computer breaks down in a month then he sits down idle. If there is a problem, then we call our engineers." (YA, ITC)*

Unlike other international organizations, ITC is being affected by the cost of acquisition and maintenance of its IT infrastructure. The non-availability of a local area network in the organization is due to the associated high cost and expected low utilization.

> *"………We don't have the LAN (Local Area Network) because of the one time investment cost to install it is quite expensive. We need to have the server, a systems manager and to do all the wiring. And around here we are clustered together but we still have other people some meters away, so with that the center has been discouraged because of financial resources, we don't want to go into cost of having a LAN……… it will seem inappropriate, we are very small, we need a critical mass of staff to justify the cost involved, there is no point doing LAN for ten people. If you have a staff strength of 100, then it is good to have LAN. Then you can put your notices on it and so many things on it, but if your staff strength is not high then the cost benefit is not there……….."(YA, ITC)*

They have a dialup connection to the Internet through a local ISP, with e-mail access for all the senior staff. Unlike national organizations with similar arrangements, the researchers do not have to pay for the cost of connection themselves.

Case 4: Nigeria Institute of Social Economic Research (NISER)
NISER is a national organization in Nigeria. Of all the national organizations in this study, NISER had the best IT infrastructure capability, with 12 of the 23 services available. Like IITA they have a computer section but the spending cannot be compared with the IITA's spending on IT infrastructure. The head of the computer section estimated an average spending of about USD 40,000 in the last five years (1996-2001). The mode of acquisition of IT infrastructure services at project and individual level does not permit easy evaluation of the real investment in IT. There are difficulties in getting adequate funds required for IT services and the organization was not able to meet the IT needs of the researchers.

> *"………No, there is little funding. There is no special funding for that within the institute. The government does not seem to have it as a policy that IT should be provided for research. So it is from the meager budget that the organization tries to squeeze out some funds to buy one or two PC each year, it is not adequate enough for growth." (IB, NISER)*

They have a dial-up connection to the Internet through a local ISP. Each staff member has access to email services at a cost, which has been discouraging many scientists from making use of it. The service is only available on a few workstations and sometimes, they have to queue for several hours:

> *"………we have, but it is not widely available to everybody, if you understand, it is not widely available because the cost of access is high. Even though it [Internet] is opened to everybody, the cost is scaring them off and they are not using it. That is why I was a bit cautious in my answer, but there is access. You have to pay N200 ($2) for 15 minutes of browsing, some of them use it when it is very important and critical."(IB, NISER)*

There was no local area networking (LAN) in the organization, and hence no intranet or Groupware system. They have a web site that provides information about the organization, although the information may not be up-to-date. The level of the IT skills of the researchers at NISER is also lower than the researchers at international organizations:

> *"………most of them are locally trained and not exposed to the use of IT equipment right from school……….Some of them insist on having training but after you trained them, and there is no computer to practice what they learn, what happens? They forget it. Another thing that I have noticed is that the younger ones are more amenable to change than the older ones………..."(IB, NISER)*

The intercom is not functioning at the time of the study and external phone calls are centralized and restricted. Data and documents are commonly transferred on diskette for printing, editing etc. and most of the time, a low quality diskette fails due to high humidity and heat. This often results in loss of documents or data corruption. The aim of the organization is to build a local area networking system, improve their communication systems and train their employees in the use of the available IT infrastructure.

Case 5: National Agriculture Research Institute (NARI)

NARI is a national organization in The Gambia. NARI had a low IT infrastructure capability and it ranked fifth among all the organizations. With 7 of the 23 services available, NARI's case was not too different from the other national organizations. Major problems existed in regard to funding and lack of expertise to provide the required services. The computer section had two people with little expertise. It was difficult to estimate the spending on IT since no proper records were kept. There was no local area network even though its importance was recognized. The initial cost was the main barrier preventing the installation of such a network.

