Science and Technology Information Services and Systems in Africa: Revised Edition (1990)

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Science and Technology Information Services and Systems in Africa

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National Research Council

Revised edition

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NOTICE: The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the committee responsible for the report were chosen for their special competence and with regard for appropriate balance.

This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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The Board on Science and Technology for International Development (BOSTID) of the Office of International Affairs addresses a range of issues arising from the ways in which science and technology in developing countries can stimulate and complement the complex processes of social and economic development. It oversees a broad program of bilateral workshops with scientific organizations in developing countries and conducts special studies. BOSTID's Advisory Committee on Technology Innovation publishes topical reviews of technical processes and biological resources of potential importance to developing countries.

This report has been prepared by a panel of the Board on Science and Technology for International Development, Office of International Affairs, National Research Council. The activity was funded by the Carnegie Corporation of New York.

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Preface

Economic development in Africa will depend heavily on the development of the information sector. Countries will need the ability to communicate efficiently with local and overseas markets to determine where they may have comparative advantages for supplying their products to consumers or to purchase essential imports, based on current prices and services. Many of the economic development problems facing African countries have scientific and technological components that will require solutions to be developed in Africa by African scientists. It is thus essential that they obtain the means to carry on the necessary research and development and to provide realistic policy options to their governments and society. Lack of information is a critical constraint.

Because of the relative isolation of many African scientists, they depend to a greater degree than scientists elsewhere on obtaining information from outside the continent. African countries and their scientists are also suffering currently from a chronic shortage of funds, particularly hard currency, for purchasing books, periodicals, and subscriptions to international sources of information. This makes their problem of accessing information and the possibility of applying innovative solutions especially challenging.

This report is based on a BOSTID activity undertaken with financial support from the Carnegie Corporation of New York, in cooperation with the National Technical Information Service, the Library of Congress, the University of Guelph, the American Association for the Advancement of Science, the African Academy of Sciences, the International Centre for Insect Physiology and Ecology (ICIPE), the International Development Research Centre (IDRC), the International Council for Research in Agroforestry (ICRAF), the African Regional Centre for Technology, the African Development Bank, Ghana's Council for Scientific and Industrial Research, the University of Sierra Leone, the University of Ibadan, the University of Zimbabwe, the Zimbabwe National Research Council, Addis Ababa University, and others. (See Appendix A.)

The BOSTID panel reviewed recent African experience in strengthening scientific and technical information (STI) capabilities through innovative uses of information technologies or through the introduction of new information services. Three teams of two people each visited seven African countries: Senegal, Cote d'Ivoire, Ethiopia, Zimbabwe, Ghana, Nigeria, and Sierra Leone. The entire panel then visited Kenya. The purpose of these site visits was to identify centers of excellence that might serve as models for other African organizations, determine the levels of involvement of the donor community, and assess ongoing and future information needs of these centers. Local STI specialists were invited to participate in the assessment and to serve as local counterparts in helping to organize the site visits and gather information.

At the conclusion of the site visits, BOSTID staff, panel members, and the local specialists met in Nairobi to prepare this report, which discusses the key issues facing governments, donors, and STI user communities and makes recommendations for future development of STI. It describes the findings of the site visits and of the Nairobi meeting, then describes some trends in the information sector that may have potential impact on the development of STI services in Africa.

We acknowledge the assistance of Dr. Patricia Rosenfield of the Carnegie Corporation of New York, the time and effort donated by the panel, Jane Bortnick, John Black, and John Hounsell, the special assistance of Akin Adubifa, who served as a consultant to the project and was responsible for many of the local arrangements in Africa, and of the reviewers Rob Schware, Lee Burchinal, and Vladimir Slamecka. During the course of this activity, we depended on the expert advice of many people. Rather than acknowledging them individually here, their names and addresses are given in Appendix B, which by itself stands as a useful database of those involved in this growing field. Finally, we acknowledge the able assistance of our colleagues Pamela Gamble and Susan Piarulli.

Wendy D. White
Michael McD. Dow

Washington, D.C.
September 1, 1989

A note about this revised edition

This report was reprinted in April 1990. While some new text was added, the reprint, for the most part, contains only corrections and clarifications. The efforts described in the report are continuing thanks to a renewal of the grant from the Carnegie Corporation of New York. We encourage readers interested in joining the growing STI network in Africa to contact us. You can reach us in any of the following ways:

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We look forward to hearing from you.

Wendy D. White
April 1990

Contents

Glossary of Acronyms

AAAS	American Association for the Advancement of Science (USA)
AAS	African Academy of Sciences (Kenya)
BOSTID	Board on Science and Technology for International Development (USA)
CD-ROM	Compact disc, read-only memory
CGIAR	Consultative Group on International Agricultural Research (USA)
CIDARC	Centre d'Information et de Documentation des Regions Chaudes
CODESRIA	Council for the Development of Socioeconomic Research in Africa (Senegal)
CRAT/ARCT	African Regional Centre for Technology (Senegal)
FAO	Food and Agriculture Organization of the United Nations (Italy)
ICIPE	International Centre for Insect Physiology and Ecology (Kenya)
ICSU	International Council of Scientific Unions (France)
ICRAF	International Council for Research on Agroforestry (Kenya)
IDRC	International Development Research Centre (Canada)
INTELSAT	International Telecommunications Satellite Organisation
ISIS	Integrated Set of Information Systems
ISNAR	International Service to National Agricultural Research (Netherlands)
ISRA	Institut Senegalais de la Recherche Agricole (Senegal)
Micro-CDS-ISIS	Microcomputer version of ISIS
MIS	Management Information Systems
MS-DOS	Microsoft-Disk Operating System
NRC	National Research Council (USA)
PADIS	Pan-African Development Information Service (Ethiopia)
PC	Personal computer
PTT	Posts, Telephone, and Telegraph
RAM	Random Access Memory
S&T	Science and Technology
SITA	Societe Internationale de Telecommunications Aeronautiques
STI	Scientific and Technical Information
TCDC	Technical Cooperation among Developing Countries
TWAS	Third World Academy of Sciences (Italy)
UNESCO	United Nations Educational, Scientific, and Cultural Organization (France)
UNIDO	United Nations Industrial Development Organization (Austria)
USAID	United States Agency for International Development (USA)
WORM	Write-once, read-many times optical disc

Executive Summary

Many information projects are currently underway in Africa. Information specialists are initiating new systems, purchasing new personal computers and software, and benefiting from improved telephone connections. There is a strong interest among governments and technical assistance agencies in improving scientific and technical information (STI) services. Some African countries have active projects that are proving that much can be accomplished with relatively simple and inexpensive technologies. These technologies do not replace traditional library and documentation services, but complement and enhance their ability to overcome some of the critical constraints limiting access to information.

Several trends are coming together that give the African information or communication professional unprecedented opportunities to develop innovative and effective information systems. The link between information and communications and economic development has been more clearly established and, throughout Africa, and indeed the world, there is an evolving recognition of the importance of networks and of linkages among institutions, countries, researchers, and other players in the information exchange process. Many of the latest information technologies appear to be custom-made for developing country situations. CD-ROM, desktop publishing, and electronic messaging and conferencing are already being used in several countries in Africa. Where these technologies have been accepted, their benefits can be seen. Now these benefits need to be consolidated, the technologies need to be integrated into networks, and long-term cost recovery issues need to be worked out.

This is not to say there are not problems associated with developing new STI services but in many instances these can be described as "last mile problems". The "last mile" is, for example, the want of a reliable local connection between a research institute and functioning telephone system. More figuratively, it can be the money required for a few journal subscriptions to make a newly-built library a functional institution. In practical terms it can be the lack of agreement between the minister in charge of the PTT and the scientific community to develop policies and pricing strategies that would promote access to electronic networks for research. Some of the problems preventing the development of African STI networks are:

- Shortage of funds;
- Communication difficulties;
- Shortage of trained personnel; and
- Absence of an enabling environment within which effective STI systems can be built.

These broad problems make it difficult for African information specialists to successfully formulate and execute STI projects. They often lack:

- Information about information services and technologies;
- A "computer culture" and, therefore, a support network;
- Compatibility among systems;
- Support for the acquired hardware: simple peripherals, paper, or toner are expensive and hard to find; and
- Easy-to-use, and affordable software.

Despite these limitations, the BOSTID panel site visits identified some successful grassroots projects. Dedicated information specialists are providing excellent services to targeted groups of users. As these projects achieve recognition from the local community, it becomes clear that these programs have many beneficial impacts. For example, library and information professionals are not often accorded a high status but, once these professionals begin to work with new technologies, their status is increased. By being in a position to provide better service, the information specialist is able to interact with the requestor on a professional level. Using information technologies in an "everyday" setting demonstrates to the users that these technologies need not be feared, that instead they can be manipulated to give the user the information wanted. A successful demonstration project pulls people into the information center and thus encourages them to take advantage of the resources. It even encourages the users to ask more sophisticated questions.

The projects visited by the BOSTID panel are exploiting the materials and resources already existing in their countries. Because the information systems make it easier to identify relevant publications, the information specialists are encouraged to pool resources, build cooperative bibliographies, and continue to improve access programs. The information specialists involved in these projects are building an experiential base that will be useful in future projects.

Among the many new information and communication technologies, several are generating a substantial amount of interest in Africa and these do seem to be the most appropriate in answering the difficulties discussed during this activity. The BOSTID panel members were asked repeatedly to describe desktop publishing, CD-ROM, electronic mail and computer conferencing, and database management systems.

African colleagues with whom the panel members discussed information services and technologies during the site visits consistently and continually urged that a specific fund for small projects be established by the donor agencies. They listed the following as types of projects for which they would like to receive funding:

- Pilot projects that allow for experimentation and demonstrate the use and costs of CD-ROM, desktop publishing, electronic mail and computer conferencing, and software development using personal computers and off-the-shelf database management software.

- Training programs--both for information providers and for organization directors and managers. This training should include broad overviews of microcomputers and networking, as well as consciousness raising about the importance of information.

- Experiments with the "last mile" problem; that is, the inclusion of rural or distant communities in the communication and information network via packet radio or other technologies.

In developing these projects, the workshop participants urged that the projects be defined according to the societal needs for the information product or service being proposed. They would like to see more research on how to conduct user surveys before an information service is proposed. They would also like assurance that new services are being defined following sound systems management practices; in other words, the integration, growth potential, and flexibility of the system must be considered and understood. At the same time, the delivery of the information service or product must be considered. Information service marketing programs are of critical importance so that existing and proposed services can be promoted.

Following are the major conclusions reached by the BOSTID panel after discussions during the site visits and during the Nairobi workshop.

The successful implementation of science and technology information systems and services is based on the convergence of a range of disciplines. These include computer science, library science, communications, publishing, and management.

Certain information and communication technologies hold immediate promise for improving STI systems and services in Africa.

- Because of its low cost, durability, vast storage potential, ease of use, and the fact that it by-passes telecommunications problems, CD-ROM seems to provide answers to a number of developing country difficulties, particularly access to bibliographic and full text material.

- Desktop publishing offers an attractive means of producing textbooks and other scientific material of interest to a limited audience.

- More reliable and less expensive telecommunications will allow for the broader application of electronic mail and computer conferencing for information exchange among local, national and regional centers.

There is inadequate information available in Africa about information technologies, their costs, and the advantages and disadvantages for certain applications.

Many different interventions are needed in order to help individuals and institutions establish information services, adapt new technologies, and create an informed user community.

A shortage of funds, lack of trained personnel, lack of an enabling environment, and technological problems all impede the development of STI networks. A friendly environment for the development of information networks needs to be established. This will require training programs for managers and users alike, projects that promote the understanding of the value of information to economic development, and the formulation of national policies that encourage and support the growth of the information sector.

Suitable software for many African STI applications does not exist or is not fully exploited.

- There is a need for native-language information processing. Users need access to generic native-language software interfaces that allow them to access and manipulate information in native languages and scripts.

- Management Information Systems are important tools through which developing country governments and institutions can improve the cost effectiveness of their operations. Their use in the planning, management and implementation of scientific programs should be encouraged as a parallel, and linked, aspect of STI systems.

The building of indigenous databases needs to be encouraged, not only for the use of an individual institutions, but also to serve as a basis for sharing information.

Recommendations

The BOSTID panel agreed that a joint African/North American expert committee should be established to promote cooperation in the development of STI services and systems in Africa. The expert committee should be responsible for the following types of activities.

Organization of networks among African scientific and technical information centers by providing:

- Assistance with systems design, including objectives, policy, economics, management, marketing, operations, training, as well as choice of suitable technologies;
- Help in defining needs for information products and services;
- Technical assistance and trouble-shooting, by arranging short expert visits;
- Training, including travel for African personnel to learn and see new systems and visits by trainers from North America or Europe;
- Monitoring of new STI-related projects; and
- Information about information services and technologies, serving as a link for the dissemination of information about software, equipment, training opportunities, and new projects.

Discussions with the U.S. national committees of the ICSU constituent unions, the professional associations, and publishers of the major scientific journals about the need for a regular transfer of full text journal material of particular interest and relevance to African researchers.

Since journal availability is potentially responsive to technological solutions, such as CD-ROM, the expert committee should explain how these technologies are currently being used in Africa. The program should collaborate with the African Academy of Sciences, AAAS, and TWAS in promoting their journal and national library collection programs.

Assistance to information specialists and others with small grant project support for information technology development and acquisition.

Small amounts of funds to complete a system or seed money to build on to an existing one can be highly leveraged and, therefore, a small grants mechanism that would allow African information specialists to "go the last mile" is needed. The committee should also have at its disposal a peripheral and software fund to use in solving some of the more immediate problems encountered.

Advice and assistance in creating the enabling environment needed to promote the further development of the information sector in Africa. The committee should undertake projects that increase the awareness of the importance of STI to economic development. These might include:

- Assistance with the development of national information policies and development plans;
- Discussions with government officials about the need to offer reliable communications systems, such as packet-switching networks;

- Assistance with native-language information processing and the development of software packages that provide familiar user-interfaces;

- Assessment of the possibility of local manufacture of peripherals and supplies, such as diskettes, cables, paper of suitable quality, toner, and ink; and

- Encouragement of computer user groups and networks through which knowledge, experience, and assistance can be offered and shared.

Networking of STI experts, users, and producers throughout Africa in order to share experiences and methodologies.

Following implementation of a number of small projects, it would be appropriate to bring together the specialists and the government officials at the country level to review experience, raise consciousness, and suggest policy changes. There is continuing need for conferences, workshops, or symposia for policymakers, information specialists, and users to underline the importance of information to national development, identify the problems encountered when implementing STI networks, and share examples of innovative information services based on applications of new information and communication technologies.

Chapter 1

Status of Scientific and Technical Information Systems and Service in Selected African Countries

Introduction

Modern society depends on information. "Information is a resource, and like other resources--oil, ore, crops--its value can be enhanced by processing. ...Unlike other resources that are finite in supply and easily exhausted if used imprudently, the amount of available information tends to increase over time, often at a geometric rate. As the reserves of information grow, so does the need for more efficient means of processing it. The sheer quantity of raw data now available in areas such as agriculture, business, energy resources, and government is well beyond the ability of the human mind to process, at least within a reasonable time."[1]

Computer technology makes it possible to collect, store, manipulate, and transmit information about all kinds of things--banking and business transactions, government records and statistics, or medical and other technical information. Until recently, however, the computer was affordable to only a few. Only in the last decade, with the introduction of microcomputer-based technologies, has the cost of owning and operating a computer decreased. Because of their low-cost and flexibility, microcomputers are penetrating regions and sectors where computer use had not before been known.

Microcomputer-based technologies and associated software programs offer a broad range of applications for solving some of the problems related to information management needs. Their very availability, however, imposes in turn the need to develop a viable information services sector that can use the technologies effectively, provide ongoing maintenance and support, and generate enough demand for, or interest in, the service to sustain the recurrent costs.

Many developing countries, particularly in Latin America and Asia, are taking advantage of these technologies to support economic and social development. Brazil, India, and Indonesia have launched their own telecommunications satellites, and other countries are using modern electronic information management systems in their public and private sectors. In Africa, however, the adoption of information and communications technologies has proceeded more slowly, due in part to the severe economic crisis that most African countries have experienced in the last decade. New and innovative approaches are needed to provide effective support for mechanisms that would promote real and lasting development in Africa.

In this context, there is broad interest among governments and donor agencies in following the evolution of the information sector in African countries to ensure that their assistance is providing the most suitable services and technologies and solving information system problems rather than adding to them. Many organizations have seen opportunities in the new technologies now available at reasonable cost: microcomputers; modems; compact disc/read-only memory (CD-ROM) or videodisc storage/retrieval equipment; and the associated software by which the electronic information can be stored, edited and manipulated, and transmitted locally and internationally. Among these organizations are those of the United Nations family, particularly UNESCO, FAO, and UNIDO; donor organizations, including the World Bank, the International Development Research Centre, USAID, and other bilateral donors; and private foundations. The Board on Science and Technology for

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[1] National Research Council (1986) *Microcomputers and Their Applications for Developing* Countries. Westview Press, Boulder, Colorado. p. 1.

International Development (BOSTID) of the U.S. National Research Council has undertaken a number of science and technology information systems activities, including most recently a series of international meetings on applying microcomputer technologies to development. The field of information technology is evolving rapidly, and there is need to continually monitor and evaluate opportunities offered by new developments in the information industry.

The panel appointed by the National Research Council made short but intensive site visits to the following countries: Cote d'Ivoire, Ethiopia, Ghana, Nigeria, Senegal, Sierra Leone, and Zimbabwe. They also met in Kenya where a final workshop was hosted in part by ICRAF, ICIPE, and IDRC. During the site visits and the Nairobi workshop, the panel held discussions with a wide range of users, managers, and planning officials involved with STI applications to learn the nature and scope of their activities, the kinds of innovation required to operate systems or to avoid problems, and their own perception of the potential of new services and technologies to contribute to future STI needs.

While it is not surprising that there are common infrastructure problems and constraints to developing and using information systems, it is significant that isolated pockets of modern, functioning systems do exist in the region, proving the technical feasibility of establishing and managing such systems. (See Appendix C for the site visit reports.)

Economic Overview

In Africa, the shortage of foreign exchange for purchase of imported computers and other equipment, the relative lack of trained personnel, and the lack of adequate investment in the communications infrastructure in many countries has left the continent lagging behind Asia and Latin America in using information technologies in commercial and public sectors. Most African countries are agricultural, and many depend on export of agricultural products to earn foreign exchange to import oil and other essentials not produced locally, as well as to repay debts incurred during the oil and drought crises of the early 1970s. Others rely on minerals, many of which also are suffering from depressed world markets. Few countries have a positive balance of trade.

International assistance to African countries has focused to a large extent on supporting the development of food self-sufficiency. This paradoxical situation for agricultural countries has complex origins, involving in any individual country a mixture of causes, including: drought; internal and external conflict; policy disincentives (such as compulsory purchase by national commodity boards); inefficient distribution of seed, fertilizer, pesticides and other inputs; poor marketing; unavailability of credit; inefficient transport from farm to market; and high production costs (often much higher than world market prices) accompanied by artificially low local market prices.

Recent developments have enabled several African countries to improve their productivity. Policy changes have liberated the private sector from inappropriate controls and farmers have responded with large increases in production (though real prices for the products are higher than on world markets). Yet much of this production remains at the primary level, and few countries have been able to diversify their agriculture to insulate themselves from the grip of international commodity markets. (Please see the graphs at the end of this chapter for additional demographic and economic statistics for the countries involved in this activity.)

