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THE DIGITAL FUTURE OF SCIENTIFIC AND TECHNOLOGICAL INFORMATION (STI) IN THE SUDANESE RESEARCH COMMUNITY

Dr Rafaa A. Ghobrial Morgos
Director, Documentation and Information Centre
National Centre for Research
Ministry of Science and Technology, Khartoum, Sudan.
Email: rafaasham@yahoo.com

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Abstract

Sudan is a country rich in heritage; scientific research outputs and traditional knowledge are the Collective Scientific Memory. This paper reviews S&D and Information and Communications Technology (ICT) development in the country. It aims to optimize the use of information and knowledge systems in the research community to explore new areas of research and elaborate on expected values of the digital future. The most important findings of this study are that the existence of entities within traditional organizational structures and the environment is conducive to creativity, and that the range of innovation is limited. STI is hampered by lack of coordination, communication and cooperation, a fragile infrastructure and insufficient financial and human resources. In conclusion the study proposes a digital system for sharing and exchange of S&T knowledge i.e. for the open flow of information and knowledge for research projects, in order to revolutionize the prevailing reality in research institutions for them to cope and position themselves in the information and knowledge society.

Introduction

Sudan is rich in heritage, in arts of ancient science, writings, inscriptions, creative industries, with tremendous traditional knowledge, research outputs and studies (Welsby & Anderson, 2004; Ghobrial, 2010). Their precision, splendour and beauty are considered an integral component of the scientific memory of civilization. Some of them are the life experiences and traditional products of the Sudanese society. These have been invested to raise the real income of the rural nomadic segments and satisfy their basic needs (Gasim and Osman, 2010). The scientific and technical revolution has established distinct and successive innovations and contributed effectively in economic development and change (OECD, 1997). There is a wide range of applications of development and production methods which reflect the ability of information systems to process, store and retrieve information. Currently the widespread knowledge revolution and new initiatives implemented by various sectors or institutional partnerships provide the unprecedented extension of information to broad categories of the public in spite of the knowledge gap (Ghobrial, 2010).

Research Questions

However, there are a number of questions continuously raised in research communities during the setting up of scientific and technological plans, strategies and research programmes:

1. What is the role of information systems and technology in discovering areas of research that lead to economic development?
2. Which information is most important for researchers?
3. What are the best ways to transmit that information from one person to another, i.e. methods of information exchange, and to represent and display information so that it becomes understandable and researchable?
4. How can the digital future be developed further?

This study attempts to examine research information and access needs in the Sudanese research community within the context of the community's culture and Internet access. It also tries to identify existing facilities, systems or projects which contribute to realizing the digital future in research materials/collections, networks for email communication, and management information systems.

Objectives

The aim of this research is to optimize the use of information and knowledge systems in the research community to explore new areas of research and adoption of new technologies. It attempts to understand what values the research community expects in the digital future, in order for scientific and technological research plans and outputs to be more dynamic and free of general stagnation.

Methodology

The research methodology was a combination of methods to gather and analyze data on the nature and types of collections in research institutions, the policies and programmes to specify the place of digital technology needs and requirements, and future digital plans and programmes in the research community. Between March and May 2011 the research study surveyed randomly 80 researchers (researchers who held M.Sc. degrees or were Assistant Professors, Associate Professors and Professors) in different specializations and also interviewed some information professionals (librarians and information technologists). These were mainly in Ministry of Science and Technology institutions and were interviewed to provide additional qualitative insights into the problems they face and their perceptions and appreciation of the adoption of digital technology.

Information and Communication Technologies (ICTs) in Sudan

ICTs form an important pillar of economic, social development and scientific in different parts of the world. Sudan has realized the growing role of information and communication technologies and services and attention to the Sudanese and the information society which adopted the National Strategy for the IT Industry in mid-2001[1] which was based on institutional frameworks

[1]http://www.sudannic.gov.sd

and legislative and regulatory structure. It has achieved openness and transparency in promoting competition and innovation, capacity building and development of human resources able to respond and interact with the requirements of the information age. This is done through continuous training, and development of infrastructure as represented in the provision of information networks providing easy access through the competitive free market to the use of modern technologies, services and applications. It deals with the adoption of a system of partnership between the public sector and the private sector to move forward in the application of information and communication strategies. A support fund was established which contributed to a number of projects including those including lecturers and researchers; a school computer; an e-government project; the Universities Information Network project; and a Network Project, which includes banking services, smart card and electronic banking[2].