> *"We have looked at networking and compared with standalone computers, putting up a server and things like that but the cost dissuaded us from following that up…. … … when we approached a company to network the computers, they asked for over $20,000, that is ridiculous. Not because we don't want to do it or not see the advantage but due to cost implications."(BO, NARI)*

Nevertheless, the majority of the researchers have access to a computer and from 1998, they have access to the Internet. They did not have to pay for access due to the reasonable cost of connection in The Gambia.

> *"………for the access, the email we cannot entirely receive accolade for that. The institute has done its best in opening an account but it is because we have Quantum, GAMTEL etc that makes it easier to do things. There is benefit in paying GMD200.00 ($10) every month, because somebody can contact you as easily as possible and you also, can have access to people."(BO, NARI)*

NARI was also affected by a lack of awareness, training, and willingness to use IT infrastructure (like other national organizations).

> *"………They are all sitting at the computer trying to do something. Some of them don't have the time to use the computer. They call the secretary to come and use the computer to write their memo for them. And also, it is age difference issue. Some of the older guys want the secretary to do their typing for them. Some of the younger guys want to do it themselves. Then we have the secretarial cadre that some of them are good and the rest are terrible………. " (BO, NARI)*

There was even a lack of adequate information systems to support basic work processes, which could help them to be competitive, accountable and responsive to their donors.

> *"………research institute like ours could do well with somebody with training in information technology, to manage files etc even with accounting, to make sure that payments and expenditures are monitored. We need to have some accounting system, which will allow us to monitor our expenditures. For every activity, I like to know how much has been spent and the balance on each account. I think they [information systems] are very critical for the life of the organization like ours, we are not in the business of making money, we get grants and subvention, we have to be judicious about how we spend our funds… … …"(BO, NARI)*

The telecommunication system at NARI was not efficient. The internal telecommunication (intercom) was not functioning and phone calls could only be made via the exchange, which didn't function most of the time.

Case 6: Nigeria Institute of Medical Research (NIMR)

NIMR is a national organization in Nigeria. NIMR had a low IT infrastructure with 7 of the 23 services available. The computer unit was not well staffed and developed. The IT hardware and software were obsolete and appeared to be inadequate.

> *"………We have a problem, most of the computers that we have, they are very old and you find out that the capacity is quite low. Only some of them have Windows 95, in fact very few have Windows 95, they even have a much lower version of Windows, and you can imagine the type of software you can run on it. We have problems trying to convince them that we need computers with higher capabilities. We don't have any Windows 2000 in this office."(ON, NIMR)*

NIMR also had a dial-up connection to the Internet, which is quite bad due to persistent connection problems to the ISP. During the interview, the connection to the Internet was broken and an attempt to call the service provider proved abortive due to telephone problems. The only telephone phone line available for researchers rarely function.

> *"………because we don't have telephone like if you want to phone, we must all pass through the PBX, and the PBX is not functioning. They said they have only one line which doesn't often have dialing tone. So what do we do when we have urgent official calls to make? We know we have to make contact with people, we still have to go out. It hasn't been very easy because it cuts into our personal finance and yet, as of now [12 February 2001] we haven't been paid [January salary]. So it is not easy and it is delaying our work." (NO, NIMR)*

According to some of our interviewees, the few available IT infrastructures have not been put into full use by the staff, due to lack of skills, especially by some senior scientific staff.

> *"……… I don't use computer. I don't know how to use computer but I want to learn it."(OA, NIMR)*
> *"………some don't even bother, some don't even want to bother themselves especially those senior ones who feel that they are almost retiring don't bother, they feel that somebody can always do it for them." (ON, NIMR)*

There is a lack of enthusiasm on the part of some researchers, which is attributed to unavailability of computers. The organization is trying to improve this.