The recovery of the African economies from their drought, strife, and debt constraints will require increasing attention to the information sector for three purposes:

- To bring research results to farmers and producers;
- To identify and publicize future market opportunities in time for productive investment response; and

- To support the research sector and to provide the enabling environment in which information is managed in the public and private sectors through systems that contribute to increasing the efficiency of business and government operations.

Science and Technology Information Networks

Specific policies for STI networks are generally non-existent in the region, although in a few countries (Egypt, Ghana, and Nigeria, for instance) there are implicit references to STI within the overall framework of national economic policies. In Ghana, where there is no explicit policy on STI, public libraries have been established through legislation in all 10 regions of the country through the Ghana Library Board. In other countries such as Zimbabwe and Kenya, there are Ministries or National Councils for Science and Technology. These bodies advise national STI networks and are expected to stimulate the development of STI, fund STI activities where possible, and cooperate with other relevant national, regional, or international bodies, including donors, to promote the establishment of STI networks and strengthen their use for national development.

Due to the absence of coherent or explicit policy, matters related to STI are handled by a variety of government bodies so that it is unclear whether responsibility lies with the Ministry of Education, Communications, or Science and Technology. This results not only in piecemeal policy formulation but also in the establishment of counterproductive policies by different government entities. There is a need for government agencies to comprehend the vast and varied elements of information systems and the need to perceive STI as a sector since its services and activities essentially cut across many disciplines and are applicable to all ministries. STI, therefore, needs to be seen by policy makers and planners as another important pillar on which the nation's economic activities rest.

Institutional weaknesses, poor economic environments, inadequately trained manpower, cultural and attitudinal values, and generally low levels of technological awareness can work together to prevent development of effective STI networks in Africa. Some of the immediate problems are:

- Low priority given by governments to developing information networks;
- Shortage of hard currency to procure books, journals, hardware, software, and paper.
- Lack of information on appropriate hardware and software for creating systems;
- Lack of confidence in public libraries and other information centers (causing users to create personal collections that bypass institutions);
- Diminishing avenues of publications (thus increasing the accumulation of fugitive literature, that is, literature that is not formally published and therefore difficult to identify and retrieve); and
- Weakening of the important links between users and producers of information.

The current state of African STI networks is a major concern for African scientists and researchers who fear becoming even more isolated. The global information industry, buoyed by the ever-widening horizon of the technological frontier, continues to absorb new developments in processing, storage, retrieval, marketing, and dissemination of data and information, which, in the present situation, the African countries are not always prepared to use. This will simply reinforce the weakness of the information network in Africa unless definite initiatives are taken now to give new capabilities to users in the region.

There is also a need to examine the STI hierarchy as applicable to Africa. In general, there are three main levels that can be addressed separately and to which specific assistance may be possible:

- *The individual level.* Individual scientists obtain the information they require and feed what they generate into the system in a variety of ways. These include informal discussions with colleagues, private subscriptions to journals, membership in professional associations, travel and attendance at meetings, publication in local or international journals, correspondence and telephone, and in some cases, by personal computer and telecommunication with local or international databases, "mailboxes", or computer conferences.

- *The institutional level.* The institutions at which scientists work also obtain information in a variety of ways: by acquisitions of publications; by serving as a focal point for exchange with other institutions, including international databases; by generating newsletters and other publications; and by the activities of professional informatics staff in managing bibliographies, abstracts, and other types of data. Few institutions of this type are to be found in the private sector; most institutions are therefore dependent on governments, international organizations, or foundations as their source of funding. However, the private sector in some countries is rapidly acquiring modern data management technology, which may have a profound effect on the local availability of the technology for other users. There are also a few institutional management systems linked to STI for the purposes of planning, budgeting, and tracking for S&T and R&D activities.

- *The policy level.* STI is provided to top levels of ministries by designated departments or special units, such as statistical units. They receive local information generated by their own and other institutions. In most cases, there is also a ministry of S&T or its equivalent and a national research council, which serve to "coordinate" S&T activities, both local and international. There is thus intra-ministry and inter-ministry data flow for the purposes of both scientific information and project management. In addition, this information is increasingly required for satisfying donor agency requirements and to feed a growing private sector.

At present, these systems are under severe strain in many countries because of the consequences of the economic problems of the past 15 years. Countries are hard-pressed to feed growing populations and provide necessary social services, but their foreign earnings are still earmarked for debt payment and oil importation bills. There is little foreign exchange for purchasing books or subscribing to periodicals or international databases.

Scientific Communication

> Information technology and communication are related. Without IT, the means to communicate beyond the interpersonal level would be impossible. With radio, television, newspapers, satellites, and computers, information can be exchanged worldwide and communication facilitated. IT is the machine, communication is the product; IT is the means, communication the result; IT is the hardware, communication the software.[2]

Scientific research relies heavily on the ability to communicate; gather reliable data; have access to widely dispersed data and information (including analysis); collaborate on projects; hold discussions, meetings, seminars, and conferences (some of which can be conducted via computer and telecommunication links); and disseminate the results. The pace and complexity of modern research have greatly increased the communication needs of researchers and scientists and their institutions. These needs are most sharply felt in the

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[2] Stover, William James (1984) *Information Technology in the Third World: Can I.T. Lead to National Development?* Westview Press, Boulder, Colorado, p. 3.

African region where basic information processing tools are often absent and the irreplaceable regular contact with available experts in the field is becoming increasing difficult.

African information specialists are recognizing that the information sector is growing rapidly, perhaps at a pace that far outstrips their own capability to participate effectively. They also have a clear understanding of the major role that computers and computer networks are playing in this rapid growth. Therefore, they accept that African practitioners need to master computer-based skills if they are to prevent an increasing isolation of their scientific communities. Indeed, one workshop participant stated that scientists throughout Africa would be greatly encouraged by having ease, speed, and economy of interactive communication with colleagues both at home and abroad. The imperative to create and use various forms of information networks is self-evident. The objective for now, however, is the establishment of suitable and practical procedures for achieving these goals.

Databases

A major concern of African scientists is how to acquire or gain access to the bibliographic databases that form the bedrock of the STI systems. For the African region, databases have at least three general uses:

- Information searches on research already performed to support new research activities;
- Information on science and the scientific community needed for the management of science and technology, for problem solving, and for making decisions about investments in technologies that might meet economic development goals; and
- Information on the evolution of scientific knowledge or the pursuit of science studies (needed particularly by information scientists, science historians, and social scientists).

It is possible to create local databases from the vast body of available material. This requires expertise in subject analysis and indexing, system design, database management, and access to computer hardware. The IITA library, for example, has developed an integrated database system that handles acquisition, cataloging, and circulation processes. It was implemented in BASIS A on a network of three VAX computers. The database can be accessed by more than 60 terminals and microcomputers all over the institute. But such a system could not have been installed and effectively used without the strong financial support of donors and institute sponsors. Software products, such as Micro CDS-ISIS (described more fully in Chapter 3) are extremely helpful in database development. This particular software was being used in many African institutions to create lists of book and journal holdings that were then being shared with other information centers in the area. IDRC emphasizes the importance of recognizing and using indigenous information:

> Putting indigenous as well as outside knowledge within reach of the people would allow them to fit the information into their systems to address their particular problems. Attempts to tap indigenous knowledge are thwarted by fixed perceptions of development objectives, negative attitudes toward people in marginal or disadvantaged circumstances, and fragmentation of services. Another constraint derives from the fact that farmers and marginal peoples explain what they do in cultural terms that seldom correspond to the views of the western scientific world or to the standard methods for paradigm changes, as currently understood. Local community knowledge is too often disregarded by others, especially scientists and administrators, and its

pragmatic basis in experience in overlooked. This knowledge and experience would effectively enhance any adaptation of new methods and systems.[3]

It is also possible to access databases from abroad. Since foreign-produced databases do not generally give adequate coverage to research efforts in developing countries, one cannot depend on such outside sources for all the current awareness services needed to keep African scientists and researchers abreast of local developments in their subject fields. The cost of international online access and local telecommunication problems also create difficulties. Access to international databases using CD-ROM technology (described in Chapter 3) will alleviate many of the problems now associated with online database access.

Development of and access to databases, therefore, is an area worthy of greater and more urgent consideration for both the African practitioners and the donors.

STI Users and User Needs

The term "STI" is often applied in a rather wide sense to cover several kinds of information, including those relating to:

- Research in both natural sciences and social sciences;
- Specific know-how and operational techniques; and
- Socio-economic indicators.

Since STI users in Africa have limited access to existing information due to a variety of infrastructural and institutional obstacles, the number of users does not appear to be growing at a rate commensurate with the growth of the information industry. A wide range of professions are participating in STI-related work but workshop participants identified these user groups as the most active:

- Staff and students of universities, colleges, science schools;
- Policy planning staff of government ministries and departments;
- Staff of research institutes;
- Staff of industrial and commercial enterprises;
- Commercial and scientific industries;
- Health personnel and other practitioners; and
- Farm extension and related workers.

Because of the undeveloped level of STI consciousness, the needs of users are not well understood. There is some perception that acquisition of computers and other modern information equipment will improve the communication process, but sometimes recipients seek computers before they decide on how they can be most effectively applied. Too often effective use of existing systems is not being made. It is significant that in several institutions, both computer centers and libraries exist, yet they do not seem to appreciate each other or collaborate to take advantage of their natural complimentarity. Another problem is the absence of an information-sharing culture among users. This creates a definite limitation on what can be achieved in developing an effective STI system for researchers. The situation calls for programs and activities that promote sharing and collaborative activities in the STI area.

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[3] International Development Research Center (1989) *Sharing Knowledge for Development.* IDRC, Ottawa, Canada, p 21.

Some Problems and Constraints in the Development of STI Systems

Fragile African economies cannot support the high cost of importing all information services and technologies. In order to foster the development of an indigenous information sector, several key constraints and obstacles must be recognized. The following issues were addressed by the workshop participants:

Shortage of funds

All countries are experiencing fiscal shortages. In most Anglophone countries there is a critical shortage of foreign exchange, which limits the purchase of goods and services from abroad. In most Francophone countries, this is not a direct problem since the CFA franc is freely convertible into French francs. However, competition for imported items in short supply, such as computer hardware and software, has driven prices to levels that largely place them beyond the reach of institutions, unless they are receiving assistance from abroad or are tax-exempt. High tariffs are placed on imports because policy makers feel that corporations will buy them anyway and for others they are "needless luxuries."

As a result, libraries have suffered terribly, and many have all but given up trying to keep up with subscriptions to foreign journals or to acquire foreign texts. One Nigerian university library has been unable to subscribe to international journals since 1983.

Communication problems

Maintenance of the telecommunication systems has suffered. In many countries it is often easier to telephone internationally than across the capital city, since the international service is usually the most profitable part of the PTT service. The PTT systems in most countries still operate on the basis that they make their profits from international calls and from their services for a small number of large subscribers at relatively high cost, rather than from a large number of small local subscribers at low cost.

World Bank experts estimate that the telecommunications sector in Africa has to grow at an annual rate of 20 percent for the next two decades, or double the average growth of the past two decades, to reach the average state of service currently available in Europe. They voice concern that the attractive international links will continue to favor large users rather than support the upgrading of the "plain old telephone" system. This has important consequences in planning future information sector management. It means, for example, that the applications of telecommunications for international data transmission, including such functions as searching international S&T databases, are likely to lag behind the rest of the world.

There are some hopeful signs. Some countries are using facsimile effectively. There are also reliable private leased lines that are used to provide international and African airlines with computer-linked reservations, baggage handling, and on-board service information. These are contracted to international commercial agencies and are paid for in foreign exchange as a recognized national necessity. Finally, some countries, such as Senegal and Zimbabwe, are offering packet-switching networks that make access to electronic mail networks easier and less expensive. IBM Europe is funding a link to the European EARN network from Cote d'Ivoire. One of the largest Zimbabwean private corporations already maintains a telephone-linked national network.

A chronic shortage of trained personnel

The African information sector has made much progress in acquiring and using new technologies. There is, however, a shortage of trained personnel. As the computer revolution creates the a demand for computer-literate and specialized personnel, more and more people

need to be trained. Training in the broadest sense, including computer literacy and consciousness-raising, is needed at all levels.

African colleagues remarked how the lack of training for senior level managers is limiting the adaptation of newer technologies. The lack of training affects information systems in many ways. It limits the effectiveness with which the new technologies are used. It causes lack of confidence in users and frustrates the "demystification" of information technologies.

The following examples of new training programs were offered by the workshop participants:

- Training programs in computer technologies are being offered at many universities. At the University of Zimbabwe in 1989, undergraduate instruction toward a Bachelor's degree was given to 17 business majors and 50 general science majors (the Ministry of Lands, Agriculture, and Rural Settlement has offered to employ them all).

- At Addis Ababa University, a regional two-year program for East and Southern Africa for training in informatics at the graduate level has received government approval and is expected to begin in September 1990. It will provide facilities for roughly 50 students, or about 20 students per year in addition to those from Ethiopia. The University and the Ministry of Industry also provide training for technicians for government departments but there is much greater demand than they can satisfy.

- In Nigeria, the government trains the staff it hires, but they are soon hired away by private industry.

- In Ghana, training is offered to between 40 and 50 students who are pursuing degrees in computer science at the University of Science and Technology in Kumasi. The University of Ghana also offers courses in computer science to students in various disciplines.

Lack of an "enabling environment"

Perhaps the most serious problem facing African information specialists is the lack of an enabling environment within which they could begin the build an effective information sector. The absence of a nurturing environment manifests itself in the following ways. There is:

- Lack of recognition that telecommunication and information are integral parts of any development project and that at least 10 percent of a project budget should be dedicated to these items.

- Less incentive on the part of researchers to use information services. They may be unwilling or unable to pay for information even though they value the information service. This makes it difficult for successful services to continue without donor subsidies.

- Little understanding of the value of information as compared to more traditional products. Where it is difficult to obtain, it confers power on its holder. In the absence of copying machines or reprints, libraries report massive theft and mutilation of their collections. The concept of sharing information is not well-established due to the generally poor conditions of local collections.

- Declining use of libraries. The deterioration of local collections due to poor storage conditions and lack of foreign currency to maintain journal subscriptions contributes

to the serious underuse of current collections. In some countries the information is actually available in the library but unused because people have little expectation of the facilities.

- Insufficient collection of locally-produced data. The output of a country is not always being captured or deposited in a central location and available to others. The quality of locally-generated material is uneven.

These broad problems make it difficult for African information specialists to successfully formulate and execute STI projects. They are faced with a lack of:

- Information about information systems and technologies. Too often the only source of information is from vendors. Project managers might request and be given older, more complicated or inappropriate technologies because they are unaware of the latest developments.

- A "computer culture" and therefore lack of a support network. If there is no back-up, no documentation, no service, nor any spare parts, users must rely on trial and error. While this has resulted in successful projects, it can be very frustrating. There are few user-groups or sources of objective advice and few magazines directed to users that elsewhere are rich sources of information.

- Compatibility among systems. There is a melange of equipment donated or left behind from project to project. Because of lack of compatibility, systems are more difficult to network, to maintain, or to use for training.

- Support for the acquired hardware: simple peripherals, paper, ribbons, or toner are hard to acquire, or extremely expensive. Very little is produced locally and therefore costs involve scarce foreign exchange. There is an additional markup of imported goods, which is reflected by higher tariffs and increased profits for suppliers.

- Good, easy-to-use software that is adaptable to local conditions. Generic native-language software interfaces that allow easier storage and retrieval of textual information in familiar languages and scripts needs to be developed.

Poor institutional coordination

In some countries there are international and regional information centers that are well-endowed in comparison to local centers. The International Center for Research in Agroforestry in Nairobi, the International Institute for Tropical Agriculture in Ibadan, and the International Livestock Centre for Africa in Addis Ababa are examples of international centers that offer a full range of modern information services. The facilities offered by such centers can be a welcome addition to the national facilities, especially because they can help demonstrate the technical feasibility of establishing and managing high-quality information services.

The coordination among the various information centers needs to be improved. Networking activities of all kinds need to be encouraged in order to share information on existing projects and to analyze the experiences each organization has had with new technologies or services. Such networks might also prove to be effective ways to gain access to information about information technologies. Coordinating bodies that can provide central services to monitor user needs, link members, influence policy makers, and coordinate the activities of a wide range of information networks are needed.

Development of National Bibliographic Systems

As the quantity and quality of African publications increase, it becomes especially important to maintain effective bibliographic control of those publications. The national bibliography, which is the authoritative and comprehensive record of a country's national output, plays a key role in the information infrastructure of and about the country. The absence of a national bibliography "creates a weak link in the information chain which has repercussions far beyond any local constituency."[4]

Although some of the countries presently have no laws or statutes regarding the establishment or operation of STI networks, some governments recognize the statutory need for all documents published in the country to be deposited in some central repository. In Sierra Leone, for example, the Library Board has been designated as the main custodian of such publications and empowered to collect them, but this regulation is not being enforced as the Library Board itself lacks the means of monitoring compliance.

In other countries, even though a National Bibliography does exist, the job of maintaining a list and collecting published documents falls to the national university or other national institution. For example, the University of Zimbabwe medical school library is also the national medical library. The Kenya Agricultural Research Institute possibly has the largest and most complete library on African agriculture anywhere in the world.

Ghana has embarked on a national project called the Ghana National Scientific and Technological Information Network (GASTINET). The network is composed of a national focal point, which is the main coordinating center based at the CSIR. IDRC has provided $200,000 CAD for the focal point. There are also nine sectorial nodes covering the major sectors of the economy--Agriculture, Water, Energy, Health, Communication, Geology, Construction, Industry, and Economics and Commerce. The agriculture sector is being funded by FAO with $90,000 and the energy sector by the World Bank.

The main thrust of GASTINET is to collect, document, conserve, and make available indigenous S&T literature for which a Ghana Science Abstracts Bulletin has been in operation since 1988. This will be computerized along with directories of current research projects, manpower availability, serials holdings, and information and documentation centers.

National documentation centers are important as repositories of nationally-generated information. Their success as providers of national STI services depends on the extent of their resources, staffing, leadership, and relations with other centers and institutions. Where there is strong leadership to develop a system that supports its users and to marshall the resources necessary to keep information flowing to them, this mechanism is productive. Where the role of the national center is neither well understood nor supported by the national political structure, it may be more productive to allow and to support the evolution of decentralized systems focused within major sectors and institutions. While there are obvious economies of scale in centralizing the services, there are also good arguments for allowing well-motivated scientists to develop their own sectorial clusters.

Book and Journal Donation Programs

A number of cooperative arrangements have been organized over the years through which scientists in industrial countries can assist their colleagues in the developing world by contributing back issues of journals and other publications or through which scientific

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[4] Gorman, G.E. and J.J. Mills (1987) *Guide to Current National Bibliographies in the Third World*. Hans Zell Publishers, London, UK.

associations and publishers can donate overrun copies of their journals. There are problems with some of these schemes, however. When books or journals are donated to libraries or other institutions in developing countries, donor-led schemes inevitably result in libraries with collections of small amounts of current, useful information and large quantities of inappropriate, obsolete, and useless information. The books take up space and lead visitors and potential donors to think that the library is well-stocked. This may result in fewer donations of useful material. According to a report of the Advisory Group on the International Campus Book Link, 90 percent of the existing donation schemes are donor-led.

One scheme praised by the Advisory Group is administered by the AAAS with financial support from the Carnegie Corporation of New York, the Ford Foundation, and USAID. The Ford Foundation Grant funds a collaborative effort by the AAAS and the American Council of Learned Societies (ACLS) to broaden social science participation in the program. In addition, both the U.S. Information Agency and the UN Centre for Science and Technology for Development provide assistance by shipping free-of-charge some of the journals.