With regard to infrastructure and networks, the Sudanese government has established the National Information Network NIN at the request of the National Information Center in coordination with the Ministry of Federal Government, to link the States, departments and units of the national network of information by Sudatel and Datanet through fast and modern communication technologies, in order to run video-conferencing and exchange reports and messages. This phased NIN project was implemented for the benefit of experiences in the States at various levels to achieve the desired goals, which are:

1. Linking of the Federal Government with the different states and sectors of the NIN.
2. The use of all types of applications expected for the progress of the NIN, such as video conferencing, email, transfer and exchange of files, databases and the Internet.
3. Facilitation of remote control and speeds expansion of files.
4. The confidentiality of transferred information.

This strengthening of electronic communications between the Sudan States, the Ministry of Cabinet and the Ministry of Federal Government was then expanded to include all ministries, state and localities, to increase the ability of participation in a timely manner in nineteen sites.

The problems and obstacles to the flow of information across the network can be summarized as follows:

- Limited capacities in the Sudan states;
- geographical expansion of Sudan makes it difficult to run periodic tests; and
- lack of technical support in some states (uninterrupted transmission lines in some states because of some natural factors).

NIN helps and contributes to the process of expansion of connectivity to allow private sector companies; establishment of information networks which allow connections; economic certified use of techniques for satellite and mass media network. Internet service providers and wireless

[2] http://www.ntc.gov.sd/index

facilitate all communication services. Communication networks are made up of fixed, mobile and satellite, and cover the national network of fibre-optic in most of the Sudan. The total cable length is about 15,000 miles, owned by Canartel and Sudatel, in addition to the optical fibre outlets that are regional and global. There are also a number of data transmission networks with different technologies (Frame Relay / ATM / DSL / 3G/mDSL/EVDO) in all areas covered by fibre optic cables and wireless networks. In addition several techniques are available for fixed wireless networks, microwave networks, including WiMAX and Wi-Max, Wi-Fi Wi-Fi)[3].

Scientific research communities

Scientific research in the Sudan dates back to the beginning of the year 1902. Great efforts have been made to improve our research and development, and there has been a great revolution in scientific research that is closely related to development and improvement of production. In 1970, scientific research received greater attention from the government and the National Council for Research (NCR) was established in 1973 as a national body responsible for formulating policies and plans and coordinating national efforts in this respect (NCR, 1973). The NCR was transferred to the Council of Higher Education and Scientific Research in 1991-1992 with a mandate to encourage, organize and promote the scientific research in its various aspects, with a view to the realization of economic development within the framework of state policy.

The government has made remarkable efforts in tertiary science and technology (S&T) education as result of the higher education revolution which is concerned with developed scientific research methods. In 2002, this guided the Sudan government to establish the Ministry of Science and Technology (MOST), whose mandate is to enhance capacity building of national science and technological research, based on powerful incentives for researchers to network themselves both professionally and technically with their peers in other research organizations and universities. It has defined the final shape of the science and technology strategy and policy which aims to harmonize and coordinate between sectoral science policies in the country, tackle research programmes, upgrade the research institutions towards excellence and futuristic studies, encourage them to generate scientific knowledge and develop indigenous knowledge, accumulate innovations, exploit ICT methods and encourage information industry.

In terms of S&T planning and in view of the increasingly competitive and rapid advance in technology and the increasing importance of S&T in accelerating economic growth and development, the previous comprehensive National Strategy (1992-2002) and the current National Quarter Century Strategy (2007-2031) give long term perspectives for S&T development in Sudan (Elamin, 2009; MOST, 2008). The Five Year work plan (2007-2012) targets information, communications and technology and the development of scientific research. The plan aims to promote S&T by promulgating the legislation, laws and regulations conductive to the enhancement of scientific research; recruiting personnel with high abilities

[3] http://www.ntc.gov.sd/index

and competencies in the fields of scientific research; adopting innovative means to encourage the private sector to participate in scientific research, fund it and benefit from it; utilizing the results of scientific research and modern technology in decision-making and sustainable development planning; developing and disseminating science and knowledge among the people; benefiting from the experience of others in scientific research; and contributing to the advancement of basic sciences. Unfortunately, however, these comprehensive strategies were not fully implemented, mainly because of the inadequate provision of the financial and human resources needed for S&T development.