> *"……… it was even recently that they have to purchase additional computers for the researchers. Initially, the heads of departments have their computers, which they hardly use, and they don't allow researchers to use them. You will find out that less than half of the researchers here are computer literate because they don't have access to computer, a lot of them can't even analyze their data, because they can't use a computer, … … … they are not even aware of the various data analysis software that we have………"(ON, NIMR)*

Comparative Analysis

Table 2 displays the availability of services and illustrates that the organizations differ in the extent of their IT infrastructure. In sum, IITA, and MRC, two international organizations have the highest IT infrastructure ranking, whereas the national organizations, NARI and NIMR, have the lowest ranking. However, ITC, which is an international organization, had fewer IT services than, for example, NISER, a national organization, although this was compensated by their outsourcing strategies.

Table 2. IT infrastructure summary and ranking

	International			National		
	Case 1 IITA	Case 2 MRC	Case 3 ITC	Case 4 NISER	Case 5 NARI	Case 6 NIMR
Services provided	19	16	8	12	7	7
Services not provided	4	7	15	11	16	16
Ranking	1	2	4	3	5	5

All the organizations, with the exception of one (case 3, ITC), employed two to ten people in their computer departments. An expatriate usually managed the IT units of the international organizations. The expatriate heads of the IT units were generally more experienced, and had knowledge of relevant modern technologies, due to their training in and access to the Western market. This usually had a positive influence on the performance of the IT unit and the adoption of technologies. The only international organization without a computer unit had an effective outsourcing strategy, which indirectly resulted in better services than national organizations with higher IT infrastructure services. The IT units of the international organizations were better staffed than the national organizations. Most of the staff had a university degree and had received some other special training. LAN and Intranet were only available in the international organizations.

Although there was Internet connectivity in all the organizations, the mode of connection varied between organizations. For example, MRC is one of the few non-commercial Internet Service Providers (ISPs) in Africa. All the national organizations had a dial-up access via local ISPs. There was a significant difference in the estimated IT expenditures based on the available figures from two international and one national organization. It was difficult to get the estimated annual IT expenditure in the national organizations due to diverse ways of acquiring of IT infrastructure services, however, based on the authors' observations, they may well have similar figures to that of NISER. All the six organizations use outsourcing partners for some services, with ITC solely dependent on vendors (Table 3). Thus, it is difficult to estimate reliably the yearly IT expenditure.

Table 3. Summary of selected IT capabilities in the six organizations.

Name	IITA	MRC	ITC	NISER	NARI	NIMR
IT Unit	Yes	Yes	No	Yes	Yes	Yes
Status of the Head	Expatriate	Expatriate	N/A	Local	Local	Local
Outsourced services	Some	Some	All	Some	Some	Some
Staff No.	10	7	N/A	8	2	4
LAN/intranet	Yes	Yes	No	No	No	No
Internet	Yes	Yes	Yes	Yes	Yes	Yes
Intercoms	Yes	Yes	No	No	No	No
Est. expenditure on IT per year	$ 200 000	$ 142 243	Not known	$ 8 900	Not known	Not known

FACTORS RESPONSIBLE FOR DIFFERENCES IN IT INFRASTRUCTURE

In this section, we discuss the key factors responsible for the differences in the availability and usage of the IT infrastructure between international and national research organizations.

Funding

National organizations usually have support from their government. Very little of this can be expended on information technology infrastructure, as other more pressing issues have higher priority. Some major IT infrastructure development has been supported from external funds and making the ensuing system available to a select few working on the funded project. In contrast, the international organizations appeared to have enough funds to acquire required IT infrastructure. They usually had a large budget from their sponsoring organizations, in addition to direct support on various projects. Most of their funds are also denominated in dollars and they are not affected by fluctuating exchange rates in their host countries.

Managerial and Technical expertise

As indicated in Table 3, an expatriate or a Western trained local expert usually heads the IT section of the international organizations. The expatriate staff often has a high standard of training and is aware of the current developments in their field of expertise. Although opinion has been divided on the issue of expatriates, it is still one of the best ways that management and technical problems can be addressed in the short term, even though its sustainability can be questioned. After the departure of an expatriate, the issue of knowledge transfer is often not properly addressed (Moyo, 1996).

