INFORMATION TECHNOLOGIES AND THEIR APPLICATION TO DATA MANAGEMENT

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Martha B. Stone
Director
Information Sciences
I.D.R.C.
Ottawa, Canada

I. INTRODUCTION

Panel IV will address the subject of information technologies and their application to data management. Before we hear from our three panelists, I wish to establish the parameters within which our presentations and subsequent discussions will take place. I should like to return to the quote from **Our Common Future** which sets the tone for this conference. "The technologies of industrial countries are not always suited or easily adaptable to the socio-economic and environmental conditions of developing countries... Not enough is being done to adapt recent innovations in materials technology, energy conservation, information technology and biotechnology to the needs of developing countries. These gaps must be covered by enhancing research, design, development and extension capabilities in the Third World."

Over the past decade, information has been gaining recognition as a key element in the development process. Certainly, researchers know that information is crucial to their work. Good research is based on first collecting and organizing information about the field or problem under study, developing and carrying out the research program in question, and then ensuring that the results of this work are made available to the information pool. Information systems which support research activities, both commercial and public-sector, are designed to facilitate this information flow. The concepts of "knowledge industries" and "knowledge workers" are gaining rapid acceptance in developed countries, where statistics show that an increasing proportion of the population is involved with these activities. Developing countries are recognizing the advantages and necessity of an adequate information base for their development. In fact, some developing countries are hoping, at least in limited sectors, to pass over the industrialization stage and go directly to information-based industries. The effective use of information technologies is a key ingredient in this process.

Technological developments, especially through the tools which they have engendered, have facilitated and popularized all aspects of the information cycle. These tools are a necessary response to the "information explosion" which has threatened to overwhelm potential information users, at the same time as it has held forth the promise of so many answers to so many questions. In most cases, it is the tool built out of the technology, rather than the inherent technology itself, which is of interest and relevance to information specialists and users.

For most purposes, when one speaks of "information technologies" one is referring to a particular class of technology-based tools. These are the "electronic", informatics-based tools, which manipulate and communicate digital information. These tools collect, process, store, retrieve, and transmit the bits and bytes which represent information. In fact, today, "information technology" and "computer technology" are sometimes taken to be synonymous. Data processing systems are now information systems. Communications is telecommunications. Thus, when one speaks of information technologies, one is really talking about informatics-based tools and systems. And even if one is not directly referring to computers, it is evident that they are quickly becoming an integral part of the attendant technological systems. For example, although there is still much data collection which is done without computer assistance, much of the research analysis work is done using computers, and the information is converted to digital form at some point in this process. Remote sensing applications can produce analogue media rather than digital, but digital processing and enhancement techniques are those which are becoming most important. The "technologies" which are relevant to information systems are, for the most part, those which interface with computers.

Is this progression to informatics-based tools inevitable? If so, given present limiations of financial resources, skilled manpower, and infrastructure, how can they be most effectively introduced in developing countries? Although the tools are essentially neutral in and of themselves, their application can lead to both positive and negative consequences. Some tools are better than others: how does one select? Developing countries are especially interested in issues such as: who developed the tools; who exercises control over them; can the technologies be transferred; in which sector can and should they be applied; what are the economics of the introduction of such tools; what are the social consequences?

However, even before such questions are raised and debated, with regard to any particular tool or technology, there is the question which is usually raised first: is the tool or technology in some sense "appropriate" for developing countries? The danger here is that because of circumstances in force at the moment, a particular technology or tool may be prejudged as "inappropriate" and rejected. There is a need for informed choice, based on sufficient research, experimentation, and analysis. This is especially the case since often some sort of implicit pre-selection process is carried out by the developed countries or by agencies involved in the transfer of technology, even if they do not do so deliberately.

If one accepts that information technologies are indeed relevant for many developing-country information needs, this leads one immediately to a set of broader questions. How important is it to emphasize the need for national planning in the introduction and development of information technologies? Is there really a potential "information industry" in some of the less technologically-developed regions in the near future? Would such an industry include, for example:

production of software packages; production of specialized hardware of general purpose microcomputers; adaptation of software or hardware to local needs; commercial data base and information services; information access and facilitation services; value-added communications services?