The 2011 MOST plans have formulated about 337 research projects, 20 of them focused on knowledge, including:

- ICT services and sources
- Sudan National Grid
- Innovation and Informatics Compound
- Electronic union catalogue of Ministry of Science and Technology Libraries
- Computer industry and assembling
- Atlas of Local Names of Sudanese medicinal and aromatic plants
- Medical traditions and practices
- Databank of Sudanese scientific research outputs.

The 2010 annual research reports and studies indicate that the main problems hampering development are the weak public sector finance and deployment of budgets; shortage of a specialized researcher cadre and human resources seems to be somewhat less important, together with weak relationships, networks and consistency and cooperation, and the lack of awareness and appreciation of the economic values of research and development.

Scientific and Technological Information (STI)

Information and communication have become blood vessels to any scientific undertaking. Information on science, technology and the scientific community is vital for the management of science and technology, for problem solving, and for making decisions about investments in technologies, that is needed to meet economic development goals and to advance research in a country. Information on the evolution of scientific knowledge or the pursuit of science studies can play a key role for advancement of science and technology. The widening economic gap between nations is mostly linked to corresponding gaps in S&T. To be effective, S&T needs to maintain relevance and have a sufficient resource base. In order to maintain relevance and garner support from influential sectors, S&T research and development (R&D) agendas need to be set locally. By maintaining relevance and gaining support, R&D should contribute more effectively to economic development and influence emerging national policies.

The Sudanese research community has formulated annually a number of research programmes based on national, regional and international initiatives to uphold and organize the distribution

of information in order to reduce these inequalities and to achieve the sustainable Millennium Development Goals, science, technology and innovation. The Sudan has supported this objective to ensure that information was protected from all forms of discrimination and corrupting influences.

In this context, it would be important to eliminate monopolies in software and hardware and to respect cultural and linguistic diversity. The important thing is to achieve a balance between change and traditionalism; indeed, change itself becomes an essential factor in the process of building the Sudanese national identity. The goal of the STI initiative is a continually evolving, but directly useful setting of best practices and guiding principles for doing research and reference work. The process is that of collectively building "Collective Scientific Memory" based on the shared knowledge that everyone learns in doing their work - and that is why work culture is so important. But it also involves management leadership: identifying the driving or core principles, clarifying what is valuable in evolving the best practices and drawing them into the actionable standards and expectations. The constant informal interaction focused on knowledge sharing about building corporate memory and collective expertise is an essential underpinning of research work.

This team-based environment also involves considerable delegation of defined leadership or coordinating responsibilities. Such collaborative work and team culture is common in the knowledge industry and is designed to encourage individual initiative and autonomy for front-line service providers and support flexible planning and continual innovation. A significant amount of information accumulates over the years in research centres covering a wide range of scientific aspects such as research projects, reports and publications. Technical cooperation programmes between national and international institutions could also be part of the knowledge to be managed effectively by staff. Reporting capabilities based on custom-made queries, pre-planned reports, and graphical illustrations serve as an indispensable aid to decision making at all levels of top management.

Widespread access to personal computers and Windows-based relational database management software in the nineties has led to isolated efforts towards building useful databases for the various administrative departments. However, these stand-alone databases were mostly confined to single personal computers for whose daily supervision nominated personnel were responsible. As a result these islands of data suffered from inconsistency and lack of cross-linking, and were subject to partial or permanent loss due to lack of proper back-up procedures. Repetitive data manipulation tasks across databases were also common practice and their reporting tools were not adaptive to rising needs and certainly lacked uniformity.