The AAAS Sub-Saharan Africa Journal Distribution Program provides current subscriptions to U.S. scientific, engineering, and other scholarly journals to 150 university and research institution libraries in 35 countries. The program began as a pilot project of the AAAS Consortium of Affiliates for International Programs (CAIP) in 1985, but since then has grown enormously. At the outset, AAAS and five of its affiliates provided subscriptions to 25 individual journals Today, 89 learned societies affiliated to AAAS and ACLS supply almost 200 journal titles. The AAAS does not view this program as a solution to the problem; rather it is a short-term mechanism to assist African researchers while looking for ways to ensure the continuation of subscriptions beyond the life of foundation grants and other subsidies. Through an innovative plan, the AAAS has introduced a cost-sharing element in some countries through which recipients will pay for highly discounted subscriptions in local currencies. The funds generated will be used to finance scholarly activities in these countries. Thus far, agreements have been reached with Ghana, Kenya, Nigeria, and Senegal.

The Third World Academy of Sciences (TWAS) is sponsoring a similar program, aimed at 43 developing countries, in which the objective is to endow a national library with a complete, updated collection of scientific literature, principally textbooks and journals. TWAS will seek funds from donor agencies, work with publishers to identify the relevant scientific literature and negotiate purchase (or donations if possible) of overrun copies for distribution to the national collections. The principle is that scientists must have some place to go in their country where they can have access to the complete world scientific literature. It is, as it were, a "birthright" of the scientist, as land is to the farmer.

Introduction of New Technologies

Despite the many limitations to the introduction of new technologies, the BOSTID panel site visits identified several successful grassroots projects. For example:

- At the University of Addis Ababa a number of mathematics textbooks are being produced through desktop publishing by the departmental faculty.
- The Chitedze Agricultural Research Institute in Malawi has an operating CD-ROM bibliographic search system.
- The Medical Library at the University of Zimbabwe has recently installed a CD-ROM drive in order to search the Medline database.
- Many of the regional and national systems have the MINISIS or Micro CDS-ISIS bibliographic database systems developed by IDRC and Unesco.

Dedicated specialists are providing information services to targeted groups of users. As these projects receive recognition from the local community, they have many beneficial impacts. For example, library and information professionals are not often accorded a high status in any community but when they begin to work with new technologies their status increases. By being in a position to provide better service, the information specialist is able to interact with the requestor on a professional level. Using information technologies in an "everyday" setting demonstrates to the users that these technologies need not be feared but that they can be manipulated to give the user the information wanted. A successful demonstration project pulls people into the information center and thus encourages them to take advantage of resources. It even encourages the users to ask more sophisticated questions.

The successful projects visited by the BOSTID panel were exploiting material and resources already existing in their countries. Because the information systems made it easier to identify relevant publications, the information specialists were encouraged to pool resources, build cooperative bibliographies, and continue to improve resource-sharing networks. Participants in the Nairobi workshop often spoke of how the effective application of information technologies can have an empowering or "status-enhancing" effect and can serve as a motivating force to provide better information services. Information technologies can help increase users' awareness of the importance of STI services and generate a much-needed support group.

African colleagues with whom the panel members discussed information technologies during the site visits consistently and continually urged that a specific fund for small projects be established by the donor agencies. The Nairobi workshop participants listed the following as types of projects for which they would like to receive funding.

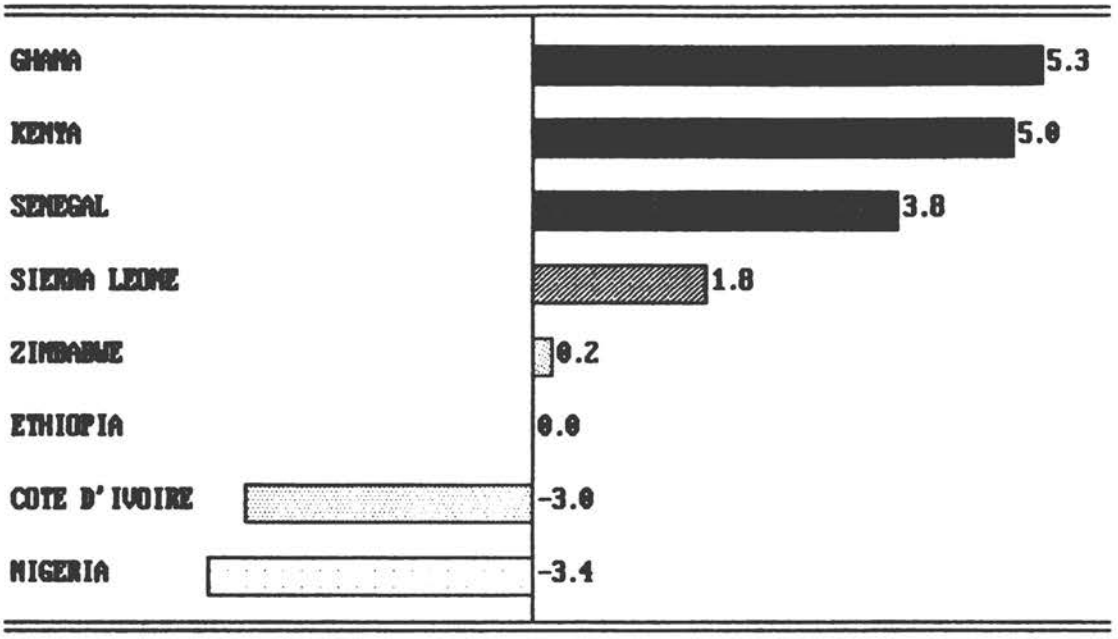
- Pilot projects that allow for experimentation and demonstrate the use and costs of CD-ROM, desktop publishing, electronic mail and computer conferencing, and database development using personal computers and off-the-shelf database management software.

- Training programs--both for information providers and for organization directors and managers. This training should include broad overviews of microcomputers and networking, as well as consciousness raising about the importance of information. Training and education will lead to the demystification of information technologies and more effective integration of the information component into a wide range of programs and activities.

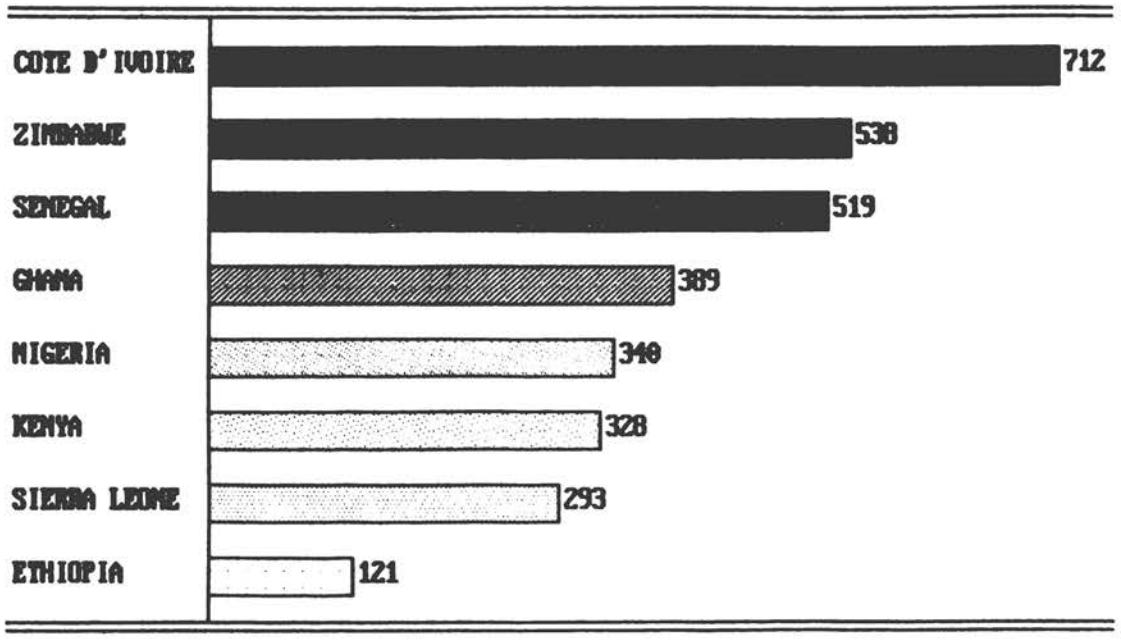
- Experiments with the "last mile" problem; that is, the inclusion of rural or distant communities in the communication and information network via packet radio or other technologies. Experiments should be encouraged with information linkages from central facilities (hospital, medical research center, ministry) to rural information centers (rural clinic, agricultural extension center, local school) and their possible consolidation for recurrent cost recovery.

In developing these projects, the Nairobi workshop participants urged that the projects be defined according to the societal needs for the information product or service being proposed. They would like to see more research about how to conduct user surveys before an information service is proposed. They would also like assurance that new services are being defined following sound systems management practices; in other words, the integration, growth potential, and flexibility of the system must be considered and understood. At the same time, the delivery of the information service or product must be considered. Information service marketing programs are of critical importance so that existing and proposed services can be promoted.

GNP GROWTH
(in percent)

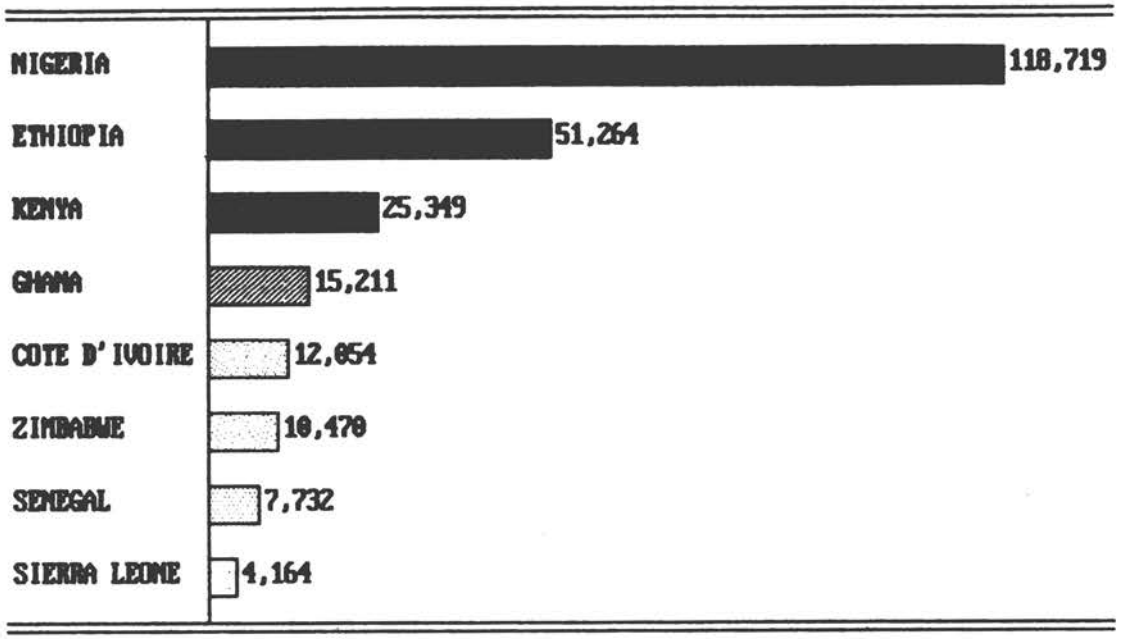


GNP PER CAPITA
(in $US)

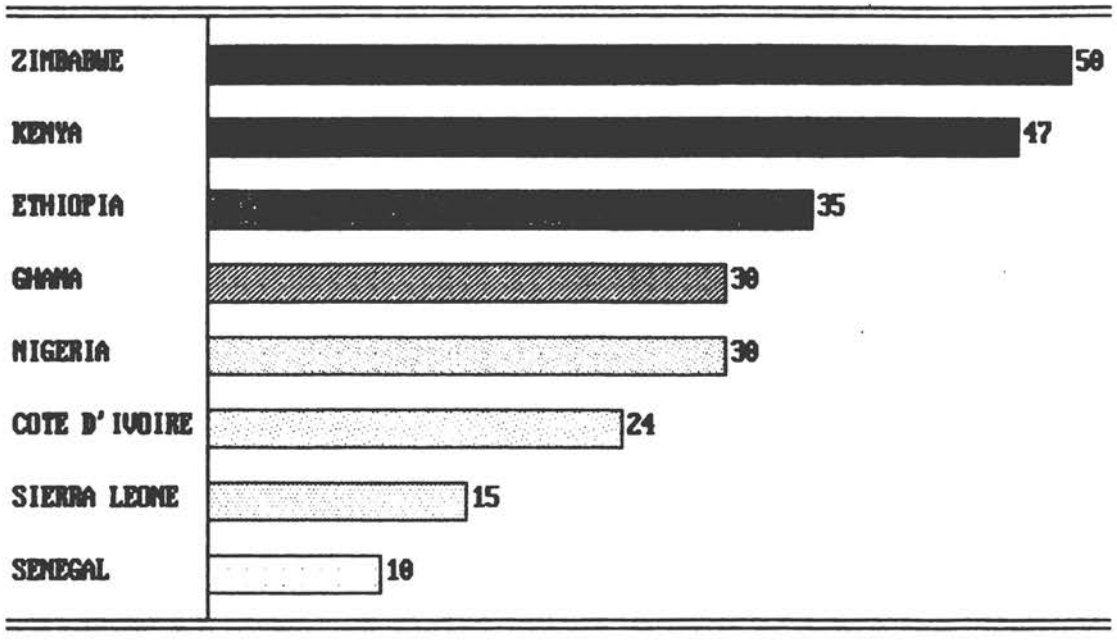


Data Courtesy of PCGlobe 3.0

POPULATION 1990
(in thousands)



LITERACY RATE
(in percent)



Data Courtesy of PCGlobe 3.0

Chapter 2

Framework for Developing an STI System

During the final day of the Nairobi workshop, the BOSTID panel and other participants sought to establish a framework to assist developing countries in planning scientific and technological information systems. The discussion was based upon the individual and collective experiences of the participants as information providers and users and upon the knowledge acquired during the site visits. It was hoped that by identifying the key issues to consider when establishing a new information system, the group might provide some general guidance for information professionals working in Africa. In addition, the framework could prove useful for donors when evaluating grant proposals for STI systems.

The workshop concluded that several steps should be undertaken when designing information systems to ensure that the desired objectives are achieved. These include:

- Identifying the various users of STI.
- Analyzing the different information needs of users.
- Considering current and potential mechanisms for disseminating information.
- Identifying existing constraints.
- Evaluating available options.

The Users

A prime consideration in the development of an information system must be the ultimate users. Because different users often have different information needs, targeting the intended audience is an essential first step in the process. In some instances, the same information may have value to different audiences as long as it can be reformatted to fit the particular needs of each group. In some cases, the information needs may be so diverse that entirely different materials are required. What seems clear is that no single information system can serve a broad spectrum of users and that access to a combination of clearly delineated information sources may prove most beneficial. As a result, special attention needs to be paid to making access to systems as transparent to the user as possible and to establishing some common standards that will allow greater interconnectivity among systems.

The workshop participants identified a wide range of potential individual users of STI. These include: government policy makers; information providers, including librarians and managers of information systems; academic researchers; technicians; farmers; and consumers. In many instances, these individual users receive information from the institutions they are affiliated with and therefore the participants believed it important to identify the corresponding institutions. These include government ministries, libraries and information centers, universities and research institutes, business enterprises, and communities and villages.

The Needs

Once the end users and related institutions have been targeted, the next step involves identifying specific information products that would be most valuable to them. For example, farmers, research scientists, and officials of the Ministry of Agriculture might all be interested in the latest discoveries for eradicating pests. However, the ministry official would want information to help understand what the impact might be on the country's crop production, while the scientists would require original data and findings upon which future

research could be based, and the extension worker would need information to determine how these discoveries might be applied in specific settings. An understanding of the types of information and the specific formats by which that information should be packaged would be most useful to the different users of scientific and technical information and should provide the basis for designing systems with a greater potential for success. IDRC concludes:

> Sometimes information has to be repackaged or consolidated before delivery to specific target audiences. For example, published results of scientific and technological research on agriculture, health, the environment, economics, etc. must be repackaged to be understood by administrators, policymakers, extension workers and other intermediaries, or farmers. Prepackaging of written materials may be in audiovisual or other nonprint forms. Oral traditions are a strong link in the information chain in Africa, and they have potential for disseminating information on health, sanitation, and farming methods. The aim is to use all types of media in innovative and appropriate ways to reach the end users.[5]

Dissemination Mechanisms

The next step in the process involves assessing what might be the most effective mechanisms for transferring information. Within this context, there was much discussion about how new technology-based approaches for handling information (CD-ROM, desktop publishing, telecommunications, for example) might be applied. Here again the participants stated that it is important to consider the different ways various users acquire information and perform their jobs. Informal mechanisms for exchanging information are often extremely effective and there was a consensus that such things as casual contact among colleagues should be supported together with more formal systems. For example, many of the participants believed some of the new technologies (facsimile, electronic mail, computer conferencing) would provide new methods for encouraging collegial contacts on a regular basis. Access to databases and journal literature was considered a high priority for getting needed information to universities and research centers. Other approaches, including extension services and demonstrations, were considered more effective for disseminating information at the community level.

Existing Constraints

The workshop participants concluded that for each category of users, existing constraints would need to be considered when analyzing various options for improving access to STI. An understanding of the barriers that prevent users from receiving needed information would prove valuable when considering which new technologies hold particular promise and what innovative approaches might be successful. The participants discussed a number of constraints and options for each category of STI users. Below are highlights of the items identified.

- Lack of understanding of the value of quality information services to support decision making.
- Lack of coordinating mechanisms at both the regional and national level.
- Lack of information about national STI resources.

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[5] International Development Research Centre (1989) *Sharing Knowledge for Development: IDRC;s Information Strategy for Africa.* IDRC, Ottawa, Canada.

- Lack of management information systems to assist in tracking data and setting priorities.
- Inadequate telecommunications infrastructure.
- Lack of sustained, adequate funding, particularly foreign exchange for acquisitions.
- Lack of trained personnel, coupled with few professional rewards.
- Poor library facilities, including a lack of technology and limited holdings.
- Lack of affordable, easy-to-use software and access to peripheral supplies.
- Lack of contact with end users.
- Inhibiting government policies.
- Lack of STI tailored to specific user communities; for example, businesses do not have information on patents, while consumers do not have product information.

Available Options

- Provide "consciousness-raising" for senior level policy makers regarding the importance of STI.
- Establish a national coordinating/advisory body.
- Inventory national STI resources.
- Introduce effective management information systems.
- Allocate resources to upgrading telecommunications.
- Seek external support for projects to introduce new technologies, such as desktop publishing of textbooks, bibliographic systems, or CD-ROM.
- Improve coordination and networking with other institutions.
- Collect local information suitable for publishing; save material collected in electronic formats for future distribution.
- Establish training courses for all levels of STI users, including policy makers.
- Develop innovative dissemination linkages with end users in local businesses, rural clinics, or agricultural extension services.
- Improve links between government, industry, and academia.
- Establish laws, regulations, and policies that encourage adoption of new information technologies.
- Establish outreach programs in libraries to introduce users to new information technologies and available information resources.
- Improve access to information about technology options.

- **Establish better methods for collecting fugitive literature and making it available to a broader audience.**

The group concluded that perhaps the most pervasive problem for all sectors was a lack of training and that projects undertaken to introduce new technologies must include adequate training. Workshops, seminars, computer-based training, improved documentation and manuals could contribute to alleviating this problem. Whatever training approaches are pursued, however, the participants strongly stated the need to tailor them to fit local requirements and reflect the needs and particular environment within Africa.