Other important points include to what extent do tools produced in develped countries really need adaptation? Would it be best to emphasize widespread introduction of many types of technologies and tools or limited adaptation of fewer? Is local technology development desirable and feasible? Given the variety of types of technology and possible application areas, which should receive priority? Are there any for which a small investment now is likely to have a more immediate multiplier effect? As can be seem from these questions, the list of issues is extensive.

Information technologies include manual methods, computers, micrographics, telecommunications systems, remote sensing, and so on. However, it is especially in the area of modern information technologies and informatics that the information gap is widest in developing countries.

Information specialists as well as users require information on: the "state of the art" in information methods and technologies, including trends; technologies adapted for particular circumstances or working conditions; case studies of both successful and unsuccessful information systems and approaches; local availability, cost, and experiences with particular technologies; local policies and regulatory conditions (especially in the area of telecommunications); local sources of technical expertise; and so on. This information is required to permit informed choice in the selection of tools and technologies, to allow for effective sharing of experience and expertise in a region where resources are limited, and to encourage the development of realistic user-oriented applications which solve real-world information problems.

II. ISSUES

IDRC, the International Development Research Centre, is a public corporation created by the Parliament of Canada in 1970 to stimulate and support scientific and technical research by developing countries for its own benefit. Although the Centre was funded by Parliament, its programs and operations are guided by an international twenty-one

member Board of Governors; eleven are Canadians and, of the remaining ten, seven are developing country scientists and researchers.

Currently there are five broad themes which guide IDRC's program delivery: **Skills Enhancement:** every society is capable of enhancing its human resources by providing them with the basic skills for taking responsibility for their own well being and for making a self-fulfilling contribution to the greater community; **Physical Well-being:** each woman, man, and child exists in a condition of physical well-being, derived from an environment providing access to the appropriate goods, systems and services; **Economic Participation:** every society is able to harmonize the use of all its resources by providing opportunities for adequate incomes and for individual contributions to indigenously determined development goals; **Food Security:** consistent with adequate and equitable returns to resources and with environmental protection, each household, community and nation is able to provide its members with a secure, regular, and nutritious diet; and **Technological Choice:** each nation attains a state of technological democracy by being able to obtain information about the available technological candidates; to generate its own candidates; to bargain and vote freely for those it chooses; and to stop using and depending on those that no longer give net social and economic gains.

Within this thematic framework, the Centre assists developing countries build the scientific competence of their institutions and researchers so that these countries can be in control of the processes by which their problems can be solved. Thus Centre-supported research projects are identified, designed, conducted and managed by developing country researchers in their own countries, in response to their own priorities. More specifically, the fields of investigation to which IDRC gives its financial and professional support include farming; food storage, processing and distribution; forestry; fisheries; animal sciences; energy; tropical diseases; water supplies; health services; education; population studies; economics; communications; urban policies; earth and engineering sciences; science and technology; and information sciences.

It is this last field of investigation, information sciences, to which I would like to address my comments; and, more specifically, highlight some of the issues relating to the useful and effective application of information technologies (defined in my introductory comments at the beginning of the Panel) to the processes of information handling, transfer, and utilization.

A first issue is the **need for training in informatics-based information techynologies.** It is generally accepted that an area in which training in especially important for information professionals is that related to information technologies, tools, and methodologies - the means by which information specialists do their work. Information workers themselves have a tremendous on-going need for information in numerous domains, their training should provide them with the basic information set and the means to acquire updating on an on-going basis (through continuing education, access to relevant

information services, etc.). This aspect of updating is especially critical with relation to the rapidly changing new information technologies.

Of course, any specific curriculum needs to be tailored to the level, needs, and likely working environment of the individual in question. The key element is to teach enough so that information specialists can make informed choices or can effectively use technical expertise gained.

In addition, there is the issue of providing technical training to produce the ensemble of technical skills needed to support the information technologies themselves. This is related to the overall question of building up local information/information technology industries and infrastructure. It seems clear that regional and cooperative approaches are needed in many cases.