Training

National organizations try their best to train staff, but the cost is usually beyond their budget. When a member of the staff is sponsored abroad, they rarely return to the same organization (even if they return to the country). The affordable local training centers are not usually able to provide adequate training, and the higher education institutions are not properly equipped. According to Bennett, the issues of managerial and technical expertise discussed above "stem from lack of education and experience or from environments with no formal systems of control" (in Odedra et al., 1993). When the training is organized "in-house", the lack of equipment for practicing on causes difficulties for the staff who forget what they have learnt since they have no opportunity for applying their recently gained knowledge. The same applies for many people who receive their education abroad: once they return home and lack access to the kind of environment in which they studied, they soon lose most of their acquired knowledge.

Awareness and exposure to technology

Two factors directly related to training are the awareness of and exposure to available technology. Most of the researchers at the national organizations have limited exposure to the possibilities of IT and they may not even be aware of an upgrade in the software they are using. Also, in national organizations, some of the older senior staff were IT illiterate and suffer from IT-phobia. They are not enthusiastic about learning new IT applications. They are at ease delegating all IT related activities to their younger colleagues, or hiring staff

specifically for that purpose. Whereas in international organizations, everyone seems to be aware and prepared to apply IT.

Other infrastructural elements

The problems of other infrastructures were expressed several times during our interviews at the national organizations, a phenomenon observed and summarized by Odedra:

> *"Certain prerequisites, such as reliable power supply to operate the computers, a well-functioning telephone network to transmit data, foreign currency to import the technology, and the computer literate personnel, are necessary for successful use of IT. Such infrastructural elements remain inadequate in many sub-Saharan Africa countries."(Odedra et al. 1993)*

Although there has been some improvement in the provision of these services, we still found them to be grossly inadequate in the national organizations which had to depend primarily on the national infrastructure. International organizations are able to provide these infrastructures where it is not adequately provided by the national government. For example, some of the remotest field stations we visited during our study still managed to provide a 24 hour supply of electricity, even though their host community had to ration between 4-8 hours of supply via their national grid. Due to a good relationship, or probably influence with the government, these organizations are not overtly affected by a shortage of fuel, needed to run their generator or delays at ports to clear their imported spare parts.

We have limited our discussion to the problems that were specific to the organizations studied. There are numerous indigenous problems that have already been well discussed in the literature. These include complex purchasing procedures, vendor control of technical direction, dependency on outsiders, poor maintenance procedures, under utilization of machines and human potential and others (Odedra et al., 1993; Moyo, 1996; Barata et al., 2001; Darley, 2001). There are difficulties not only with the availability of IT infrastructure (Odedra et al. 1993), but also with their application (Morales-Gomez and Melesse, 1998; Avgerou, 1998).

RECOMMENDATIONS

Our analysis of the results presented above indicates disparities on the level of funding, managerial and technical expertise, training and exposure to available technologies, and other infrastructures between the international and national organizations. Surprisingly, all these were noticed more than five years ago, as reported in the articles by Odedra et al. (1993) and Moyo (1996). Although there have been some improvements, our findings revealed that their recommendations have not been followed.

Although our recommendation concerns lessons drawn from international organizations, its implementation does not necessarily have to follow the pattern of these international organizations. Each organization has to determine the most suitable strategies for its own situation taking local factors into due consideration (Moyo, 1996). The following measures are recommended for improving the IT infrastructure in national organizations in sub-Saharan Africa and for sustaining the IT infrastructure in all organizations whether national or international.