Sudanese research libraries and information centres attempt to provide a link between local researchers and scholars and their counterparts in other parts of the world. Internet connectivity, for example, is about the surest way of achieving this objective. All users (students, postgraduates, researchers, and planners) of the Internet enjoy a wide range of

services such as email, database access, and so on. Unfettered access to databases around the world through the Internet offers a great opportunity for scientists and technologists in the Sudan to acquire knowledge from their colleagues elsewhere. The Internet could also afford Sudanese scientists and technologists the opportunity to collaborate with their counterparts around the world on research projects. Researchers call attention to the fact that increasingly research is carried out by multinational teams, as indicated in the citation analysis of the Sudanese Bibliographical database and international databases (CD-ROM and Internet) of the National Centre for Research Documentation and Information Centre. There has been an enormous increase in recent years in the number of research papers resulting from international collaboration.

Can ICTs promote technology transfer and ensure high quality research services? This takes place at both strategic and operational levels; is about informal collaborative processes and adaptability as much as editorial procedures and explicit standards; is far more about knowledge sharing, consensus building and teamwork than management edicts and monitoring; ultimately depends on a work culture of innovation, imagination and commitment to client needs first and foremost (Ghobrial, 2003). The digital revolution has radically changed the way scientific information is spread. Most publications are now available online. Access to this vast quantity of e-data is essential for innovation, because most new ideas are built on previous research and to safeguard our scientific heritage. This wealth of information must be adequately preserved for future generations and online access to the world's scientific literature.

With major initiatives such as Research4life there are about 50 academic, governmental and civil society research institutions joined together. These initiatives help to involve the national scientific research community in the international community in terms of:

- facilitation of scientific research processes;
- direct access to the available items, keeping abreast of developments in the field and overcoming a number of problems;
- direction to scientific research publishing that announces scientific research outputs;
- follow-up news of scientific seminars, reports and scientific activities and inventions.

Results and Discussions

Situational analysis

As indicated in the previous paragraphs ICTs in all dimensions will play a key role in the transmission of information between workers in the research institutions, and interaction with the transfer of such information. The importance of ICTs can be considered in terms of:

- positive response to ICTs and fit with the needs of users;
- the contents, structures and accessibility of larger systems in order to secure quick and easy access to information and knowledge accumulated in documents;

- adoption of new standards of content quality which facilitate accessibility, affordability and availability. ICTs enable organizations and individuals to build and generate knowledge.

ICT infrastructure increases the integration of telecommunications, software and information networks, radio and television systems and databases and other forms of information technology institutions to form a global information infrastructure. Digital publishing is considered the lifeblood of the information flow in the veins of the networks. Hence the digital strategy has become a core element of the growth and innovation framework within government initiatives to create a knowledge society and national identity. This strategy requires new expenditures, programmes and financial support. Based on S&T structure and strategy is the awareness of how we will create a digital future for all Sudanese using the power ICTs to enhance all aspects of our lives. In the digital future, many things will change for the better. The results will be seen in how research institutions will be able to interact with each other, and how we can use a whole range of government services. This will increase confidence in using digital technologies to create values for the researcher and connect to new markets. The great opportunities provided by information and services will be easier to use, customized to individual needs, and delivered through many channels in urban and rural areas.

Descriptive analysis of questionnaires and interviews

The previous paragraphs have examined the current situation of STI and found some apparent discrepancies between services offered and the information needs of users. Systems need to establish procedures for constantly researching and monitoring the changing patterns in their user environment. The questionnaire was constructed to generate data for information users (researchers) to know their opinion about the existing STI system, usage of Internet resources, evaluation of Internet resources and reasons for not using the Internet. The questionnaire was analyzed after appropriate follow up of responses with researchers (78.66%).

Quantitative analysis was carried out to examine how many research units were connected to the Internet, electronic/digital collections and availability of computers. The response showed that 82.3% of respondents indicated that their computers, mostly laptops, were connected to the Internet. Respondents were also asked to indicate where they found the source/information materials to produce their publications. In this response 11% indicated they found the information from library and research institution collections and 69.% indicated they found the information from the Internet and 20% from other sources. Reasons for using the Internet rather than the library are summarized below:

- It is a very useful communication technique for contact, and current information is easily found;
- it is good scientific information reference and documentation;
- because it gives us new information, updating knowledge;
- It is international and universal;
- the very recent content and up to date innovation;
- very short time; very easy to get more information, i.e. save time, easy to access;

- update information - keep connected to all the people in the area of interaction;
- availability of Internet more than the library; has specific time; poorness of library and the old collection reserve especially in updating of knowledge;
- accessible scholarly electronic materials and easily downloaded.