Chapter 3

Information Technologies and Their Application in Africa

As the need to record and produce information expands, so too does the need to collect, manage, and disseminate that information. Information technologies, such as microcomputers, telecommunications, and high-density storage devices, are having a major impact on the way information is handled. Because technologies are becoming both more efficient and less costly, the opportunities for developing country applications have never been greater. In this next section, we will review those trends that appear to have the greatest relevance to Africa: desktop publishing, CD-ROM, telecommunications, and software development. Following brief descriptions of these trends, we will discuss their relevance to the African situation.

Trends in Information Technology Applications

Desktop Publishing

Desktop publishing is the product of technological advances in personal computing, print graphics, and computer-generated typography. It synthesizes the capabilities of typesetting, graphic design, book production, and platemaking in one integrated, cost effective hardware and software configuration.

Desktop publishing allows the operator to combine text and image files, manipulate those files, and format the resulting page--usually using a "mouse" and a microcomputer. The operator can select different typefaces and type sizes, can format the text in several columns, and can run text around graphic images. With a high resolution monitor, the operator can then see exactly what the page will look like before the page is printed. (What You See Is What You Get, or WYSIWYG, has become one of the key advantages to desktop publishing.) The page can then be sent to a laser printer for inexpensive page proofs or to a typesetting device for final printing.

Desktop publishing software is becoming more sophisticated and accessible. Many programs allow for simple operations appropriate for newsletters, proposals, or announcements. Other programs allow for book-length formats and give the operator a high degree of control. The skills required to operate this software at a professional level are not always easy to learn. The difficulties of obtaining good design, typography, and layout are not at all diminished by desktop publishing software. Indeed, as one participant pointed out, one of the costs to consider when proposing a desktop publishing system is that of "creative time-wasting." Due to the flexibility of most systems, one can create virtually limitless designs and layouts for each and every page.

CD-ROM

CD-ROM (compact disc, read-only memory) is a high density storage medium on which electronic data is etched by laser on to a compact disc[6] master. Plastic copies can be produced from the master. CD-ROMs are very durable; they are scratch resistant because the "read"

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[6] Disc versus disk: two spellings have developed for the round, thin items on which data are recorded. For optical technologies use discs; for magnetic technologies use disks. *Chemical and Engineering News*, May 29, 1989, p.22.

head of the CD-ROM drive does not touch the disc. They do not warp as easily as floppy discs and, since the data are etched onto the discs, they are not susceptible to erasure from electric currents or magnetic fields. CD-ROMs offer rapid search response time in respect to the size of the database(s) being searched. A single disc can hold still images, motion video, audio, and digital data. The user has control of the system because rather than being "online with the meter running" the user is searching the system directly, without need to work with a computer department or other intermediary.

The most impressive aspect of the CD-ROM is its storage capacity. A single CD-ROM can store as much data as 1,500 floppy disks or 200,000 printed pages of text. Discs can hold very large databases, such as Agricola or Medline, the full text of an encyclopedia or other reference work, or the full text and images of several years of a scientific journal.

The CD-ROM reader, which can be used in connection with most microcomputers, now retails in the United STates for around $700. CD-ROM archive discs containing, for example, 5 years of the complete issues of *Pediatrics* retail in the U.S. for $295. A CD-ROM of current data is more expensive: Medline and Agricola, for example, cost about $1000 per year. Mastering and replication costs have fallen substantially in the past two years and this trend is likely to continue as the number of products and users increases.

That CD-ROM has captured the imagination of information professionals is proven by the ever-increasing number of products that are available in this format. According to Jean-Paul Emard in the preface to *CD-ROMs in Print, 1988-1989*, CD-ROMs are exciting because of their diverse applications. He states:

> A number of institutions already are using CD-ROMs for catalog processing and/or public access catalogs. A long list of traditional, print-based publishers have placed large reference works on this medium. Online database producers have taken the tack that CD-ROMs are an adjunct delivery system to the 'standard' online products and now are mounting a wide variety of bibliographic, full text, numeric, and graphic databases on CD-ROM.[7]

He goes on to state that 25,000 CD-ROM drives were in use in the United States at the end of 1987 and that projections indicate that the number will reach one-half million in 1990 and go over the million mark in 1991. Because of this demand, the number of products available on this medium will continue to increase. A partial list of currently available CD-ROM products is reprinted in Appendix D.

Another attraction of the CD-ROM is its relatively low manufacturing cost per unit of information. According to the *Chemical and Engineering News* article, "CD-ROM costs about half a cent per megabyte. Paper, at about $7.00 per MB, is 1400 times more expensive than CD-ROM as a storage medium. Floppy disk data cost $1.00 to $2.00 per MB and hard disk information costs $10 to $20 per MB. ... Because of connection charges and usage charges, online services can cost up to $200 per MB accessed."

Telecommunications

As the telecommunications infrastructure in Africa improves, scientists and information specialists alike will find they can use several microcomputer-based telecommunications services. While it may be technically feasible to make a long distance call via satellite, in practice it is much cheaper and easier to establish communication first with a "value-added

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[7] Emard, Jean Paul (1988) *CD-ROMs in Print, 1988-89*. Meckler, Westport, Connecticut.

network".[8] Such networks use "packet-switching", a digital-processing technique that allows many digital "conversations" to share the same channel while providing very high-quality communications. Built-in error checking routines help to maintain the quality of the data being transmitted. The availability of packet-switching networks is critical to inexpensive and reliable telecommunication services. As pointed out in the previous chapter, Senegal now has an operational packet-switching network. SENPAC was used several times by panelists to link with electronic mail and computer conferencing networks in North America and CRAT is using SENPAC to link to a computer conference on STI for development.[9]

Electronic Mail and Computer Conferencing

Electronic messaging is a process of transferring the electronic equivalent of a piece of paper from one location to another, perhaps with copies to several addresses, or even a whole mailing list. After receiving the message, people can then respond, again copying their response to others. One is dealing with discrete pieces of information. Telex systems are a type of electronic mail that have been popular for many years, although the term electronic mail is more widely used when referring to computer-based systems operating on a time-sharing basis.

Computer conferencing systems take electronic messaging several steps further. While they include a private "messaging" module to simulate the corridor or coatroom discussions that often take place at meetings, conferencing systems permit communication among multiple users and allow more flexible treatment of conference comments. In effect, they provide the basis for a location-independent "virtual meeting" with an open-ended database of the contributions to the discussion. Some popular conferencing systems include EIES, CAUCUS, PARTICIPATE, COM, and CoSy.

Computer conferencing provides a means to bridge time and distance to facilitate interpersonal communication. The basic concept of computer conferencing is perhaps all the more powerful and appealing because of its simplicity; in essence it presents the opportunity for as many people as have the need or desire to communicate about a particular subject (or many subjects) to do so without being either physically present in the same location (as in a conventional meeting), or even available at the same time (as in a telephone conference call or a video teleconference).

A system needs the use of data access links (which may be a simple, ordinary telephone or an international packet-switched data network), a computer to act as "host" for the discussion, and a terminal device. All those who wish (or need) to participate in a computer conference may do so, each at their own convenience, on their own time schedule, and from their own choice of location. Computer conferencing provides a low-cost, time and distance insensitive means of communications, incorporating all the features and facilities normally associated with computer-based messaging systems (electronic mail). (For information on managing a successful computer conference see box 1.)

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[8] National Research Council (1986), p. 30

[9] Using the CoSy computer conferencing system, the BOSTID panelists, staff, and advisors are continuing the discussions begun in Nairobi through a computer conference dedicated to the topic of scientific and technological information for development. The conference will grow as others in Africa gain access to the network.

Regardless of the subject of the computer conference, experience has proved that there are a number of factors that contribute to the success of the conference. These include the following points.

- There must be a need to communicate: those involved must have something to say to each other and must be willing to say it and pay for it.
- The moderator of the conference plays a key role in stimulating discussion and the flow of information, and in guiding and, when necessary, controlling the debate.
- Reliable, low-cost, readily-available data communication facilities are essential.
- Participants must have easy access to a terminal, as the systems work best when accessed directly by the participants.
- The host system must be reliable, accessible, and easy to use.
- A communications advisor must be involved who will help the moderator and participants to start the conference process and keep it moving.
- Institutional recognition and support, beyond funding and provision of equipment is needed. Participation in this type of information exchange must be appreciated as being as valuable as traditional forms of scientific communication.
- A leader who is able to fire the imagination of the key participants and funding agencies helps keep the conference moving.

The scientific community can benefit from computer conferencing in several ways. It can lead to:

- A better information flow,
- More continuing and immediate contacts among scientists of like interests,
- More opportunity for wide involvement in discussions and less opportunity for domination by a small number of vocal participants,
- The bridging of some language barriers, as it is generally easier for people to deal in the written form of unfamiliar languages,
- The creation of an ongoing, permanent record of discussions,
- Some reduction in the need for travel,
- Opportunities for professional development, and
- The development of a global network of scientists with a common interest.

Box 1. Tips for a Successful Computer Conference

The direct applications of this very powerful facility include:

- scientific or research communications;
- collaborative research and writing;
- project management;
- data exchange;
- planning groups;
- distance education;
- policy formation; and
- participant preparation for conferences and meetings, as well as post-conference follow-up.

Computer conferencing is a technical reality and is in every-day use in many organizations. However, getting it into place in a new environment can be another matter. Complex economic, social, political, and legal factors will certainly affect the use of the technology and may in some cases present barriers to its successful implementation. Nonetheless, it is certain that many opportunities are present. The challenge is to approach these opportunities with imagination and sensitivity.

Facsimile Transmission

Facsimile transmission (fax) of letters and documents by the telephone system has already become an important mode of local and global communication. Individual pages are scanned into a facsimile devise, digitized, and sent via telephone lines. The receiving equipment reconverts the transmission and prints out a replica of the original document. There has been substantial growth of facsimile equipment and rise in the amount of information transmitted via facsimile. As the price of the equipment becomes lower, small businesses and individuals are finding that they can take advantage of this technology. Dr. Philip Abelson predicts that:

> "... in the not too distant future most scientists will either have a fax or have access to one nearby. ... Fax is cheaper and faster than overnight express. Big business has found that by dispatching documents across the country at times when telephone rates are minimal, fax can be cheaper than first-class mail. Already on some campuses use of fax is speeding internal communications. Scientists engaged in international collaboration with others halfway around the world have found fax a substitute for telephoning at inconvenient hours. Chemists and others wishing to transfer detailed structural formulas find fax a convenient tool. Engineering drawings and spread sheets can also be transmitted."[10]

The efficient use of fax assumes reliable and inexpensive telephone service. Those in North America are much better able to take full advantage of fax than most. Nonetheless, almost every country in the world is using fax machines, and they are a welcome substitute in those countries where the mail is slow or unreliable. (For information on the different types of fax machines, see box 2.) People whose languages use non-roman script can reap additional benefits of fax. Again, according to Abelson, since a page of material in kanji script is as easily transmitted as roman, "half the telephone traffic between Japan and the United States is devoted to fax."

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[10] Abelson, Philip H. (1989) Fax. *Science* 243(4895):1121.

The International Telecommunications Union (ITU) has established standards that divide facsimile devices into groups based upon their speed of operation and the particular analog or digital techniques they employ. The most widely used machines today are Group 3 devices. They can transmit information over ordinary telephone lines at a rate of 15-20 seconds per page with a resolution of 200 dots per inch (dpi). The newest facsimile technology is Group 4, which is designed to work with digital networks. It can transmit at a rate of 3-5 seconds per page and with a resolution of 300-400 dpi. Because it requires special digital communications lines and can only transmit to another Group 4 device, it can be used only in certain environments. Because it is new on the market, the costs ($7,000-$10,000) are considerably higher than Group 3 machines which can cost less than $2000. As a result, it is doubtful that Group 4 machines will be widely used in Africa in the near future.

Box 2. Facsimile standards

As the demand for fax grows, manufacturers are hurrying to add new features. The less expensive machine using thermal paper will soon be overtaken by a laser printing on plain paper. Color transmission with higher resolutions will also become available, as well as the capability to store multiple addresses and perform store and forward operations. Abelson concludes, "We are only in the beginning phases of a revolution in local and global communication that will have substantial impact on how business is conducted and on collaboration in science."

Another method of fax transmission is through fax boards in personal computers. The installation of an expansion board in a microcomputer, combined with appropriate software, and connections to a telephone line enables ASCII documents and PC-generated graphics to be converted to a fax format for sending and receiving. This approach allows for information to be sent or received directly between a microcomputer and facsimile device or another microcomputer with a fax board, where it can be stored, merged with other documents, and printed out if desired. While there are limitations to this approach, it is expected to grow in popularity as the number of personal computers increases.

Software

Software is a major component in any information system and a major cost factor. Indeed, it is likely that software costs will exceed many hardware costs in the coming years.[11] Software for the microcomputer environment has increased dramatically and is now especially useful for word processing, financial management, communications, and database management.

[11] National Research Council (1986), p. 22.

Of all these applications, trends in database management software were of most interest to the meeting participants. Database management software lets one manage information using powerful file systems that can store, sort, search, and retrieve information quickly and efficiently. The software organizes data into records, which are units of related information. For example, one record might consist of the following information about a book: author, title, publisher, and date. Categories of information such as author and title are called fields. With database management software, one can search an entire record or selected fields for specific words and phrases, sort records by multiple criteria, and generate reports.

With the computer revolution came a revolution in database management software. Large databases that could previously be run only on mainframe computers could now be managed on microcomputers with the assistance of such programs as Micro CDS-ISIS, DBase, Paradox, RBase, or Inmagic. These programs combine database creation and management facilities and information retrieval in one package, they are easy to learn, even for people with little or no experience with computerized information systems, and they help establish quality standards for the entry and organization of the data.

Management Information Systems (MIS) were also of interest to the workshop participants. Many management tasks can be aided by automatic data processing. Information systems designed to help improve the performance of management functions can be grouped in a category called MIS. Microcomputers used in conjunction with MIS programs can be a low-cost way to improve:

- the decision-making process;
- information about financial and human resources;
- allocation of resources to accomplish project goals;
- turnaround time for data analysis and report writing;
- planning and scheduling; and
- the quality of data organization and analysis.[12]

Applications of Information Technologies in Africa

During the BOSTID site visits, the panel was impressed to find virtually all of the information technologies described above already in use in some African institutions. To understand why these technologies are being disseminated and adopted so quickly, one must first understand the information situation in most of Africa.

African libraries have been particularly hard-hit in the current financial crisis. In many countries, acquisitions have been almost entirely suspended (unless subsidized from external sources) and aging, deteriorating collections now seldom offer more than out-of-date reading materials for students. One Nigerian university library has been unable to subscribe to international journals since 1983. The Science Faculty at the University of Zimbabwe devotes half of its allocation of hard currency to foreign journal subscriptions. Increasing costs of books and journals make it unlikely that libraries will ever be able to make up the gaps in their collections let alone return to the times when resources were available for purchasing almost any relevant publication. Harsh environmental conditions make traditional storage media expensive for long term purposes and, unless carefully maintained, almost useless.

Because of the increasing cost of current subscriptions and the ease and availability of electronic analogs, in industrial countries much of the library function as a repository of hard-copy bibliographic reference is being taken over by electronic databases In many

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[12] National Research Council (1986), p. 16.

developing countries the quality and cost of international telecommunications may limit the extent to which bibliographic searches of databases in industrial countries can be undertaken. Even as the international system improves, local accessibility may remain a problem, depending on the quality of local telephone connections. Because of this situation, the information technologies described in the previous section hold much promise for African applications.

Desktop Publishing in Africa

To the extent that scientists can organize into professional associations, they will be in a better position to organize local production of textbooks and journals. They will also be better placed to negotiate favorable agreements for information exchange with professional societies in other countries. Local publishing challenges small scientific communities to find good quality material to publish and to maintain the quality and reputation of the product---but it is likely to be worth the effort. Above all, it offers opportunities for providing teaching materials that may have much more relevance for students because the material is selected by authors with local experience. They can draw on local information and use examples that may be more relevant than those in foreign texts.

Where the local market for a given textbook may only be several hundred copies in a given year and local currency availability may not allow prices to be high enough to cover costs, there may not be any incentive for local publishers to produce textbooks. In this case, universities and schools should consider producing their own texts with microcomputers in the relatively small numbers their classes may require. The currently available software permits almost all scientific formulae and technical drawings or graphs to be reproduced with a quality very similar to typesetting. Single copies of texts prepared by this method can then be multiplied by photo-offset printing.

The advantage of this technique is that it allows the author to convert the manuscript into final form without requiring the services of a commercial typesetter. It also permits the text to be stored electronically, corrections to be made, and revisions included very easily and cheaply. New editions can be brought out frequently at little additional cost. It can have the limitation that the author may receive neither recognition for the work nor royalties from the sale of it. Desktop publishing has been used to good effect in several countries:

- Desktop publishing is being used to produce textbooks in Ethiopia, where authors receive a cash incentive to publish in this way.

- This year a joint press consisting of three universities and the CSIR is being established in Ghana. It will use desktop publishing and offset printing to publish local scientific journals and other publications.

- The Institut Senegalais de la Recherche Agricole (ISRA) is making effective use of desktop publishing. Every ten days it publishes data on rain, soil, and general agricultural conditions that have been collected from regional reporting stations. Within 24 hours after the new data have been received, ISRA distributes 70 copies of this statistical information to government officials. The data, presented via easy-to-read pie charts and bar graphs, are in a usable form and delivered in a timely manner thanks to three Apple Computers and a laser printer. Such specialized and rapid service would never have been feasible using traditional publishing practices.[13]

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[13] It is interesting to observe the conditions under which ISRA's desktop publishing program is operating. In a room with no air conditioners and little dust control, the Macintosh network is humming along with no problem. The only concession ISRA has made to local conditions is a power surge protector on each machine.

- The African Academy of Sciences in Nairobi is using both Macintosh-based and IBM-based desktop publishing systems.

Institutions such as these should be encouraged to experiment with desktop publishing, keep close track of costs, and determine how best to employ it. The cost of desktop publishing systems can vary widely. Some systems with high resolution monitors and laser printers can cost less than $10,000. However, with various add-ons, a system can cost as much as $24,000. A word processor, which might cost around $1,000, may be a perfectly adequate option for some users. Training will also add to the cost of installing at system. With all these cost variables to consider, it is important to have a clear understanding of the cost/benefit analysis. As more organizations acquire desktop publishing systems, their help in evaluating the costs and benefits should be enlisted.

CD-ROM in Africa

This technology seems "custom-made" for the problems faced by African information specialists. One machine at a national center (or one per special subject area) could make information available for wide distribution. CD-ROM discs are ideal to mail from a central reference service for frequent extended use by their recipients. They can thus be used to store large amounts of bibliographic information and be easily shipped anywhere in the world. They can be used to store full text medical books, a high school science library, or a tropical agricultural library for use in developing countries.

This technology will substantially improve the provision of low-cost information in Africa and has already been introduced into a number of countries.

- ISRA is contributing information to the SESAME CD-ROM project, a bibliographic system of agricultural research and rural development literature written by francophone scientists. SESAME, which also contains the records of one Belgium company and four French ones, is coordinated by CIDARC.

- Also in Senegal, the university library is using CD-ROM for database searching and both CRAT and CODESRIA have placed orders for readers.

- Malawi has also successfully demonstrated the benefits of CD-ROM technology at the local level.

- The Medical Library at the University of Zimbabwe is running an AIDS database and MEDLINE on CD-ROM.