13

IT Policy and Strategy

We would like to recommend that the national organizations formulate a sustainable IT policy and develop an appropriate strategy for implementing this policy. For example, in IITA they have defined their goals in a 10-year strategic plan and only alter it as changes in the work environment and technology demands (IITA, 1988). We are also aware of a similar long-term plan at MRC. There has been emphasis on the national IT policies and strategies in developing countries, but few organizations have an IT policy. Some of the IT infrastructure in these national organizations is acquired through externally supported projects and the equipment is meant to serve the need of the donor. After the completion of a project, the managing or updating of the equipment is not usually easy (Odedra et al., 1993). We recognize the limitations of researchers at the national organizations, but the current availability of the Internet enhances communication with their local colleagues abroad and, therefore, they could improve their awareness and become IT-literate. In doing so, they could define the kind of IT infrastructure they need without completely relying on external sources.

Related to organizational policies and strategies are what Moyo (1996) refers to as 'personal strategies'. As described earlier, apart from the well defined policy and strategies, the personal needs and requirements of staff are shaping the direction of technology acquisition in international organizations.

> *"………when they are recruited from abroad, all those technologies they are familiar with must be available here for them to do their jobs well. They go for vacation in their various home countries and return with knowledge of currently available technology. So we too have to be versatile and be aware of recent developments in IT and its use, to update our systems as well."(YA, IITA)*

Cooperation and Alliances

When considering the problems associated with the acquisition of the necessary IT infrastructure, the national organizations could learn from the approach of the international organizations by having an agent abroad to ease the process. Several national organizations could merge to use one agent and spread the cost. Another possibility would be to forge an alliance with the international organizations on this issue. Since most national organizations already have good relationships with international organizations, this might not be too difficult, especially on an ad hoc basis.

Funding

Although, there is very little the national organizations can do on their own to improve their funding, we would still like to suggest that they try to have a foreign currency denominated account, which would speed up the process of foreign purchases. The international organizations use this approach and it seems to alleviate some of the problems associated with delays in receiving equipment. They could also persuade the government to provide more funds to develop and maintain their own infrastructure, based on their needs.

Training

Training and problems of managerial and technical expertise seem to be in the domain of the government. We cannot encourage the national organizations to adopt a policy of hiring

expatriates like the international organizations, as it is unsustainable. We suggest that the government follows the recommendations suggested earlier (Moyo, 1996; Jarvis, 1999; and Nasseh, 2000), i.e., widespread standardized IT training and higher educational institutions responsive to the IT needs of the knowledge society. There is a need to introduce some IT management courses into the Computer Science programme, common in most universities in sub-Saharan Africa (Marshall and Ruohonen, 1997).

CONCLUSIONS

We have discussed our findings on the disparity between the availability of IT infrastructure and the usage of the services in international and national research organizations. All the factors had their roots in low funding, which national organizations cannot control. As long as the major source of IT infrastructure of the national organizations depends on external project funding, the socio-cultural conflicts that come with it will remain (Odedra et al., 1993). Nevertheless, if the cases of the international organizations are carefully studied and adopted, with due consideration to factors specific to national organizations, some improvement is achievable. We suggest cooperation among research organizations to cushion the costs and problems associated with the acquisition of IT equipment. Having adequate policies and feasible strategies could also assist in guiding the national organizations. As the real gap between the North and the South has been attributed to the criteria of skill, it is imperative to start improving modern technologies within organizations. By this means, the skills and the knowledge level of people could be improved and thus also the wealth of the nation.

The limitation to the findings and recommendations of this study is that the findings were based on a limited number of organizations in only two out of the forty-eight countries in sub-Saharan Africa. Considering the diversity in socio-economic and political situations in these countries, the findings in this study cannot be directly generalized to all sub-Saharan Africa countries, although they provide an understanding of the deeper structure of organizational information technology infrastructure in two countries which are representative of sub-Saharan Africa and, thus, could inform other settings. We have also used non-profit research organizations in our study, but these problems are not limited to them alone, and could be more pronounced in profit oriented national organizations. Most of the factors responsible for the differences could also be found in other developing countries because the socio-political situation and government commitment to the IT infrastructure are often similar. We would like to conclude that the governments of developing countries should carefully examine how the international organizations receive their IT infrastructure and maintain it. It might then be possible to apply the same principles in national organizations, in which they have an interest, and which are affected by the same local conditions.