One area of particular concern is the difficulty in communication between information professionals and those involved with the supporting technologies, for example, between documentalists and computer systems analysts and programmers. Just as it is important that information professionals be exposed in their training to computer-based applications, so too should computer professionals be exposed to **information** applications.

A second issue is the **need for local information and informatics industries.** In many developed countries, the "information" sector is already recognized as an important one in the economy, especially if one includes activities which produce or integrate the technologies, tools, and services to support it (including, for example, computers, software, data communications, etc.). However, in some developing regions, this sector is very small and often virtually unrecognized, even as a potential vehicle for economic development. Many factors contribute to this situation: shortages of skilled personnel, training and research facilities, telecommunications and industrial infrastructure, policies, professional bodies, and so on; furthermore, it would be unrealistic to expect major shifts into this area in the short term. Related to this is the fact that information is not often seen as a commodity of value, one that must be paid for somewhere along the way; this especially inhibits the financing of an information services sector, whether commercial or public sector.

It is evident that the ability to offer information services and to develop information technology skills is enhanced by a local capacity to produce, adapt, and maintain the technologies and tools; conversely, any local industry depends on a market and a supply of skilled personnel.

A key ingredient to the ongoing success of any information project is the availability of local technical expertise. This expertise can be required for training, system analysis and design, implementation, ongoing technical support, maintenance, evaluation, etc. The advantages are evident: familiarity with local conditions, constraints, cultural factors; local contacts; ability to work in local lanaguages; follow-up and ongoing support and availability to respond to queries and (usually) a lower cost payable in local currency. However, the local supply of persons with such expertise may be extremely limited and sometimes in great demand; in addition, the depth and breadth of experience and familiarity with the latest advances in technology may be less than those of a "foreign" expert. Note that in this context, "local" expertise is taken to mean national or even regional as opposed to that coming from a developed country.

In some of the more technologically-advanced countries, the "information sector" is being viewed as one client of a potential "informatics" industry -- one involving computer hardware, software, and applications for a variety of uses including public and private administration, resource management, planning, and, of course, information. It appears that to be successful, regional strategies and cooperation will be required (to support the training, capital, and market needs), and that the emphasis should be on software and other non-capital-intensive (but information-intensive) industries. The entry point for effective immediate action in many developing countries appears to be applications involving the microcomputer.

While information programs require adequate infrastructure, including local information and information technology industries, there are other related areas in which assistance can be provided: sensitization of policy-makers to the importance of information as a tool for development; promotion of national policies in information and information technologies; support for the development and use of appropriate information technologies in information projects in the region; training; studies on specific needs for information sciences and informatics technologies (e.g. the types of software required in priority development disciplines); and so on. Finally, improved information services on the relevant technologies can promote greater awareness of existing gaps, and hence opportunities for the development of products and services.

An important third issue is the **need for local experimentation with and adaptation of information technologies.** Even when specific information technologies are known in developing countries there is often a lack of local experience with the technologies. This lack of experience is often tied to other lacks: training, local expertise, maintenance, etc.; in many ways, it is a vicious circle.

Experience with a tool or technology can be gained in essentially two situations: when the object of the exercise is experimentation/ testing/adaptation of the tool or technology, or when the tool or

technology is simply being used to carry out some function within an information system. It should be noted that, in the former case, the testing should still be linked to a "real-world", user-driven application, although certain experimental constraints or conditions can be imposed; in the latter case, some attention can still be placed on evaluating the "appropriateness" and success of the tool or technology in question. In both cases, user feedback and evaluation are crucial.

Adaptation refers to making changes to the tool or technology itself or to the way it is used in order to make it more "appropriate" to the use or application at hand. Thus, changes to hardware, software, language, character set, documentation, interfaces, application for which used, or even environment in which used, can all be considered adaptations. To the extent that such work can involved major changes, novel approaches, innovative uses of the technique or development or new technologies and tools, this adaptation process can be considered applied research.

The reality of the situation in developing countries today, especially with regard to the newer information technologies, is that these are imported from the developed world. Without going into a debate on the desirability of this approach in the long-term or the likelihood of a local information/information tools industry, it appears that working with imported technologies is here to stay in many developing countries for quite some time and has the potential to greatly assist with information delivery and development processes.