- The Technical Centre for Agricultural and Rural Cooperation (CTA, Netherlands) has initiated a project with the Information and Documentation Department of the Royal Tropical Institute (KIT, Netherlands) to introduce CD-ROM in developing countries. Participants in the project receive CD-ROM workstations, a complement of agricultural databases on CD-ROM, and basic training. The CTA/KIT project has been implemented in Cameroon, Kenya, Mali, Zambia, and Zimbabwe.

- In February 1990, the Sudan-American Foundation for Education sponsored a CD-ROM Workshop and Conference, which was attended by many scientists, researchers, and other "end-users." Three new institutions in Sudan, plus the British Council Library, are using CD-ROM for full-text and bibliographic searching.

Mastering CD-ROM discs requires relatively expensive equipment but the main cost is in the conversion of hard copy to electronic form prior to imprinting the master disc. The

actual cost of mastering the disc once the data is prepared is around $1,500. The copies of the discs themselves cost only a few dollars.[14]

For institutions with inadequate collections and difficulty in obtaining journal articles or other source documents, full text articles on CD-ROM present a viable solution for building hardcopy collections. However, several problems remain to be solved before the introduction of this technology for this purpose can be successful.

First, users in developing countries must identify the areas of science and technology for which the system is appropriate and for which they would like to negotiate republication in CD-ROM form with the publishers. Information in the public domain or bibliographic information can easily be provided in this format because it is not bounded by copyright and royalty restrictions. Some major international journals have been published in full text CD-ROM format. For example, *Pediatrics On Disc: 1983-1987* contains the full text and images of five years of *Pediatrics*. The American Medical Association has recently agreed to release back issues of its journals in CD-ROM form.

Donors are beginning to recognize the need to identify relevant literature for dissemination to developing countries on CD-ROM. For instance, the Mann Library of the College of Agriculture and Life Sciences at Cornell University has received a grant from the Rockefeller Foundation to identify the core literature of the agricultural sciences that is appropriate for education and research in Third World countries. The intent is to record the selected literature on CD-ROM in full text for distribution to developing countries. It is estimated that the selected literature can be contained on 40 compact discs. The core literature will be determined by citation analysis and other bibliometric techniques, and will be qualitatively reviewed by specialists in eight subject disciplines. An international advisory board is being established with Third World librarians and scientists.

Another source of specialized expertise is the constituent International Unions of the International Council of Scientific Unions (ICSU). These exist to promote the international interests of their specialties, one aspect of which is access to relevant information by scientists in developing countries. ICSU Unions represent national professional associations' interests and have access to (and influence with) the publishers of major journals in the various scientific fields. It should be possible to arrange for journal information on computer tapes to be converted to CD-ROM for developing country libraries.

In the future, one can envisage a healthy commercial market in "remaindered" information, in which slightly out-of-date but still important information is packaged by a commercial enterprise for information centers worldwide. However, at the early stages, before these commercial possibilities are recognized and exploited, the interests of developing country scientists will have to be "brokered" by such organizations as the ICSU Unions, the African Academy, the Third World Academy of Sciences, and their colleagues in counterpart industrial country organizations.

Under the terms of many CD-ROM purchasing or licensing agreements, the user must return superseded copies of the disk to the CD-ROM publisher. This is to prevent a "secondary" market from developing or to prevent the redistribution of the disk to an unlicensed or non-paying customer. Because the returned discs are not reusable by the vendor, it seems possible that CD-ROM publishers could create a "clearinghouse" of superseded discs. These discs could be limited to developing country distribution where they could be resold to

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[14] It is important for publishers to store any electronic format of the journals and books they are producing now. To be entered into database of the future, it will be important to have the original keystrokes already captured in electronic form. Re-keying data is a considerable waste of resources.

this market for a substantial discount. In this manner, the publishers would be able to reap additional profit from their product, while providing a highly needed public service. So great was the interest in this idea at the workshop that several participants offered to approach CD-ROM publishers to establish a pilot project.

CD-ROM technology is overcoming some of its earlier limitations. For example, MS-DOS had a 32 megabyte (MB) limit on file size, which meant that early CD-ROM applications had to find a way around this limitation. Most producers developed proprietary software to allow the operating system to access the CD-ROM disc and work with the large files there. This meant that applications could not migrate to another CD-ROM drive and microcomputer unless the user loaded the special application software into the computer. Recently, however, Microsoft released the CD-ROM extension software that overcomes this limitation and lets the user program MS-DOS and PC-DOS to treat the CD-ROM drive as any hard drive with a drive letter of the user's choice. Each brand of CD-ROM reader requires its own version of Microsoft extensions. (There are at least three manufacturers of readers---Philipps, Sony, and Hitachi--although other companies, such as Panasonic and Toshiba, are entering the field.)

Different brands of discs also come with different search application software, usually tailored to the type of material on the disc. It may thus be necessary for a user to learn different searching systems but since this has always been true for searching online databases as well, it should not prove to be a great difficulty.

Unless the library or organization using the CD-ROM has a local area network in place and the appropriate software to make the CD-ROM available one computer at a time, CD-ROM remains a single-station, single-user medium. With a few exceptions, the simple readers cannot search more than one disc concurrently so that a database on multiple discs would have to be searched using one disc at a time. More sophisticated readers are capable of handling multiple discs.

One workshop participant who had recently ordered a CD-ROM drive was particularly interested in running large CD-ROM databases for multiple users. She has since learned that large databases can be loaded on a multi-drive CD-ROM player that is connected via a personal computer to a server on a mainframe. The database can then be accessed by anyone in the network. With CD-ROM databases being quite expensive and central banks of databases being able to offer the most cost-effective use, she is now interested in the possibility of offering multiple access to a CD-ROM database to the members of a regional communication network. The feasibility of this should be explored by the workshop participants.

Indeed, CD-ROM technology is so promising that the workshop participants spent one full morning discussing it and seeing demonstrations. This technology was also discussed at each site visit. The participants unanimously agreed that seldom before had there been such a natural and suitable information technology for developing countries. Because of the importance and popularity of CD-ROM, a subgroup of the workshop produced a "manifesto". (See box 3.)

Telecommunications

Telecommunications are a vital aspect of modern S&T systems. They enable scientists working on similar problems around the world to send data to one another with an efficiency and speed that have contributed dramatically to improving international cooperation in scientific research, much in the same way they have contributed to improving international business operations. A recent *West Africa* article quoted British communications policy specialist Sir Donald Maitland:

"Effective communications has a catalytic effect on economic development, and countries which don't have good communications are therefore at an immediate disadvantage." With computer networks taking an ever-increasing role in the world of economy, telecommunications have assumed a new significance. And nowhere is the statement more applicable than in Africa.[15]

The telecommunications systems in many African countries are suffering from deteriorating equipment and inadequate investment. The advent of relatively inexpensive fax, personal computers connected via modems, packet-switching data transmission at high speed, and low-cost packet-radio systems ideally will provide African countries opportunities to use modern telecommunications in support of economic development and to counter the isolation of their scientists.

- CRAT is using a computer network to build a food technology network, initially linking five institutions in Cameroon, Morocco, Nigeria, Senegal, and Kenya.

- ICIPE is linking to CGNET, a network of the CGIAR centers, twice a day via satellite.

- IDRC in Africa is looking at packet-radio as an innovative means to bridge the communication gap in even the most remote areas.

- Zimbabwe has announced the availability of its new packet-switching network called ZIMNET.

- The Societe Internationale de Telecommunications Aeronautiques (SITA) is a cooperative organization that provides airlines with telecommunication services. It pools the private radio and telegraph circuits of its members for the benefit of all. SITA has 57 centers in Africa, which are linked into the service through the most reliable and economic means possible. Low volume members may use public data networks or public switched telephone networks. Direct dial-up and private leased lines are also used.

Improvements in the quality of the telecommunications system will enhance the ability of scientists to communicate and transmit data to each other. However these facilities are most likely to be concentrated in the commercial centers, where they are already available from the local PTT. It is the quality and availability of the local telephone system--not the external communications quality--that is the problem (known as the "problem of the last mile").

Another problem is one of cost: data sharing and access in the industrial world through telecommunications is inexpensive compared to alternatives and compared to other operational costs (salaries, maintenance, capital depreciation, etc.) In developing countries telecommunications costs are high in relation to other costs, and the specialized access to international databases that would help African scientists require scarce foreign exchange. The new telecommunications arrangements with multinationals may improve certain parts of local networks, but benefits of lowered costs that can be expected from competition among rival services are unlikely to accrue from exclusive arrangements with the multinationals.

Software

Suitable software does not always exist for African applications. Since the software industry is concentrated in developed countries, the bulk of the packages are available only in English. Although French and Spanish versions of the most popular programs are available, seldom are other language versions sold. Local development of software is important but,

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[15] Fitzgerald, P. (1989) Good communications pay. *West Africa* pp. 544-545.

CD-ROM today is an established technology:

- High Sierra/ISO standards, plus MS DOS CD extensions provide the open door to a wide range of non-vendor specific applications.
- The range of disk drives and vendors is rapidly increasing.
- The range of products offered is expanding, although most are still North American or West European.
- Mastering and replication costs are coming down rapidly.

CD-ROM is a "natural" for libraries, and for all who need to distribute large databases or other machine-readable files. CD-ROM:

- Eliminates the need for costly/difficult telecommunication links.
- Can survive/operate even under difficult conditions (such as heat, humidity, dust, and unstable power supply.)
- User stations can be portable or battery operated.
- Uses relatively "simple" information technology--a basic personal computer will do many CD-ROM applications.
- Has a relatively low capital cost for equipment--may only be an add-on for existing equipment.

CD-ROM is attractive to users. It:

- Provides a local holding of a very large database.
- Has powerful, user-friendly search software with the potential for complex searches, but needs only simple, low-cost computing resources.
- Has known fixed costs (that is, for purchase of equipment and discs), not the open-ended costs of online retrieval systems.
- Can be a powerful tool to develop local computer literacy by providing the opportunity for hands-on use of a powerful system.
- Has the potential to enable distribution of pan-African databases, for example through pooling the mastering and replication costs, providing in many cases the first practical possibility of regional resource sharing and communication.
- Has the potential for use in conjunction with other related information technologies, such as microfiche, to achieve complete information retrieval and dissemination.

CD-ROM should be attractive to national and international funding agencies and donors because:

- It is a proven technology, well past the "experimental" stage.
- It has been seen to work in Africa and elsewhere, so one knows that if put into place, it will work.
- There are quantifiable means of determining the potential value of a database before it is purchased.
- The costs are known and predictable--equipment and CD-ROM costs are known.
- There can be virtually instant gratification, provided careful planning is carried out to meet document delivery demands generated by some CD-ROM products.
- The stakes are relatively low--considerable impact can be achieved for limited expenditures.
- It can be clearly targeted to specific needs.

Box 3. The CD-ROM Manifesto

unfortunately, this is not an easy task. The effort that goes into the making of software cannot be overlooked.

If software is written specifically for the developing country environment, it can be instantly successful. Seeing a need for a low-cost hardware and software package that permitted online data entry and interactive retrieval, the Canadian International Development Research Centre (IDRC) developed MINISIS. MINISIS is a generalized information management system designed to run on Hewlett-Packard (HP) minicomputers. It gets its name from ISIS--the Integrated Set of Information Systems--a software package developed by the U.N.'s International Labour Office in Geneva. MINISIS performs essentially the same functions as ISIS, but does not require a mainframe computer. Developed primarily for use in bibliographic information systems, MINISIS is flexible enough for many types of database applications.

MINISIS is licensed by IDRC to organizations around the world. Because it supports multilingual recognition of thesaurus terms, it is popular in international organizations, such as the World Bank and U.S. Agency for International Development. It is also used by many African information systems. It has the advantage of providing a common format for all countries using it (so that they can easily share information). The original system, however, has one major drawback--its lack of compatibility with any hardware other than the HP minicomputer.

The HP minicomputer is more expensive than the more modern personal computers and, understandably, many organizations are reluctant to lock themselves into one hardware vendor. The development of the Micro CDS-ISIS system by UNESCO Library staff solved this problem of systems compatibility and provides a powerful database management system that can be used on a variety of IBM-compatible microcomputers. The recommended configuration to run Micro CDS-ISIS includes 512K of RAM memory, a hard Winchester disk unit (10 megabytes or more), one 5¼ inch floppy disk unit, a monochrome display (color displays are also supported), and one printer.

Micro CDS-ISIS is distributed free of charge to qualified non-profit organizations in UNESCO's member states by the UNESCO Regional Centre for Africa (ROSTA) in Nairobi. It has been adopted by many African institutions that know exactly how to take advantage of such a powerful information management tool. (See the list of Micro CDS-ISIS users in Africa in Appendix D.) The result of this is that now African information specialists have a *de facto* standard for database management. Annotated bibliographies, library catalogs, and indexes entered in Micro CDS-ISIS format can be exchanged freely without a compatibility problem.

CRAT uses Micro CDS-ISIS for the following databases:

- Industrial Development Abstracts
- Directory of Technician Training Institutions in Africa
- Institutions and Experts on S&T in Africa
- Directory of Scientific and Engineering Societies in Africa
- Guide to Directories on Science and Technology in Africa

There are many other database management systems available from commercial vendors. It is not our intention to describe and critique these packages here. However, it should be noted that many packages are not suitable for handling bibliographic information. In order to handle bibliographic records efficiently, the database management software must:

- Deal with variable length fields and variable length records in an efficient manner.
- Have the ability to deal with a variable number of fields in each record.
- Easily and intelligently deal with complex searches.

- Have the ability to import and export standard ASCII files.

The African Academy of Sciences, for example, uses DBase III for its database, Profiles of African Scientists.

Management Information Systems emphasize the importance of STI at the policy and decision making level. As the use of microcomputers increases, so too does the awareness that STI can be used for management purposes. There is need to promote the use of these MIS applications more widely, by top management as well as the middle and lower level enthusiasts.

- Such systems have been developed by the International Service for National Agricultural Research for ministries of agriculture to plan, budget and track national agricultural research, using laptop personal computers and a simple software package specially selected for ease of use by the non-computer specialist.

- In Ethiopia, the Ministry of Industry Computer Center has developed an MIS system, which consists of separate databases for manpower, production, and financial analysis. The information generated is used by policy makers to help improve plant efficiency in the country.

Such systems offer governments greatly improved means to deploy local S&T resources, and use information for supporting greater efficiency in technology choice, management and monitoring. They should be developed and used within both private and public sector.

Chapter 4

Conclusions and Recommendations

Conclusions

Following are the major conclusions reached by the BOSTID panel after discussions during the site visits and during the Nairobi workshop.

The successful implementation of science and technology information systems and services is based on the convergence of a range of disciplines. These include computer science, library science, communications, publishing, and management.

Improvements in any part of the information sector will contribute to improving the whole sector and hence to economic development. Improvements in any part of the STI system will contribute to an improvement in scientific communication and information exchange.

Certain information and communication technologies hold immediate promise for improving STI systems and services in Africa.

- Because of its low cost, durability, vast storage potential, ease of use, and the fact that it by-passes telecommunications problems, CD-ROM seems to provide answers to a number of developing country difficulties, particularly access to bibliographic and full text material. The projects now under way to produce CD-ROM material should be monitored carefully for their applications in Africa. National, regional, and local databases need to be developed in many areas of scientific and technological research and development, and CD-ROM should be explored as an attractive form of inexpensive permanent storage. Cooperative sharing of a CD-ROM "platform" should be encouraged--for example, putting multiple small databases on a single disc or providing access to a CD-ROM database to a network of users.

- Desktop publishing offers an attractive means of producing textbooks and other scientific material of interest to a limited audience. This may have particular application in countries whose foreign exchange shortage precludes buying texts on the international market, and whose domestic market is too small to interest local publishers. It may also have applicability to local journal publishing.

- Until more reliable and less expensive telecommunications is more readily available, electronic mail and computer conferencing will be primarily a source of information for national and regional centers, from which individual local users can be served. For the immediate future, it is unlikely that large numbers of individual researchers will be able to access national or international electronic databases in a form that will meet a significant level of their information needs. Librarians and information service managers have an important role to play in mediating the use of the new technologies and assisting their clients in using them.

There is inadequate information available in Africa about information technologies, their costs, and the advantages and disadvantages for certain applications.

No single technology will solve all information needs and future national systems will include a suitable integrated mixture of different technologies. Informal networks and users groups need to be formed so that information about the costs and suitability of different technologies can be shared.

The panel recognizes that standard cost/benefit analyses are not always accurate when used to evaluate investments in information systems and services because the benefits may, at first, be intangible or difficult to demonstrate. However, as diverse STI projects are funded, the project managers should include mechanisms for studying the cost-benefit ratio of their projects. The mechanisms they use and the information they generate should be shared with other network members and with donor agencies.

Many different interventions are needed in order to help individuals and institutions establish information services, adapt new technologies, and create an informed user community.

A shortage of funds, lack of trained personnel, lack of an enabling environment, and technological problems all impede the development of STI networks. A friendly environment for the development of information networks needs to be established. This will require training programs for managers and users alike, projects that promote the understanding of the value of information to economic development, and the formulation of national policies that encourage and support the growth of the information sector.

In the effort to establish an enabling environment, professional societies and associations have an important role to play. In particular, they can promote the selection of relevant information for inclusion in databases, and assist in discriminating among alternative technologies to find the most cost effective. They can also promote production of materials for local publishing of journals and textbooks and help to establish common interfaces, formats, and other standards.

Suitable software for many African STI applications does not exist or is not fully exploited.

- There is a need for native-language information processing. Users need access to generic native-language software interfaces that allow them to access and manipulate information in native languages and scripts.

- Management Information Systems are important tools through which developing country governments and institutions can improve the cost effectiveness of their operations. Their use in the planning, management and implementation of scientific programs should be encouraged as a parallel, and linked, aspect of STI systems.

The building of indigenous databases needs to be encouraged, not only for the use of an individual institutions, but also to serve as a basis for sharing information.

- Many of the economic development problems facing African countries have scientific and technological components that will require solutions to be developed in Africa by African scientists.

- There is currently an insufficient collection of locally-produced data. The scientific research of a country is not always being captured or entered into a database to which others in the country could have access. This can result in a duplication of effort and the poor use of valuable resources.

- Indigenous knowledge must be collected and used in order to solve local problems. Scientists must learn to accept the validity of traditional knowledge systems and have the ability to access traditional knowledge easily.

Recommendations

The BOSTID panel agreed that a joint African/North American expert committee should be established to promote cooperation in the development of STI services and systems in Africa. The expert committee should be responsible for the following activities.

Organization of networks among African scientific and technical information centers by providing:

- Help in defining needs for information products and services,
- Choice of suitable technologies,
- Assistance with systems design and development of these networks so that all the necessary elements are addressed, including objectives, policy, economics, management, marketing, operations, training,
- Technical assistance and trouble-shooting, by arranging short expert visits,
- Training, including travel for African personnel to learn and see new systems and visits by trainers from North America or Europe,
- Monitoring of new STI-related projects, and
- Information about information services and technologies, serving as a link for the dissemination of information about software, equipment, training opportunities, and new projects.

Discussions with the U.S. national committees of the ICSU constituent unions, the professional association, and publishers of the major scientific journals about the need for a regular transfer of full text journal material of particular interest and relevance to African researchers.

Since journal availability is potentially responsive to technological solutions, such as CD-ROM, desktop publishing, and related techniques, the expert committee should explain how these technologies are currently being used in Africa. The program should collaborate with the African Academy of Science, AAAS, and TWAS in promoting their journal and national library collection programs.

This should be done on an experimental basis in order to work out arrangements with journal publishers and CD-ROM mastering facilities; to ascertain user response in African countries; and to assess costs and determine possibilities for commercial, routine service, or subsidy. The journal material should also be supplemented with CD-ROM discs through remainders, or secondhand discs from North American or European suppliers.