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REFERENCES

1. Avgerou, C. (1998). How Can IT Enable Economic Growth in Developing Countries? *Information Technology for Development,* 8(1), pp. 15-29

2. Bangemann Commission (1994).*Recommendations to the European Council: Europe and the Global Information Society.* At http://europa.eu.int/ISPO/infosoc/backg/bangeman.html [Accessed June 6th 2001]

3. Barata, K, Kutzner, F., and Wamukoya, J. (2001). Records, Computers, Resources: A Difficult Equation for Sub-Saharan Africa," *Information Management Journal*, 35(1), pp.34-42

4. Beranek, P. (2000). Information Technology Infrastructure CIS 811, *Bentley College Website*, Available from http://cis.bentley.edu/pberanek/CIS811/CIS811.html, 1997 [Accessed March 22nd 2000]

5. Braga, P. and Alberto, C. (1998). Inclusion or Exclusion?" *UNESCO Courier*, December, pp. 24-27.

6. Broadbent, M. and Weill, P. (1997). Management by Maxim: How business and IT managers can create IT Infrastructures, *Sloan Management Review*, Spring, pp. 77-92.

7. Ciborra, C. and Hanseth, O. (1998). Towards a contingency view of infrastructure & knowledge: an exploratory study. In Hirscheim, R. Newman, M., and DeGross, J. I. (eds.) *Proceedings from 19th Annual International Conference on Information Systems (ICIS)*, Helsinki, Finland, December 13-16, pp.263 - 272.

8. Crede, A. and Mansell, R., (Eds) (1998). *ICTs In Developing countries*. The Hague, Netherlands: IICD.

9. Darley W. (2001). The Internet and Emerging e-Commerce: Challenge and Implications for Management In sub-Saharan Africa. *Journal of Global Information Technology Management*. 4(4), pp 4-18.

10. De Boer, S. and Walbeek, M. (1999) Information Technology in Developing Countries: A Study to Guide Policy Formulation. *International Journal of Information Management*, 19(3), pp 207-218

11. Digital Opportunity Task Force (DotForce) (2000). Addressing the Digital Global Divide. Available from http://www.dotforce.org [Accessed June 6th 2001]

12. Dunning, J. and Narula, R. (1999). Developing Countries Versus Multinationals in a Globalizing World: the Dangers of Falling Behind, *Forum for Development Studies*, Issue 2, pp 261-287

13. Economic Commission for Africa ECA (1996). Development of National Information and Communication Infrastructure Plans- Terms of Reference. Available at http://www.uneca.org/aisi/docs/TOR%20NICI%20English.doc [Accessed on 23rd April 2001]

14. Economic Community of Africa (ECA). (1998). *National Information and Communications Infrastructure (NICI) Indicators: An overview of the African ICT Sector*. 1998. Available from http://www.un.org/depts/eca/adf/nici/nici%20indicators.htm [Accessed June 6th 2001]

15. Global Information and Communication Technologies Department (GICTD). (2000). *The Networking Revolution: Opportunities and Challenges for Developing Countries*. InfoDev working Paper 2000. Available at http://www.infodev.org/library/working.htm [Accessed June 6th 2001]

16. Hanseth, O. (1996). *Information Technology as Infrastructure*. Ph.D Thesis, University of Gothenburg, Sweden.

17. Hanseth, O. and Monteiro, E. (1997). *Understanding Information Infrastructure*. Available at http://www.ifi.uio.no/~oleha/Publications/bok.html [Accessed 16th June 2001]

18. Hildebrand, C. (1998). What is Infrastructure? *CIO*, 11, Feb15, 1998, pp 66

19. Information Infrastructure Task Force (IITF) (1993), U.S. Department of Commerce, *The National Information Infrastructure: Agenda for Action*. September 15. Available from http://www.ibiblio.org/nii/toc.html) [Accessed Tuesday, March 18, 2003]

20. International Institute of Tropical Agriculture (IITA) (1988). *IITA Strategic Plan: 1989-2000*. Ibadan, Nigeria: International Institute of Tropical Agriculture.