The final issue I wish to address is the **need for "appropriate" information tools and technologies.** In establishing and operating information systems and services, information workers make use of a variety of information tools, technologies and methods -- both manual and automated. The selection of these tools and technologies, especially at the design stage of an information system or service, usually has a major impact on the requirements for funding, personnel, infrastructure, and connections to other systems, and on the overall effectiveness of the activity. However, the choice of an appropriate tool or technology is often a difficult one, depending upon: local infrastructure; available information; experience with and availability of adapted, documented, and useable tools or technologies; local expertise; and standards.

But what is an appropriate" tool or technology? Is it to be appropriate with reference to: training and skills of the personnel who will use it (present or potential), clientele for whom it will ultimately be used, institutional environment, local infrastructure, physical requirements, local support and maintenance, financial resources, functional requirements, volume and type of information to be handled, regulatory constraints, current practices of other related information services, standards, changing circumstances and conditions, etc.? Ideally all of the above conditions apply, as well as others. Each case must be studied carefully and individually before a choice is made.

INFORMATION SCIENCES DIVISION: PROGRAM

Many of the information technologies which have been discussed are being assessed, applied, and evaluated in several projects supported by IDRC's Information Sciences Division. Two major programs are of relevance here, the Science and Technology Information, which has a very important sub-program Earth and Marine Sciences. The capacity of developing countries to maintain control over their natural resources on land and in the ocean is considered to be of major and increasing importance, thus the Earth and Marine Sciences sub-program supports information projects dealing with agroclimatology, fisheries, forestry, geology, hydrological sciences, soils, natural resources, and energy. Within the fisheries sector, all aspects of information activity relating to living marine resources management, including aquaculture, are considered. Within the hydrological sciences sector the development, management, and control of all water resources - surface and groundwater and salt and fresh water are considered of priority; and emphasis is placed upon irrigation and watershed and river basin management.

The second major program is managed by the Information Tools and Methods Section (ITM). This program was established to assist developing countries to acquire, manage, adapt, develop, and test appropriate information-handling tools using a variety of technologies and methods.

The telematics sub-program, within ITM, supports institutions in the testing, adapting, and using computer-messaging, bulletin board, and conferencing systems using non-real time and relatively low-cost data communication techniques; regular telephone networks, packet-switched networks or even staellite- or ground-based packet radio networks.

ITM's informatics sub-program supports the development, modification, and testing of software packages suitable to solve stated development problems. Other aspects covered by this sector include support for systems integration, software adaptation to meet local language requirements, and manuals to provide basic local advice on selecting information technologies. One promising approach for developing countries in the near future will be the use of "expert systems".

And, finally, the remote sensing and cartography sub-program is aimed at enabling research institutions that wish to investigate the usefulness and approrpiateness of modern techniques, such as remote sensing, geographical information systems (GIS), and computer-assisted mapping, to respond to the information needs of their countries and regions.

Following are brief descriptions of projects supported by one or both of the Information Sciences Division's programs described above. I trust they illustrate the utilization of existing or new information technologies in their quest to solve serious information handling and processing problems.

1. **Remote Sensing for Artisanal Fishing and Swordfish (Chile)**

Remote sensing data such as those generated by the U.S. National Oceanic and Atmospheric Administration (NOAA) satellite series provide a synoptic view of sea conditions which can help fishermen in their search for fishing zones. Through a case study of tuna and swordfish along the coast of the region of Valparaiso (Chile), a team of oceanographers and remote sensing experts will develop and test a methodology to produce timely maps of sea conditions to assist artisanal fishermen in locating probable fishing zones. In support of this, a number of software-based tools and intermediate information products will be developed. Information will be delivered directly to the fishermen through maps and a newsletter.