Assistance to information specialists and others with small grant project support for information technology development and acquisition.

Small amounts of funds to complete a system or seed money to build on to an existing one can be highly leveraged and, therefore, a small grants mechanism that would allow African information specialists to "go the last mile" is needed. The administration of a small grants program might be very difficult and time consuming unless an appropriate institutional base is found. The expert committee should help identify the correct institution and ascertain more precisely the financial needs of the potential grantees. Until the grant-making mechanism is established, the committee should comment on the proposals for information systems received by donor agencies and make funding recommendations.

The committee should also have at its disposal a peripheral and software fund to use in solving some of the more immediate problems encountered. If, for example, a modem or a printer is needed at an institutions in order to improve the delivery of an existing STI service, the committee should select, deliver, and, if necessary, install the needed item.

Advice and assistance in creating the enabling environment needed to promote the further development of the information sector in Africa.

The committee should undertake projects that increase the awareness of the importance of STI to economic development. These might include:

- Assistance with the development of national information policies and development plans;
- Discussions with government officials about the need to offer reliable communications systems, such as packet-switching network;,
- Assistance with native-language information processing and the development of software packages that provide familiar user-interfaces;
- Assessment of the possibility of local manufacture of peripherals and supplies, such as diskettes, cables, paper of suitable quality, toner, and ink; and
- Encouragement of computer user groups and networks through which knowledge, experience, and assistance can be offered and shared.

Networking of STI experts, users, and providers throughout Africa in order to share experiences and methodologies.

Following implementation of a number of small projects, it would be appropriate to bring together the specialists and the government officials at the country level to review experience, raise consciousness, and suggest policy changes. There is continuing need for conferences, workshops, or symposia for policymakers, information specialists, and users to underline the importance of information to national development, identify the problems encountered when implementing STI networks, and share examples of innovative information services based on applications of new information and communication technologies.

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Appendix C

Site Visit Reports

Cote d'Ivoire

The principal contact in Cote d'Ivoire was Dr. Edward S. Ayensu of the African Development Bank. Cote d'Ivoire was included in the site visits in order to learn what the African Development Bank was doing in the information sector. The short visit to Abidjan, therefore, included only one appointment with the Director of Computer Services of the ADB. Mr. Gilman explained that there are many infrastructural difficulties in Cote d'Ivoire. These include a poor telecommunications systems, lack of documentation and back-up, lack of technical support, and high tariffs levied against imported computer equipment. The country does not have enough telephones and connect charges are very high.

There is some expectation that IBM/Europe will be installing a link to the European computer conferencing system, EARN, but effort to track down more information about this link proved futile. BOSTID has since learned that the EARN link has been established but is not yet fully operational.

Gilman said that what was needed are simple technologies with lots of redundancy and low maintenance. He also said that new STI projects should use what already exists rather than building from scratch. He feels that the scientists in the country have high expectations for an STI system and would prove to be good users. He emphasized that up-to-the-second information would not be needed. Access to relatively current information using relatively modern equipment would be sufficient.

As in other African countries, document preservation in Cote d'Ivoire is a serious problem. Insects, humidity, heat, and dust are proving especially devastating and have already caused losses in important legal document collections. The life of computer equipment is also shortened due to these environmental conditions. While there is some regional support for Wang and IBM equipment, service is not always available quickly for foreign-bought equipment. There are some good local technicians who are building good spare parts collections.

In short, the fundamental building blocks for an information system are getting established. Expectations are high for an eventual national STI network.

Ethiopia

The contact for the Ethiopian site visit was Ato Getachew Birru, Librarian of Addis Ababa University. He arranged for visits to a number of different institutions in Addis that are involved in scientific and technical information activities. These included national entities: the Ethiopian Science and Technology Commission; several departments of Addis Ababa University; the National Information and Documentation Center; the Ministry of Industry; and two international organizations: the Pan African Development Information System (PADIS) and the International Livestock Center for Africa (ILCA).

The team discovered a great deal of activity in the development of STI systems. There is a growing amount of hardware in the country and strong interest in improving access to STI. Several new initiatives are underway and organizations are exploring various opportunities for enhancing existing services. For example, the National Information and Documentation Center is developing a network to link the STI systems of various organizations in Ethiopia. The Ministry of Industry computer center has established several databases

designed to provide accurate information to policymakers about industrial production in Ethiopia.

At Addis Ababa University a Masters Degree in Information Science will be offered beginning in September 1990 for students from eastern and southern African countries. The computer center at the University is training staff in the use of computers; supporting management functions such as payroll, inventory, personnel, and budgeting; and providing student access to computing facilities. The Department of Mathematics, which has a small microcomputer laboratory, offers a diploma in computer science and hopes to establish a B.S. degree program. This department has already published a newsletter and one textbook using desktop publishing and is the process of preparing more.

The two international organizations visited had considerably more equipment, staff, and facilities available for developing STI systems than the national entities. The disparity between resources at these institutions and those of the national institutions was noteworthy. ILCA commits $1.2 million to its information and documentation efforts. It has two main areas of activity: a publishing program for distributing their own research results and a documentation and dissemination service. PADIS maintains linkages to approximately 10 countries for developing and accessing bibliographic and statistical databases, as well as full text of UN documents. It has conducted a number of studies and found that about 50 percent of documentation centers in Africa are using information technology in some form.

Discussions with staff at various organizations helped to identify a number of opportunities as well as problems that need to be overcome in developing STI systems. In particular, microcomputers, CD-ROM, fax, and desktop publishing were highlighted as particularly promising in the African environment. The fact that more material is being captured in electronic form also contributes to building greatly improved databases that include African material. New training initiatives being offered by the universities and international organizations also should improve the tremendous technical personnel shortage.

The problems cited tended to echo those heard throughout the site visits. In additional to the shortage of trained personnel, there is a need for good software that is easy to use; improved compatibility among systems; better access to supplies, such as paper and toner; improved telecommunication facilities and services at lower costs; better access to journals in universities and government agencies; greater sharing of materials; and the establishment of supportive government policies.

Ghana

The local contact for the Ghana site visits was John A. Villars, Librarian for the Council for Scientific and Industrial Research. The team visited a number of institutions to assess Ghana's development of science and technology information systems. In general, Ghana has no explicit policy on science and technology information, but public libraries have been established (by legislation) in all 10 regions of the country by the Ghana Library Board. The regional, district, and branch libraries form a national network of public libraries, which jointly operate a school library service. The Council for Scientific and Industrial Research (CSIR) is the focal point for science and technology and serves as the coordinating agency for Ghana's 10 research and development institutions. None of the three university libraries is computerized. Most of the government-sponsored information centers lack computer facilities. Personal computers can be found in some private sector information centers as well as in a few public institutions.

The Energy Information Centre

The Centre is part of the Energy Board that advises the Ministry of Fuel and Power. It collects data for the energy sector and carries our policy planning and analysis. It also

serves as a focal point for energy studies. Its database is a component of the national STI network that is being planned.

The Centre has a professional staff of about 20 and a small reference library. Users of the facilities include students and researchers from other institutions. The Centre is one of the few places in Ghana to have installed a local area network, using six personal computers and three terminals. The major operational problems cited by the staff are:

- Inadequate and unreliable power supply,
- Inconvenient physical location, and
- Dusty and humid climate that makes machine maintenance a continuing problem.

Although the Centre has not carried out a survey of user needs, it has initiated a number of baseline studies to collect data for policy analysis and planning. It is the overall goal of the Centre to establish a comprehensive energy information system to facilitate planning, analysis, development, and use of Ghana's energy resources.

Ghana Statistical Services Board

The Board was established by law to gather data on the socio-economic and demographic indicators in the country and to publish these annually on behalf of the government. Most of the work of the statistical office is done manually since the Board has access to a mainframe computer only about 25% of the time. The Board plans to install desktop publishing equipment in the near future. The Board gathers and publishes reports on population, fertility and health, living standards, industrial productivity, price information, and national account statistics.

Ghana Post and Telegraphs Department

Some priority is currently being given to the modernization of the Ghana's telephone system. There is an earth station that has an international gateway as well as a Telestar link with its immediate neighbors (Togo, Cote d'Ivoire, and Burkina Faso).

University of Science and Technology, Kumasi

The university has a number of science and technology centers and a university library. They all suffer from poor infrastructure, lack of funds for maintenance, and lack of foreign exchange for book and journal purchases. The research centers at the university include the Road Research Institute, the Technology Development Centre, the Renewable Natural Resources Institute, the Forestry Research Institute, and the Medical Research Institute. These centers rely heavily on cost-free information provided by a variety of external sources. Some journals have not been updated since 1978. The main university library has a collection of some 140,000 books and 400 periodicals. It has no computer.

Centre for Scientific and Industrial Research (CSIR)

The CSIR serves as the focal point for all science and technology matters in Ghana. It coordinates the activities of the research institutions and advises government on matters of science and technology policy.

One of the major initiatives of the CSIR is the establishment of a national network for science and technology information. This project, called GASTINET, includes nine sectors, each of which is to have its own database. GASTINET will involve the collection, processing, storage, retrieval. and dissemination of STI to all categories of users, including researchers, scientists, policy-makers, planners, industrialists, and the general public. It will create and maintain computerized bibliographic databases of STI, as well as of research activities and

personnel. It will also strengthen human and institutional capabilities in library and information science and services through training programs. Finally, GASTINET will establish linkages with regional and international networks and databases.

Kenya

Site visits *per se* were not conducted in Kenya. Rather, since the final workshop was held in Nairobi, the participants took advantage of the location and held their meetings at different sites. Many information specialists based in Kenya also participated in the meeting.

One morning session was held at the International Council for Research in Agroforestry, where their CD-ROM search capabilities were demonstrated to the workshop participants. BOSTID panel member, Dr. John Black, gave lectures on CD-ROM and on computer conferencing.

A second morning session was held at the International Center for Insect Physiology and Ecology. Here, workshop participants saw a demonstration of CGNET, an electronic messaging system based in the Dialcom network.

The desktop publishing system used by the African Academy of Sciences was also shown to the workshop participants.

Nigeria

The contact for the Nigerian site visits was G.A. Alabi from the Department of Library, Archival, and Information Systems of the University of Ibadan. Until recently, STI activities in Nigeria have been limited to the provision of traditional library services in institutions of higher learning and to research institutes. Each library had its own collection and, when necessary, interlibrary loans among the libraries filled the gaps.

The development of an effective STI network in Nigeria has not been encouraging. With the rapid advances in scientific research, the amount of STI generated has increased. While much attention has been given to the value of science and technology for economic development, very little emphasis has been placed on creating institutions devoted to the organization of science and technological information.

Of the 30 university libraries in Nigeria today, only the medical libraries at the University College Hospital in Ibadan, the University of Nigeria Teaching Hospital in Enugu, and the Lagos University Teaching Hospital have functioning computers. The banks have the highest number of computers. The oil companies are also effective users of microcomputers. While most of the computer systems are functioning well in the private sector, the failure of many university library automation projects can be attributed to the lack of the framework necessary.

The Forestry Management Evaluation and Coordination Unit (FORMECU), Ibadan

This center provides support for the World Bank forestry projects in Nigeria. It uses a management information system and a forestry database. It currently has projects in 11 of the 21 states in Nigeria but plans to eventually provide services to all states. FORMECU has plans to install IBM personal computers at each of its project sites. These projects are now tied into the Agricultural Development Projects (ADP), which are already computerized.

FORMECU's work focuses on ecological preservation and prevention of desertification. It is involved in collaborative research with a number of universities. It has experienced difficulties in using computers because of power and maintenance problems. It is hoped that operating within a microcomputer environment will prove more satisfactory.

International Institute of Tropical Agriculture

IITA, a member of the CGIAR, operates an impressive Library and Documentation Center. Its collection of 27,800 volumes and 850 journal subscriptions covers agricultural sciences and related fields. It offers information services such as ready reference, current awareness, and bibliographic searches to scientists, researchers, trainees, and students. The Centre is involved in such projects as source document scanning, indexing and abstracting, and database production and management.

The IITA Library is equipped with three integrated minicomputers. Using DBase III software, the book and journal holdings are entered into a computer database. The database is accessible from 6 terminals in the library or from 100 in the rest of the institute. Despite its relative richness, the IITA Library still suffers from inadequate funding, poor telecommunications infrastructure, and lack of commitment from the users.

The Federal Institute of Industrial Research Oshodi (FIIRO)

FIIRO is the primary R&D centre of the Ministry of Science and Technology. It is known for its major breakthroughs in food processing, especially in the development of new and improved food preservation and preparation methods, use of locally-available raw materials, and appropriate modification to imported food technologies. It has an Industrial Information and Library Services Division.

The information center was funded jointly by the Government of Nigeria and the United Nations Development Program. It disseminates industrial and technological information to the various sectors of the Nigerian industry. Its clientele includes its own research staff, industrialists, entrepreneurs, consultants, scientists, researchers, and students. It indexes and abstracts incoming material for entry into a microcomputer database.

Senegal

The contact for the site visits in Senegal was Dr. Mohamed Timoulali, Director of the Division of Information and Documentation at CRAT. There are a number of interesting information projects underway in Senegal, both in national and regional institutions. Although Senegal suffers from the same problems encountered elsewhere, it has been successful in launching the SENPAC packet-switching network and in importing a wide range of computers for institutional use. One unique problem faced by Senegalese information specialists is the very harsh environment. Dry winds blow across Dakar from the Sahara desert and combine with the salt-filled sea breezes. The salt and the desert dust collide, forming tiny particles of a highly corrosive silt. The silt has a devastating effect on computer equipment and library collections alike. Organizations that have not taken steps to protect their offices from this silt soon face severely deteriorating collections or unusable equipment.

The site visit team was told that computer support is quite good in Dakar (there is a Computerland store) and that equipment can be purchased with the convertible CFA. Some of the institutions are well-funded but need advice on how to use their funds to the best advantage. The site visit team observed many informal networks among the information specialists, even though it also found itself in the position of "carrying" news it had learned from one library to another. For instance, the news that the university library had acquired a CD-ROM reader was spread throughout Dakar by the team.

The African Regional Center for Technology (CRAT)

CRAT was established under the aegis of the Organization of African Unity and the UN Economic Commission for Africa. Under the terms of its charter, it has the specific

responsibility for serving as a regional center for information dissemination on technology, especially in the areas of postharvest food preservation and renewable energy. Its services include a library of 6,000 documents, a patents information collection, and a number of publications. Besides several newsletters and a journal, CRAT publishes directories of technical training, societies, and institutions and experts in science and technology. CRAT can conduct online literature searches or connect with electronic mail and computer conferencing networks with some ease (although not without some expense) thanks to the new packet-switching network.

CRAT is currently embarking on an IDRC-sponsored study to build a food technology network, initially linking five institutions in Cameroon, Morocco, Nigeria, Senegal, and Kenya. The study will test the best possible technologies for the exchange of information among these countries. In addition, CRAT serves as the focal point for science and technology literature that is entered into the national information system and provides training workshops for UNIDO and IDRC.

The library is automated using the Micro CDS-ISIS software and an IBM XT. It also has an IBM AT, an HP laser printer, an optical character scanner, and the Page-Maker software to operate desktop publishing systems. A local area network links these and several other machines for maximum flexibility and use. A compact-disc player is on order through a UNIDO-funded project.

Bibliotheque Centrale, Universite Cheikh Anta Diop

The main university library suffers most from being too small: it was built when the university was expecting only 5,000 students and it now has more than 15,000 students in attendance. The staff, therefore, cannot respond to all user requests. The library budget has remained constant despite the increasing demand for its services. Most of the 26 members of the professional staff were trained in the library and documentation school at the university. The university was closed at the time of the site visit and it was not possible to talk with the staff of the library school.

Since 1981, the library has been working on a university-wide network for the exchange of information. The library will then serve as a focal point for a national information network that includes 24 other libraries. Since there is no national library in Senegal (there is a national archives, however), the university library is undertaking a Unesco-funded pilot project to build an automated national catalog of publications. The library itself is not yet automated but had recently acquired a CD-ROM reader for database searching.

The library is not air conditioned so it is extremely difficult to preserve documents. Continuity of reliable electrical power is also a problem. The director of the library, who met with the site visit team, demonstrated just how the severe the problem could be. The library uses a closed stack system. When a book is requested, a clerk on one of the seven stack floors retrieves the book and sends it to the circulation desk via an electrical dumb waiter. When the power is out, which is a frequent occurrence, service to the users is stopped.

Conseil Pour le Developpement de la Recherche Economique et Sociale en Afrique (CODESRIA)

CODESRIA is the social science research institute for Africa. It promotes social science research for all of Africa, supports national social science research groups, and acts as a channel for funding. It publishes *African Development* and does online searches for its members. It studies mostly the social sciences but interacts with the hard sciences when examining the social factors involved in science and technology. It is a dynamic organization with a strong director who is anxious to lead the way in the application of information and communication technology. The organization is currently involved with an IDRC-funded

project to link four of its member states in an online communications network. It uses Micro CDS-ISIS, has several IBM XTs and one IBM AT.

The discussion with the director of CODESRIA, Mr. Mkandawire, centered on the general problems he has encountered when implementing information networks. He felt that many information programs never really got started because the director of the agency feared that if he did not understand the technology, he would be replaced by it. Conversely, the director may be a "technology enthusiast" and any new equipment would be seconded by him for his personal use. Training at all levels is crucial, he said, because the directors of organizations need to understand the need for an information program before they can put their support behind it. Computers and other information technologies need to be "demystified" before they can be used effectively.

Another problem he has encountered is that information and computer specialists in Senegal are not always aware of the progress made in informatics. When proposing projects, they may request older, more complicated technologies because they are unaware of the latest developments. Guidance on technology choices is not always easy to find in the funding agencies either, and this has resulted in a lot of incompatible equipment being installed.

Centre National de Documentation Scientifique et Technique (CNDST)

The CNDST, in the Ministry of Planning and Cooperation, is charged with coordinating national activities dealing with science and technology, including those of the ministries and of the public sector It is also charged with collecting all science and technology information generated in Senegal. This includes expert reports, research results, and grey literature. CNDST coordinates a network of information centers that are each charged with collecting the material in their specific subject field, such as agriculture, health, energy, or commerce and industry. Each of these centers collects and sends materials to CNDST, where it is microfiched, indexed, and integrated into a national bibliography. The CNDST itself is not automated but it does have access to the central computer center, which runs the ISIS software. About 1,000 documents each year are processed manually by the CNDST staff.

The director of CNDST has a computer terminal in his office and the site visit team was able to connect to a North American computer conferencing system through the SENPAC network.

United Nations -- IDEP

This economic planning institute has students from around Africa attending its courses. Senior civil servants attend IDEP to learn about the problems facing Africa, project appraisal, and national accounts. The library budget has been cut from $70,000 to $10,000 in the last few years and this money goes primarily for journal subscriptions. The library houses 20,000 books and maintains 100 journal subscriptions. It holds many documents from international agencies. The library has no automation equipment and the staff complains that even the photocopier breaks down too often. Storage is a severe problem, especially in the basement stack areas that are open to the outside. The dust and humidity have nearly destroyed this part of the collection, as the librarian demonstrated when he pulled a monograph from the shelf. It all but crumbled in his hands. Although the UN has been promising for years to provide safer storage, the building plans had not yet been seen by the librarian.

Institute Senegalais de Recherches Agricoles

ISRA serves as the national focal point for agricultural information and was the only national organization visited by the site visit team. Founded in 1920, ISRA tries to cover the country's needs in terms of agricultural research. It sees the transfer of information as its most important function. The Information Unit within ISRA was created to assure the

dissemination of information to the farmer as well as to the policy maker. To do this it has a central documentation center that collects national documents, reviews the periodical literature, searches foreign databases, and prepares records for a database.