21. Jarvis, P. (1999), Global Trends in Lifelong Learning and The Response of The Universities. *Comparative Education*, 35(2), 1999, p249, 9p

22.   Kolodner, E. (1994). Transnational Corporations: Impediments or Catalysts of Social Development? Occasional Paper No 5, *World summit for Social Development*. Available at http://www.unrisd.org/engindex/publ/list/op/op5/toc.htm [Accessed 16th June 2001]

23.   Korpela, M. (1994). *Nigerian practice in computer systems development. A multidisciplinary theoretical framework, applied to health informatics.* Doctoral dissertation. Helsinki University of Technology, Department of Computer Science. Reports TKO-A31. 1994.

24.   Lynch, K. (2000). Undivided Attention. *tele.com*, 5(24), 12/11/2000, pp.42 -45Lyytinen, K. (1991). Penetration of Information Technology in Organizations: A Comparative Study Using Stage Models and Transaction Costs. *Scandinavian Journal of Information Systems*, 3(1), pp. 87-109

26.   Marshall, G. and Ruohonen, M. (Eds.) (1997). *Capacity Building for IT in Education in Developing Countries.* IFIP TC3 WG3.1, 3.4 &3.5 Working Conference on Capacity Building for IT in Education in Developing Countries August 1997 Harare, Zimbabwe. London: Chapman and Hall

27.   Mazrui, A. and Andrew, W. (1991). Gender, Skill and Power: Africa in Search of Transformation. In: Adedeji Adebayo & Teriba Owodunni & Bugembe Patrick (Eds.). *The Challenge of African Economic Recovery and Development*. London: Frank Cass

28.   McConnell, S. (2000). A Champion in Our Midst: Lessons Learned from the Impacts of NGO's Use of the Internet. *Electronic Journal of Information Systems in Developing Countries* 2(5), pp. 1-14.

29.   Merriam, S. (1988), *Case study research in education: A qualitative approach*. San Francisco: Jossey-Bass Publishers.

30.   Miller, J. and Day, B. (2000). *National Information and communications Technology Policy and Planning Processes: Lessons from South Africa*. In IFIP WG 9.4 Conference 2000 - Information Flows, Local Improvisations and Work Practices Cape Town May 2000.

31.   Morales-Gomez, D. and Melesse, M. (1998). Utilizing Information and Communication Technologies for Development: The Social Dimensions. *Information Technology for Development*, 8(1), pp. 3-14

32.   Moyo, L. M. (1996). Information technology strategies for Africa's survival in the twenty-first century: IT all pervasive. *Information Technology for Development*; 7(1), 1996, pp17-

33.   Nasseh, B. (2000). Forces of Change: The Emergence of a Knowledge Society and New Generations of Learners. In L. Petrides (Ed.), *Case Studies on Information Technology in Higher Education,* pp. 217-227). Hershey: Idea Group Publishing.

34.   Nkereuwem, E. (1996). The Utilization of Aid Organizations in The Development of Information Technology in Developing Countries. *Library Management,* 17(5), pp. 25-30

35.   Odedra, M., Lawrie, M., Bennett, M., and Goodman, S. (1993). International Perspectives: Sub-Saharan Africa: A Technological Desert. *Communications of the ACM,* 36(2), pp.25-29

36.   Okunoye, A, and Karsten, H. (2001). Information Technology Infrastructure and Knowledge Management in sub-Saharan Africa: Research in Progress. In *Proceedings of Second Annual Global Information Technology Management (GITM)* World Conference, June 10-12, Dallas, TX, USA