Much literature both published and unpublished is being produced internally. Many research materials are consumed by various research institutions. The survey results revealed that the main outputs were research results in the form of scientific papers in scientific journals and workshop proceedings, technical reports, newsletters, pamphlets, training materials, maps and similar items. But none of the outputs were published on the research unit websites and there is no any mechanism for delivery of these publications to end users (information users).

The Sudanese research community increasingly responds to their new environmental conditions by competition rather than cooperation. There is not any cooperation between research institutions in terms of information and knowledge sharing. Cooperation only exists among their counterparts who are working in universities as well as in private institutions. Research, or knowledge creation, is a key factor by which a research institute gives tangible content to its responsibilities, within the framework of the stakeholder view of the place of the research institute in society. A research institute is not only committed to carrying out high quality research for its own sake, but also because this is one of the most important ways to return something to society at large, since it is society which grants certain privileges to the Sudanese research community. The results of the study revealed that there are large amounts of research results at research institutions, but that there is not any mechanism to link up these research outputs and disseminate them to society. Although the Sudanese Universities Information Network (SUIN) is in progress, it seems that research centres and academic institutions are not moving fast towards this network for knowledge sharing and exchange because of the high costs and inactive links (as expressed by some administrators). When respondents were asked whether there was any collaboration from their institutes with regard to information/knowledge sharing and exchange, the results revealed that 98.3% indicated 'No'. This shows that the use information across all aspects of a research institution is ineffective, limiting knowledge sharing.

The general atmosphere and appreciation of ICT, the limited levels of connectivity and infrastructure and the opinions of Internet users give some indication that knowledge stands a good chance if appropriately approached and invested. The Internet culture in particular will continue to evolve, mutate and change as technology and society evolve. It is therefore necessary to link researchers at an institutional, national and international level.

Recommendation and conclusion

The study recommends building structures and bases for the information society and knowledge to take advantage of current technological development; expanding the user base of IT tools and communication through the development of flexible policies fit for research projects; and addressing the needs of researchers in the context of planning in the knowledge economy. The

study proposes that digital institutional information is an administrative resource and a medium through which power is exercised, as a routine element of action and interaction in an organizational setting. It both enables and constrains the information behaviours of the people who use it; those who control it can exercise power over other people and resources.

The control of digital institutional information is a fundamental characteristic of the structuring of institutions, because the "regulation of the conditions of system reproduction depends on the collation of information which can be controlled so as to influence the circumstances of social reproduction." Digital institutional information, when it is invoked and used in routine institutional information behaviours, allow those who control it to exercise a considerable amount of power over the information behaviors of other members. Digital systems for S&T knowledge sharing and exchange, i.e., for open flow of information and knowledge for research projects, revolutionize the prevailing reality in research institutions, to cope and position themselves in the information and knowledge society.

An Intranet approach should also be considered at ministerial level as a tool for knowledge sharing and exchange in the digital future. This approach encompasses the people, process and technology issues that confront the creation of an effective Intranet. The adoption of an Intranet approach is important in identifying researchers' needs and for developing a realistic strategy and road map of the usability of digital entity and practices, and information architecture techniques. These skills and knowledge must be retained within the Intranet team, to ensure they are able to make the ongoing improvements needed to adapt the Intranet to the ever-changing research environment. The Intranet now plays a central role in many organizations and every improvement should continue to build tangible & visible benefits to the researcher.

In conclusion, the digital future of scientific knowledge is the mirror that reflects and keeps pace with the investment capacity of Sudanese compliance technologies and the adoption of modern research and excellence projects. This opens the way to share knowledge and benefit from access to the technology boom and sustainable development. There must be serious and concrete steps for the reconstruction of system engineering and scientific information and technological Sudan.

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