ISRA feels it is equally important to tell the world what it is doing so the Information Unit also issues research documents. These are generated with a Macintosh-based desktop publishing system. ISRA also produces slides and films, compiles directories of agricultural researchers in Senegal, and produces radio and TV seminars.

Although the ISRA offices in Senegal are automated, computer equipment is needed in all the outlying centers. The staff also expressed frustration in doing online searches because the information obtained was so seldom relevant to Senegal. For this reason, they are anxious to produce local databases on CD-ROM.

ISRA uses IBMs for word processing. The information is transferred to one of three Macintosh SEs for desktop publishing and laser printing. Goupil computers are used for the documentation functions. A CD-ROM reader is on order.

Sierra Leone

The local contact in Sierra Leone was Dr. Ogunlade Davidson of the University of Sierra Leone. Institutional weaknesses, poor economic environment, inadequately trained manpower, and a general lack of awareness have created a poor framework for the development of STI systems in Sierra Leone. Some of the immediate problems are:

- Low priority given by government to the development of an information system,
- Shortage of foreign exchange for procurement of books, journals, paper, and other peripherals,
- Lack of confidence in public libraries and other information centers, causing potential STI users to establish personal libraries,
- Decreasing avenues for publishing, which causes the quantity of "grey" literature to increase, and
- Strained links between the users and producers of information.

There is no existing STI system in Sierra Leone but there are a number of information centers that collect, store, and retrieve scientific information.

Sierra Leone Library Board

The national library has a large complex in Freetown and branches in the country's main towns. It also has a mobile unit that provides service to some rural areas. The government recognizes the Library Board as the main custodial of all national publications. Although it is statutory that all documents published in the country be deposited here, this regulation is not being enforced.

School Libraries

About 150 schools in Sierra Leone teach sciences. These schools operate small libraries that have science books.

Libraries of Technical Institutes

There are four technical training institutes that have library facilities. In addition, the teacher training colleges include science and technology in their curricula so they also stock books and other reading materials on science and technology.

University Library

The University has three colleges and two off-campus institutes, all of which undertake training and research in science and technology. They all have libraries at both a college and institute level.

Documentation Centers

The government, with assistance from international agencies, has established documentation centers in a number of ministries. These include the following:

- The Documentation Centre of the Planning Ministry stores all reports on development projects undertaken in the country by local and external consultants. It has the capacity to reproduce and store some relevant literature useful to science and technology.

- The Documentation Centre of the Ministry of Agriculture and Forestry, under the Planning Department, stores all relevant information on agricultural statistics in the country.

- The Planning, Evaluation, Monitoring and Statistics Unit (PEMSU) is responsible for collecting and evaluating agricultural data. These include agronomic conditions, production figures, marketing, and pricing.

- The Planning, Monitoring, and Statistics Unit (PMSIU) of the Ministry of Health serves public health doctors, demographers, and statisticians who are responsible for providing all health data that may be required for planning and policy. In addition, it provides baseline data for various regions of the country before projects are implemented.

New User Survey

There is currently underway in Sierra Leone a study to determine why the use of libraries is declining, identify the information needs of scientists and engineers, and examine the STI infrastructure of the country to better discover what is needed. All methods possible, including questionnaires, personal contacts, interviews, and seminars, are being used to gather information. Based on the results of the survey, the researchers then plan to address the infrastructural problems through a series of small grants. Eventually, the STI system that is developed will be linked to regional and international systems. Through this user study, the researchers hope to demonstrate what a small country can have in the way of an STI network.

Zimbabwe

The contact for the Zimbabwe site visit was Dr. C.T. Chetsanga, Dean of the Faculty of Science at the University of Zimbabwe and head of the National Research Council of Zimbabwe. The team met with Dr. Chetsanga and Dr. Douglas Dune, Chairman of the Computer Science Department at the University of Zimbabwe to discuss the STI situation in Zimbabwe.

Dr. Chetsanga emphasized the particular problem of inadequate textbooks and the hope that desktop publishing would be one mechanism for dealing with the lack of available published materials. Problems of compatibility of hardware and software, lack of foreign currency, and inadequate information on available technology options were all identified as barriers to implementing new systems.

Dr. Dune outlined the size and curriculum of the computer science department, which grants a B.S. degree. He stated that he is unable to graduate enough students to satisfy the large demand that exists in government agencies and the private sector for computer scientists.

Dr. Chetsanga and Dr. Dune arranged a meeting with key players in the scientific and technical information community in Zimbabwe to discuss their needs, the status of computer systems, and problems they were encountering.

The meeting proved useful both for identifying opportunities and problems resulting from the use of information technology. Based upon the participants' statements, it was clear that Zimbabwe has established a computer infrastructure upon which they can build new systems and services. They have begun to identify possibilities for pilot projects and hope to expand some capabilities to regional centers. Among the opportunities the group identified that could serve user needs were desktop publishing, CD-ROM, facsimile, and the establishment of national policies to support scientific and technical information. Future STI systems would hope to include publication of local materials, access to external databases, distribution of information to district centers, and regional cooperation and exchange of information. All these elements were identified as priorities for improving access to scientific and technical information.

The country has a growing supply of hardware but compatibility between systems; inadequate software; and poor supply of paper, disks, and other peripheral materials hampers their progress. A number of cross-cutting issues needs to be addressed so that further advances can be made. These include: foreign currency constraints; training requirements; technical skills; maintenance needs; lack of standardization; telecommunication linkages; and conflicting government policies.

Appendix D

List of Micro CDS/ISIS Users in Africa

Botswana

National Institute of Development Research and Documentation
University of Botswana

Southern African Center for Cooperation in Agricultural Research

Burkina Faso

Assistance a la Planification et au Developpement
c/o UN Development Programme

Centre d'Etude et d'Experimentations Economiques et Sociales pour l'Afrique de l'Ouest

Centre National de Traitment de l'Information

Ecole Superieure de Droit

Ministere du Plan et de la Cooperation

Secretaire Permanent des Organisations Non Gouvernementales

Directeur des Relations Exterieures
Universite de Ougadougou

Cote d'Ivoire

Centre Interafricain pour le Developpemment de la Formation Professionelle

Centre Regional d'Information et de Documentation Commerciales

Ecole Nationale Superieure des Travaux Publics

Institut de la Recherche Scientifique

Ministere de la Recherche Technologiques

Centre Ivoirien de Recherches Technologiques

Universite d'Abidjan

Ethiopia

Alemaya University of Agriculture
Library

Ambo Junior College of Agriculture

Armauer Hansen Research Institute
Asmara University

Catholic Relief Services

Commission of National Water Resources Development Project Study

Ethiopian Centre for Technology

Ethiopian Science and Technology Commission

Faculty of Veterinary Medicine
Addis Ababa University

International Livestock Center for Africa

Ministry of Agriculture

Ministry of Education

Ministry of Industry

Office of the National Committee for Central Planning

Planning and Programming Dept.
Ministry of Agriculture

UN Economic Commission for Africa

University of Addis Ababa

Gabon

Haut Commissariat au Plan au Developpement et a l'Economie

Institut de l'Economie et des Finances

Institut Sous-Regional Multisectorel de Technologie Applique de Planification et de l'Evaluation

Ministere de la Culture, des Arts, et de l'Education Populaire

Ghana

Council for Scientific and Industrial Research

Environmental Protection Council

Guinea

Bureau de Strategie et Developpement

Institut National de Recherche et Documentation

Kenya

African Regional Orgnization for Standarization

Eastern and Southern African Management Institute

Environmental Liaison Centre

International Council for Research in Agroforestry

Infoterra

Institute of Computer Science
University of Nairobi

International Laboratory for Research on Animal Diseases

Jomo Kenyatta College of Agriculture and Technology

Kenya Bureau of Standards

Kenya Marine and Fisheries Research Institute

Mazingira Institute

National Council for Science and Technology

National Museums of Kenya
International Centre of Insect Physiology and Ecology

University of Nairobi

UN Development Program

UN Center for Human Settlements

Lesotho

Agricultrual Research Library
Ministry of Agriculture

Lesotho Agricultural College

National University of Lesotho

Liberia

Cuttington University College

West African Rice Development Association

Madagascar

Direction de la Planification Sectorielle

Presidence de la Republique

Malawi

Bunda College of Agriculture
University of Malawi

Chitedze Agricultural Research Station

Malawi Bureau of Standards

Library
Ministry of Health

Mali

Projet de Reforme Administrative

Centre de Technologies Adaptees

Centre Djoliba

Centre Regional d'Energie Solaire

Ecole National de Medicine et de Pharmacie de Mali

Chevalier de l'Ordre National

Institute d'Economique Rurale Institut de Sahel

International Livestock Centre for Africa/Program de Sahel

UN Development Program

Mozambique

Arquivo Historico de Macambique

Centro de Processamento de Dados

Department of Archaeology and Antropology/Universidade Eduardo Mondlane

Escola Nacional de Aeronautica

Televisao Experimental

UNESCO

Niger

Centre de Recherches sur les Meningites et les Schistosomiases

Groupement des Aides Privees

Institut National de Recherches

Ministere de l'Agriculture

Ministere du Plan

Project Planification et Utilisation des Sols et Forets

Section Informatique/Dept. de Formation en Protection des Vegetaux

Nigeria

African Regional Centre for Engineering Design and Manufacturing

Federal Institute of Industrial Research

Ibadan University Library

Nigerian Institute of International Affairs

National Institute for Policy and Strategic Studies

National Library of Nigeria

Senegal

African Regional Centre for Technology

Banque Centrale

Bibliotheque de l'Universite de Dakar

Centre d'Information des Nations Unies

Centre de Documentation Ministere du Plan et de la Cooperation

Council for the Development of Economic and Social Research in Africa

Direction des Archives du Senegal

Environment et Developpement du Tiers Monde

Institut de Recherches en Sciences Mathematiques

International Development Research Centre

Ministere de la Protection de la Nature

Ministere de la Sante Publique

Ministere du Developpement Rural

Societe Regionale de Developpement

Universite de Dakar

Swaziland

Malkerns Research Station

Swaziland National Library Service

University of Swaziland

Togo

Universite du Benin

Zaire

Bureau du President-Fondateur

Centre Cooperation Zaire-Canada

Office Zairois de Radiodiffusion et de Television OZRT

Office des Routes

Appendix E

Selected List of CD-ROM Products

The following list of CD-ROM products shows what is available on the international market. This list has been reproduced from *CD-ROMs in Print 1990: An International Guide*, which was compiled by Norman Desmarais and published by Meckler. The product list is provided here to give our readers a better idea of the growth in this field.

Type Index

Bibliographic

Social Sciences Index
Software-CD
Sport Discus
SuperCAT, The Cataloger's Power Station
Technical Book Advisor: Focused Research Through Artificial Intelligence
TOM™
TOMES™ Information System
TOMES Plus™
TOXLINE on SilverPlatter
U.S. History
UKMARC Databases--EXTC, SCITAT, BBIP
Ulrich's Plus™
Variety's Video Directory Plus
Verzeichnis Lieferbarer Bucher (German Books in Print Plus)
Whitaker's Bookbank CD-ROM
Whitaker's Bookbank OP Service

Bibliographic Databases with Abstracts

A-V Online
Agricola
Arctic & Antarctic Regions (also known as Cold Regions)
Business Periodicals OnDisc
Cancerlit® Knowledge Finder
CD PLUS MEDLINE and CD PLUS Health
CD-CHROM
CITIS CD-ROM--SAFE / CITIS CD-ROM--ICEA
ClinMED-CD
Compact Cambridge Drug Information Source Database
Compact Library: AIDS
Computer Library
Congressional Masterfile I, 1789-1969
Congressional Masterfile II, 1970-1988
Congressional Masterfile II, Current Service
Core Journals MEDLINE®
Cross-Cultural CD
DIALOG OnDisc™ AGRIBUSINESS U.S.A.®
DIALOG OnDisc™ Canadian Business & Current Affairs
DIALOG OnDisc™ ERIC
DIALOG OnDisc™ MEDLINE®
DIALOG OnDisc™ MEDLINE® Clinical Collection
DIALOG OnDisc™ NTIS
DNA Database
DODISS Plus
EINECS plus-CD
Excerpta Medica Library Service CD
General Periodicals Index/Academic Library Edition on InfoTrac
General Periodicals Index/Public Library Edition on InfoTrac
HealthPLAN-CD
IEEE/IEE Publications Ondisc
INIS Atomindex
Library & Information Science Abstracts
Logo-A Pharmaceutical Products
Magazine Article Summaries/EBSCO CD-ROM™
MathSci Disc
National Archive on Sexuality, Health & Adolescence
Natural Resources
Nursing & Allied Health (CINAHL)-CD
OncoDisc
PAIS on CD-ROM
PathLine Database
PDQ (Physicians Data Query)
Periodical Abstracts OnDisc
Pest-Bank
Popline
REX on CD-ROM
sociofile
Sport Discus
Statistical Masterfile
TOXLINE on SilverPlatter
U.S. History
Unabridged MEDLINE®
Water Resources Abstracts

Catalog Processing

BiblioFile Catalog Production
BiblioFile LC-MARC--English
BiblioFile LC-MARC--Foreign
CD-CATSS
CD-FICHE
DISCON
LaserQuest
Law Cataloging Collection
LawMARC
Medical Cataloging Collection
Serials
SuperCAT, The Cataloger's Power Station

Computer Programs

Agri/Stats I
ATARI CD-ROM
Audio CD-ROM Toolbox I
C CD-ROM
CD Assist
CD-ROM CAI System
CD-ROM Developer's Lab™
Consu/Stats I
Econ/Stats I
Econ/Stats II
Educorp CD-ROM 2.0
ELIAS
Food/Analyst™ CD-ROM
Food/Analyst™ Expanded CD-ROM
Food/Analyst™ Professional CD-ROM
HP LaserRom (3000 MPE V)XL
ICP Software Information Database on CD-ROM
KAware™ Disk Publisher
Lasergene
Mega-ROM
Microsoft Programmer's Library
National Archive on Sexuality, Health & Adolescence
Public Domain Software On File CD-ROM
RBBS in a Box
Right Stuffed Macintosh Library, The
Sea-D™ Library of Charts
Shareware Gold
Shareware Grab Bag Vol. III
Encyclopedic/Dictionary
Gale Global Access: Associations
Gefahrgut CD-ROM--Dangerous Substances on CD-ROM
Jostens Learning Corporation Programs
Master Search: Bible -- Comparative Bible Research
McGraw-Hill CD-ROM Science and Technical Reference Set
Merriam-Webster Ninth New Collegiate Dictionary
New Electronic Encyclopedia, The
New Electronic Encyclopedia, The (Macintosh version)
Oxford English Dictionary on Compact Disc
Photo Gallery
Repertorio del Foro Italiano 1981-1987
Termdok
Time Table of Science and Innovation
Van Dale Lexitron
Van Dale Lexitron Plus

Computer Documentation

HP LaserRom (3000 MPE V)XL

Computer Games

Defender of the Crown

Directory

Der Runde Herold (The Round Herald)
Ditte Italiane Operanti con l'Estero
PhoneDisc
The Postcode Address File on CD-ROM
Real Estate Transfer Database 1982-1987: Massachusetts & Connecticut
Real Estate Transfer Database 1987-1988: Massachusetts & Connecticut
Telerom
Training, Education, and Careers

Financial Markets Courseware

Telerate Expert

Full Text Sources

1986 County Business Patterns
1989 ASME Boiler & Pressure Vessel Code
ABC CD-ROM on Dutch and Belgian Companies

Physician's Desk Reference on CD-ROM
Pirelli Tire Catalogue
Place-Name Index
Plus38: Total Access Diffraction Database
Popline
Pronouncing Disc
Publishers' International Directory
Qualified Products Lists
RealScan Real Estate Information Management (Dade County and Broward County Florida)
Registry of Mass Spectral Data--5th edition
Repertorio del Foro Italiano 1981-1987
Repertorio della Giurisprudenza Italiana
REX on CD-ROM
Right Stuffed Macintosh Library, The
ROM Research Guide to Literature and History
SchoolMatch
Science Helper K-8
Selected Water Resources Abstracts
Serials Directory/EBSCO CD-ROM™, The
Sherlock Holmes on Disc
SHOKUINROKU
Skelleftebor under 200 ar
South Australian Parliamentary Debates (Hansard)
Spanish Construc Norms
Sport Discus
Standard and Poor's Corporations
State Education Encyclopedia, The
Svenska Databaser (Swedish Databases), Databas Sverige (Database Sweden)
Swedish National Company Telephone Catalog
Swiss Telephone Directory
Tariffe Doganali
Tax Library
Tax Treaties
Technical Logistics Reference Network
Teknovideo
Texas Attorney General Documents
Thomas Register of American Manufacturers
Time Table of Science and Innovation
TLG Databank of Ancient Greek Texts
TOXLINE on SilverPlatter
Tuttobilancio
Type 'N' Talk
U.K. Postcode Address File on CD-ROM
U.S. Civics/Citizenship Disc
U.S. History
VFGH 1919-1986
Washington PressText
Women in Development
Women: Partners in Development
World Factbook
World Weather Disc™
Worldscope Profiles/CD
Year Book on Disc

Graphic Databases

Ad Art Image Library
Aerospatiale Airbus A320
Art Room™ 3.0
Bechtel First
CAP cd-rom
CD-MAP
CD-ROM Developer's Lab™
CD-ROM Sourcedisc
Census 86: The 1986 New Zealand Census
Census of Australian Population & Housing, 1981 and 1986
Census of England, Scotland and Wales, Small Area Statistics, 1981
Census of Hong Kong, 1981 and 1986
Census of Sweden, 1970 to 1987
Chrysler Parts Access Information System (PAIS) Catalog
Comstock Desktop Photography
Conquest® Marketing Information System
Construction Information Database
County Business Patterns 1985
Dark Room™
Drugs and Crime CD-ROM
ei: IntelliFile
Einaudi Encyclopedia
Electromap World Atlas
Electronic Atlas of Arkansas
Electronic Encyclopedia of Art
Electronic Library Construction Information Database
Electronic Map Cabinet
Electronic U.S. Patent Library
ETAK--National Transportation Network
EXOTICA-ROM
Federal Logos Disc part of Spectrum
FEDSTAT ™/1990 Census TIGER Files on CD-ROM
First National Item Bank & Test Development System
Florida East Coast Sea-D
General Motors Electronic Parts Catalog
GEOdisc
GEOdisc Florida Atlas
GEOdisc GEORGIA Atlas
GEOdisc US Atlas
Geophysics of North America
GLORIA Sidescan Sonar Data
Government Raster Image Processing Software and Data
Graphics Lab
Honda/Acura Electronic Parts Catalog
Hong Kong 1981 Census and 1986 by-Census
Image Folio
InfoMark
Infomark Laser PC System
INHOUSE Complete '88
Jaguar
Kwikee INHOUSE Graphic Services
Kwikee INHOUSE Pal Professional Art Library--"Potpourri" Collection
LaserDisclosure
Mega-ROM
Merriam-Webster Ninth New Collegiate Dictionary
MESC Catalog
MUNDOCART/CD
National Geographic Data of Sweden
National Medical Slide Bank
New England Coast Sea-D
Nimbus Music Catalogue
Notable Americans from the National Portrait Gallery
PATENT Database
Pediatrics on Disc
Photo Gallery
ProArt Professional Art Library--Business Collection
ProArt Professional Art Library--Holidays Collection
ProArt Professional Art Library-- Sports Collection
Science Helper K-8
Sea-D™ Library of Charts
Seals of the U.S. Federal Government
Sherlock Holmes on Disc
Space Science Sampler Vol. 1
Space Science Sampler Vol. 2
Spectrum
SUPERMAP STF1-C, STF3-C, CO-STAT2, STF1-A
Time Table of Science and Innovation
Wheeler Quick Art
World Atlas
Year Book on Disc