37.   Persaud, A. (2001). The Knowledge Gap. *Foreign Affairs* 80(2), pp.107-117.

38.   Rodríguez, F. and Wilson, E. (2000). Are Poor Countries Losing the Information Revolution? *InfoDev Working paper*. May 2000 Available at http://www.infodev.org/library/working.htm [Accessed 16th June 2001]

39.   Sadare, D. (1998). Making Information Technology Systems (ITS) Work in Nigeria Against All Odds. In: Avgerou, C. (ed.) *Implementation and Evaluation of Information Systems in Developing Countries*. Proceedings of the Fifth International Working Conference of IFIP WG 9.4, Bangkok, Thailand, 18-20 February 1998, p. pp311-330. Vienna: International Federation for Information Processing.

40.   Stake, R. (1998).Case studies, in Denzin N. K. and Lincoln Y. S., (Eds.), *Strategies of Qualitative Inquiry*. pp 86-109, Sage Publications Inc, California

41.   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 from http://www.worldbank.org/html/fpd/harnessing/ [Accessed April 13th, 2000]

42.   The World Bank Group (1999). *World Bank Report 1998/99: Knowledge for Development.* Available from http://www.worldbank.org/wdr/wdr98/ [Accessed April 3rd 2000]

43.   The World Bank Group (2003). "World Development Indicator – Data Query," Available from http://devdata.worldbank.org/data-query/ [Accessed May 26th 2003]

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

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Appendix 1: Information technology infrastructure capabilities

ServId	Core Information Technology Infrastructure Services	IITA	MRC	ITC	NISER	NARI	NIMR
1.	Manage firm-wide communication network services	Y	Y	N	N	N	N
2.	Manage group-wide or firm-wide messaging services	Y	Y	Y	N	N	N
3.	Recommended standards for at least one component of IT architecture (e.g., hardware, operating systems, data, communications)	Y	Y	N	Y	Y	Y
4.	Implement security, disaster planning, and business recovery services for firm-wide installations and applications	Y	Y	N	Y	N	N
5.	Provide technology advice and support services	Y	Y	N	Y	Y	Y
6.	Manage, maintain, support large-scale data processing facilities (e.g., mainframe operations)	Y	N	N	N	N	N
7.	Manage firm-wide or business-unit applications and database	Y	N	Y	N	Y	Y
8.	Perform IS project management	Y	N	N	Y	N	N
9.	Provide data management advice and consultancy services	Y	Y	Y	N	Y	Y
10.	Perform IS planning for business units	Y	Y	N	N	N	N
	Additional Information Technology Infrastructure services						
11.	Enforce IT architecture and standards	Y	Y	Y	N	N	N
12.	Manage firm-wide or business-unit workstation networks (e.g., LANs, POS)	Y	Y	N	N	Y	N
13.	Manage and negotiate with suppliers and outsourcers	Y	Y	Y	Y	N	Y
14.	Identify and test new technologies for business purposes	Y	Y	N	Y	N	N
15.	Develop business-unit specific applications (usually on a chargeback or contractual basis)	Y	N	N	Y	N	N
16.	Implement security, disaster planning, and recovery for business units	Y	Y	N	Y	N	N
17.	Electronically provide management Information (e.g., EIS)	Y	Y	Y	Y	N	N
18.	Manage business-unit-specific applications	N	N	Y	Y	N	Y
19.	Provide firm-wide or business-unit data management, Including standards	Y	Y	Y	Y	Y	Y
20.	Develop and manage electronic linkages to supplier or customers	N	Y	N	N	N	N
21.	Develop a common systems development environment	N	N	N	N	N	N
22.	Provide technology education services (e.g., training)	Y	Y	N	Y	Y	N
23.	Provide multimedia operations and development (e.g., video-conferencing)	N	N	N	N	N	N
	Total ITI Available	**19**	**16**	**8**	**12**	**7**	**7**