Music

CD-MusicFile
CD-Play

Numeric Databases

1982 Census of Agriculture
1985 American Housing Survey
1985/86 Retail Industry Census Australia
1985/86 Standardised Local Government Statistics
1986 County Business Patterns
1987 Economic Censuses Reports Series
ABC CD-ROM on Dutch and Belgian Companies
ADC CD-ROM
Agri/Stats I
Agricultural Data Dissemination Service
Annual Accounts of Belgian Enterprises
Australia on Disc
Australian Municipal Information System
Bechtel First
Business Indicators
Business Statistics
Canadian Postal Directory
CAP cd-rom
CD-FOREX
CDATA 86: The 1981 and 1986 Australian Censuses
Census 86: The 1986 New Zealand Census
Census of Australian Population & Housing, 1981 and 1986

Program Code

Public Access Catalogs

Reference

Multilingual Technical Dictionary
National Technical Information Service
NewsBank Electronic Index
NICEM
NIOSH Criteria Documents and Intelligence Bulletins
Nurse Library, The
NYNEX FAST TRACK™ Digital Directory
O & D Plus
OPTEXT
Oxford English Dictionary on Compact Disc
PC-Sig Library on CD-ROM
Peterson's College Database
Peterson's Gradline
Physician Library, The
Pirelli Tire Catalogue
Place-Name Index
Plus38: Total Access Diffraction Database
POISINDEX® Information System
Publishers' International Directory
RAINBOW, The Connection BusinessBase
RAINBOW, The Connection HomeBase
Real Estate Data: Washington DC Metro Area
Real Estate Transfer Database 1982-1987: Massachusetts & Connecticut
Real Estate Transfer Database 1987-1988: Massachusetts & Connecticut
Registry of Mass Spectral Data--5th edition
Robotics CD-ROM Database
ROM Research Guide to Literature and History
Selected Water Resources Abstracts
SilverDAT
Sistema Ditte Operanti con L'Estero
State Education Encyclopedia, The
Swiss Telephone Directory
Technical Book Advisor: Focused Research Through Artificial Intelligence
Texas Attorney General Documents
TOM™
TOMES™ Information System
TOMES Plus™
Tuttobilancio
Ulrich's Plus™
Universe of Sound, Volume I
Universe of Sound, Volume II
Verzeichnis Lieferbarer Bucher (German Books in Print Plus)
WER LIEFERT WAS? ['Who supplies what?']
World Atlas
YMC Your Marketing Consultant

Sound Library

Audio CD-ROM Toolbox I

Time Table

Railrom

Typeface Library

LetterPress™

Subject Index

Business

1985/86 Retail Industry Census Australia
1986 County Business Patterns
1987 Economic Censuses Reports Series
ABC Europ Production
ABC Industrial Database
ABI/INFORM ONDISC
Analisi Strategica Imprese Affidate
Australian Business Connection
Bechtel First
Business Indicators
BUSINESS PERIODICALS INDEX
Business Periodicals OnDisc
CD-FOREX
CD-Town Pages
Census Test Disc #2
Centrale des Bilans (Annual Accounts of Belgian Enterprises)
Compact Disclosure
Compustat® PC Plus
Compustat® PC Plus Corporate Text
Construction Activity Locator™
Construction Information Database
Consu/Stats I
CorFile on Disc (previously announced as Brief/Case)
Corporate & Industry Research Reports
County & Metro Area Income and Employment
County Business Patterns 1985
Der Grosse Elektronik Atlas
DIALOG OnDisc™ AGRIBUSINESS U.S.A.®
DIALOG OnDisc™ Canadian Business & Current Affairs
DIALOG OnDisc™ IDD M&A Transactions Database
Disc America™--Business
Ditte Operanti con L'Estero
DOCBANK
Econ/Stats I
Econ/Stats II
ElectriGuide™ CD-ROM
European Kompass on Disc
FORM41--Airline Financial Statistics
ICP Software Information Database on CD-ROM
InfoMark
Infomark Laser PC System
Kompass on Disc
Labor/Stats
LaserDisclosure
Lotus One Source: CD/Banking
Lotus One Source: CD/Corporate
Lotus One Source: CD/International
Lotus One Source: CD/Investment
Lotus One Source: CD/M&A
Lotus One Source: CD/Private+
LynSvar
MetroScan
Microsoft Small Business Consultant
Microsoft Stat Pack
Million Dollar Directory
Moody's 5000 plus™ on CD-ROM
Moody's International plus™ on CD-ROM
National Directory of Addresses and Telephone Numbers
National Geographic Data of Sweden
O & D Plus
PHINet CD-ROM
RealScan Real Estate Information Management (Dade County and Broward County Florida)
Salescan
SilverDAT
Software-CD
Standard and Poor's Corporations
Standard and Poor's Corporations
State Income and Employment
Swedish National Company Telephone Catalog
Swiss Telephone Directory
Tariffe Doganali
Tax Library
Telerate Expert
Thomas Register of American Manufacturers
Tuttobilancio
WER LIEFERT WAS? ['Who supplies what?']
Women in Development
Worldscope Profiles/CD
YMC Your Marketing Consultant

CD-ROM Development

CD-ROM Developer's Lab™

CD-ROM Information

CD-ROM Sourcedisc

Chemical

EINECS plus-CD

Clip-Art

Art Room™ 3.0
Seals of the U.S. Federal Government
Wheeler Quick Art

Communications

Telecommunications Abstracts

Computer Programs

Educorp CD-ROM 2.0
Public Domain Software On File CD-ROM
ICP Software Information Database on CD-ROM
Shareware Gold

Computers

ADA-ROM
ATARI CD-ROM
Between Heaven and Hell
C CD-ROM
CD-ROM Explorer
CD-ROM Sourcedisc
Computer Library
Computer-Specs (formerly Compu-Info)
DECUS Fall 1986 CD-ROM Disc #1
DECUS Fall 1987 CD-ROM Disc #3
DECUS Spring 1987 CD-ROM Disc #2
HP LaserRom (3000 MPE V)XL
MENU International Database
Microsoft Programmer's Library
PC Blue Library
PC-Sig Library on CD-ROM
PUB.DOM
Shareware Xpress
Software Plus
Virginia Disc Series: VADISC 1

Construction

Construction Information Database
Electronic Library Construction Information Database

Desktop Publishing

Art Room™ 3.0
Clip Art 3-D
Dark Room™
Image Folio
INHOUSE Complete '88
ProArt Professional Art Library--Business Collection
ProArt Professional Art Library--Holidays Collection
ProArt Professional Art Library--Sports Collection
Wheeler Quick Art

Directories

A-V Online
ABC Europ Production
ABC Industrial Database
Address Verification System Plus
Australia on Disc
CD Yellow Pages
CD-ROM Sourcedisc
Computer-Specs (formerly Compu-Info)
CorFile on Disc (previously announced as Brief/Case)
Datenbank Leitverzeichnisse (Registers of Places and Streets)
Der Runde Herold (The Round Herald)
Directory of Library and Information Professionals
Ditte Italiane Operanti con l'estero
ECCTIS Courses Guide
Gale Global Access: Associations
Hoppenstedt Handbook of Large and Middle-Sized Companies
INFODIRECT--Canadian White Pages on CD-ROM
Informatore Farmaceutico
Kojien

NEIC Database
New England Coast Sea-D
NGDC-01
Norwegian CD-ROM No. 1
Place-Name Index
Right Stuffed Macintosh Library, The
Sea-D™ Library of Charts
Selected Water Resources Abstracts
Shareware Grab Bag Vol. III
SUPERMAP STF1-C, STF3-C, CO-STAT2, STF1-A
USGS Publications
Virginia Disc Series: VADISC 1
Water Resources Abstracts
World Atlas

Government Information

1985 American Housing Survey
1986 County Business Patterns
1987 Economic Censuses Reports Series
ADA-ROM
Agri/Stats I
Catalogue of United Kingdom Official Publications
CD-2
CD-FICHE
Census Test Disc #2
CIA World Factbook
Congressional Masterfile I, 1789-1969
Congressional Masterfile II, 1970-1988
Congressional Masterfile II, Current Service
Construction Criteria Base
Consu/Stats I
County and City Data Book 1988
Decisions of the Austrian Supreme Court
DIALOG OnDisc™ NTIS
Econ/Stats I
Econ/Stats II
Electronic U.S. Patent Library
ENFLEX INFO
Federal Logos Disc part of Spectrum
Federal Procurement System
Government Documents Catalog Service
Government Publications Index on InfoTrac
Government Raster Image Processing Software and Data
GPO Monthly Catalog
GPO Monthly Catalog & Index to Periodicals
GPO on SilverPlatter
Haystack™ III
INDEX TO U.S. GOVERNMENT PERIODICALS
Kokai-Tokkyo-Koho
Laserbook PRF CD-ROM
Material Safety Data Sheets
Microsoft Stat Pack
National Meteorological Center Grid Point Data Set
National Technical Information Service
Natural Resources
NTIS
Parts-Master
PATENT Database
PERSONNET
Qualified Products Lists
Robotics CD-ROM Database
Science Citation Index Compact Disc Edition
Seals in the Government Printing Office
Swiss Telephone Directory
Women in Development

Health see Food & Health, Medicine & Health

History (except U.S.)

Fast Past
Skelleftebor under 200 ar
U.S. Civics/Citizenship Disc

History (U.S.)

Constitution Papers
ROM Research Guide to Literature and History
Spectrum
U.S. Civics/Citizenship Disc
U.S. History

Humanities see also Fine Arts, Philosophy & Religion

HUMANITIES INDEX

Hydrology

Hydrodata: USGS Peak Values
Selected Water Resources Abstracts

Industry Standards

1989 ASME Boiler & Pressure Vessel Code

Language & Literature

BOOK REVIEW DIGEST
CD-Word
DiscLit: American Authors
Harrap's Multilingual CD-ROM Dictionary Database
HUMANITIES INDEX
MLA International Bibliography
Oxford English Dictionary on Compact Disc
Readers' Guide Abstracts
Readers' Guide to Periodical Literature
ROM Research Guide to Literature and History
Shareware Grab Bag Vol. III
Sherlock Holmes on Disc

Law

Bankruptcy Library
Bender's Federal Tax Service
BNA Tax Management Portfolios Library
Codice Civile
Codice del Lavoro
Codice Tributario
Compuley
Decisions of the Austrian Supreme Court
Decisions of the Swiss Federal Court since 1960
Diocles
ENFLEX INFO
European Fiscal Law
Federal Civil Practice Library
Federal Tax Library
Fiscovideo
Government Contracts Library
Great American Authors on CD-ROM
I Quattro Codici della Riforma Tributaria
IBFD Tax Treaty Database
Index '87
INDEX TO LEGAL PERIODICALS
Juridische Bibliotheek deel 1A
Juridische Bibliotheek deel 1B
Justis CD-ROM
Jusvideo
Kluver Legal Databank
Law Cataloging Collection
LawMARC
LAWPAC (CD-ROM) Case Law Series New South Wales
LAWPAC (CD-ROM) Case Law Series South Australia
LAWPAC (CD-ROM) Case Law Series Tasmania
LAWPAC (CD-ROM) Case Law Series Victoria
LegalTrac on InfoTrac
Mohan-Roppo-Zensho
OGH-SZ 1946-1987
OPTEXT
PERSONNET
PHINet CD-ROM
Repertorio del Foro Italiano 1981-1987
Repertorio della Giurisprudenza Italiana
Tax Library
Tax Treaties
Teknovideo
Texas Attorney General Documents
VFGH 1919-1986

Library & Information Science

ADONIS
ALICE CD-ROM: Italian Books in Print on CD-ROM
BiblioDisc
BiblioFile Catalog
BiblioFile Catalog Maintenance
BiblioFile Catalog Production
BiblioFile Intelligent Catalog
BiblioFile LC-MARC--English
BiblioFile LC-MARC--Foreign
Bok-Sok
BOOK REVIEW DIGEST
Books in Print Plus™

Academic Index on InfoTrac
Ad Art Image Library
Big CD-ROM
Business Periodicals OnDisc
Computer Library
Daily Oklahoman
Dataplattan
DIALOG OnDisc™ Canadian Business & Current Affairs
Facts On File News Digest CD-ROM
General Periodicals Index/Academic Library Edition on InfoTrac
General Periodicals Index/Public Library Edition on InfoTrac
Globe and Mail, The - 1985 editions
Health Index on InfoTrac
IEEE/IEE Publications Ondisc
LegalTrac on InfoTrac
Magazine Article Summaries/EBSCO CD-ROM™
Magazine Index Plus on InfoTrac
Magazine Index Select
National Newspaper Index on InfoTrac
NewsBank Electronic Index
Newspaper Abstracts Ondisc
Nordisk Media CD-ROM
Online Hotline News Service™ on CD-ROM
Periodical Abstracts OnDisc
Serials Directory/EBSCO CD-ROM™, The
TOM™

Parts Catalog see Reference

Patents

CASSIS/CD-ROM

Philosophy & Religion

Between Heaven and Hell
Bible Library®, The
Die Bibel. 3 deutsche Ubersetzungen
FABS Electronic Bible System
FABS Reference Bible System
HUMANITIES INDEX
Master Search: Bible -- Comparative Bible Research
Religion Indexes
REX on CD-ROM

Political Science

Congressional Masterfile I, 1789-1969
Congressional Masterfile II, 1970-1988
Congressional Masterfile II, Current Service
GPO Monthly Catalog & Index to Periodicals
GPO on SilverPlatter
INDEX TO U.S. GOVERNMENT PERIODICALS
Le Pac: Government Documents Option
Social Sciences Index
South Australian Parliamentary Debates (Hansard)
Washington PressText
World Factbook

Public Policy

PAIS on CD-ROM

Publishing

Electronic Publishing with CD-ROM and CDT, Techniques and Applications

Reference (Including Parts Catalogs)

1989 ASME Boiler & Pressure Vessel Code
Aerospatiale Airbus A320
ALICE CD-ROM: Italian Books in Print on CD-ROM
Automobile Parts Information System
Bibliographie Nationale Francaise depuis 1975 sur CD-ROM
British Library General Catalogue of Printed Books to 1975
British National Bibliography on CD-ROM
CAP cd-rom
CD-2
CD-FICHE
CD-ROM Developer's Lab™
Central Catalogue Belgium
Chrysler Parts Access Information System (PAIS) Catalog
Deutsche Bibliographie Aktuell CD-ROM
EDS CD-ROM
ei: IntelliFile
Electronic Library Construction Information Database
Electronic Map Cabinet
General Motors Electronic Parts Catalog
Haystack™ III
Honda/Acura Electronic Parts Catalog
HP LaserRom (3000 MPE V)XL
IC/Discrete Parameter Database Service
Laserbook PRF CD-ROM
Mega-ROM
Merriam-Webster Ninth New Collegiate Dictionary
MESC Catalog
Microsoft Bookshelf
Microsoft Programmer's Library
National Directory of Addresses and Telephone Numbers
OPAC auf CD-ROM Universitatsbibliothek Bielefeld
Pirelli Tire Catalogue
The Postcode Address File on CD-ROM
Registry of Mass Spectral Data--5th edition
Right Stuffed Macintosh Library, The
Seals of the U.S. Federal Government
Serials Directory/EBSCO CD-ROM™, The
Sigma-Aldrich Material Safety Data Sheets
Software Plus

Rural Development

KIT Abstracts

Safety

OHS MSDS ON DISC
OSH-ROM

Science & Technology

Acid Rain
ADC CD-ROM
ALDRICHEM Data Search™
Applied Science & Technology Index
Arctic & Antarctic Regions (also known as Cold Regions)
CD-CHROM
CITIS CD-ROM--SAFE / CITIS CD-ROM--ICEA
Climatedata 15 Minute Precipitation
Climatedata Clim-20
Climatedata--Hourly Precipitation
Climatedata--Summary of the Day
Compact Cambridge Aquatic Sciences and Fisheries
Compact Cambridge CANCERLIT
Compact Cambridge Pollution/Toxicology
Computer Library
Conference Proceeding
DECUS Fall 1986 CD-ROM Disc #1
DECUS Fall 1987 CD-ROM Disc #3
DECUS Spring 1987 CD-ROM Disc #2
DIALOG OnDisc™ Compendex Plus CD-ROM
DIALOG OnDisc™ NTIS
DNA Database
Earthquake Data
EINECS plus-CD
ElectriGuide™ CD-ROM
Electronic U.S. Patent Library
Energy Information
Energy Library
Environment Abstracts
Environment Library
GALE Data Set
Gefahrgut CD-ROM--Dangerous Substances on CD-ROM
GENERAL SCIENCE INDEX
Guide Star Catalog
Government Raster Image Processing Software and Data
Hydrodata Candian Surface Water Data
Hydrodata USGS Quality of Water
Hydrodata USGS Remarks
Hydrodata: USGS Daily Values
IC/Discrete Parameter Database Service
IEEE/IEE Publications Ondisc
INIS Database on CD-ROM (International Nuclear Information System)
INIS Atomindex
Kokai-Tokkyo-Koho

YMC Your Marketing Consultant

Taxation

CCH 1989 Australian Master Tax Guide
CCH Tax Reform Guides

Toxicology

TOXICHEM

Transportation

FORM41--Airline Financial Statistics

Travel & Tourism

Indian Tourism Information
Jaguar

Typefaces

LetterPress™

Weather

GALE Data Set
Surface Weather Disc

Women's Studies

Women in Development

Appendix F

Selected Readings
Science and Technology Information in Africa

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Brown, Jane E. and Helgerson, Linda W. (1989) *Using CD-ROM: A Collection of Product Appraisals by Users.* Langley Books, Key West, Florida.

Byerly, Greg (1989) *Online and On-Disc Searching: A Dictionary and Bibliographic Guide.* Libraries Unlimited, Inc., Englewood, Colorado.

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Guinchat, Claire and Michel Menou (1983) *General Introduction to the Techniques of Information and Documentation Work.* UNESCO, Paris France.

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Mann, Charles, M. Grindle and P. Shipton (1989) *Ask Aries Knowledgebase and Seeking Solutions: Framework and Cases for Small Enterprise Development Programs.* Kumarian Press, West Hartford, Connecticut.

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United Nations Economic and Social Council (1989) Report on a Survey of User Needs. Fourth meeting of the Regional Technical Committee for PADIS. Economic Commission for Africa, Addis Ababa, 23-25 March 1989.

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Useful Journals

CD-ROM End User. Monthly. DDRI, Inc., 510 North Washington Street, Suite 401, Falls Church, VA 22046-3537.

Computers in Africa. Bi-monthly. Africa File Ltd., 21 Mill Lane, London NW6 1NT, UK.

Information Processing and Management. Bi-monthly. Pergamon Press.

Information Services and Use. Bi-monthly. Elsevier Science Publishers B.V.

Library Hi-Tech Journal. Quarterly. Pierian Press, P.O. Box 1808, Ann Arbor, MI 48106.

Library Hi-Tech News. Bi-monthly.

Library Software Review. Bi-monthly. Meckler Publishing.

Library Systems Newsletter. Monthly. American Library Association.

Library Technology Reports. Bi-monthly. American Library Association.

Library Workstation and PC Report. Monthly. Meckler Publishing.

Online. Bi-monthly. Online, Inc.

Small Computers in Libraries. Monthly. University of Arizona. Graduate Library School.