2. **Fisheries Management Information System (FIMIS) (Trinidad and Tobago)**

In the past, the two main issues relating to fisheries have been (a) feeding the population and (b) generating the maximum income from the fisheries resource. However, in recent years, issues relating to sustaining the fish supply by effective management of the resource have become increasingly important as over-harvesting has resulted in a dramatic depletion of some fish stock. Recognizing that rational management of fisheries resource is essential for continual supply of fish, the Trinidad and Tobago government has requested IDRC support for establishing the Fisheries Management Information System (FIMIS). Through this project, the wealth of Trinidad and Tobago fisheries data will be consolidated and computerized to facilitate the use of current and reliable data in policy decisions and advisory services. During the life of this project remote sensing techniques will be investigated to determine the appropriateness of this technology in monitoring the migratory patterns of the various fish species under study.

3. **Multi-Period Budgetting on Perennial Crops (MULBUD) at ICRAF, Kenya**

MULBUD, is the name given to an interactive computer package designed to help appraise perennial crops in the tropics where a number of species are grown in association. The work is of direct benefit to small-scale farmers, the ultimate beneficiaries of the tool, because it enables them to get answers to frequently asked simple questions such as "How do I...?",, "What will happen if ...?". It was one of the first user friendly computer packages designed to be used by people who had never touched a computer before. It can be linked to a "computer based slide rule". It was also one of the first computer systems to operate off batteries in the field situation. Although this project does not rest within the Marine Sciences sector, the

software technology is not discipline-specific and could be transferred to many other fields.

4. Seaweed (Philippines)

Seaweeds are important raw materials for the manufacture of a variety of industrial products as well as a source of food for many Asians. Eucheuma sp. is the major seaweed in the Philippines. The development of the seaweed culture industry in the mid-1970's, gave many coastal people an important new employment and income generating activity. Unfortunately, to date, little research has been carried out on this important industry. This project will support research on seaweed stock assessment, seedling bank development and the establishment of a seaweed information centre. This multidisciplinary project will be jointly supported by the AFNS and IS Divisions to strengthen seaweed research and development in the Philippines and the Southeast Asian region.

5. Microcomputers can also assist with training of researchers. In one project, again not marine sciences related, but the technology is extremely relevant to the program of the IOI, the International Rice Research Institute (IRRI) in the Philippines is developing an information retrieval system for training objectives, and microcomputer-based instructional systems that will document and store the technical content of IRRI production courses in a modular format adaptable for dissemination in print, slide/tape, or computer-aided instruction format. These teaching media can be used interactively and individually by students, enhancing their learning and retention of the material. As well, this courseware can be replicated and/or customized for use by national rice research institutes.

6. In-shore Fisheries Information System (Chile)

This project will enable Instituto de Fomento Pesquero (IFOP), in conjunction with Servicio Nacional de Pesca (SERNAP) in Chile, to design and test a prototype information system to more accurately reflect the activities and development of the in-shore fisheries sector. The information system will be an important element in the decision-making process to develop the in-shore fisheries sector in a rational and effficient manner. The prototype information system will be developed on a test basis at six landing sites. A new set of variables reflecting social, biological, commerical and technical aspects of fisheries will be defined and new data collection will be started and a database will be created and maintained. Services will be offered to personnel of IFOP, SERNAP and six test sites, who are working on in-shore fisheries problems.

7. New technologies continue to develop and require testing in circumstances appropriate to the needs of developing countries. For example, one set of developments involves the use of optical-disk technologies to store bibliographic references,

pictures, and even full text in a computer-accessible format. One such technology, CD-ROM (Compact Disk - Read Only Memory), is actively being developed and tested around the world, especially in conjunction with microcomputers. IDRC is supporting the testing and evaluation of CD-ROM technology for the delivery of bibliographic references within six IDRC projects and the IDRC Library. An analysis is being carried out on CD-ROM's potential impact on the information sciences field, particularly as applied within developing countries.

In a related project, IDRC is assisting the Consultative Group on International Agricultural Research (CGIAR) to investigate alternative methods of permanently preserving its publications, as well as of increasing international awareness and availability of these publications, particularly in developing countries. Project participants are collecting CGIAR scientific and technical literature; cataloguing and indexing this literature; physically preparing the materials for conversion to either microfiche or optical-disk storage; and analyzing the technological feasibility and market acceptability of using optical-disk technology versus micrographics technology for preserving and disseminating the publications.

8. Finally, through the Information Sciences Division's Computer Systems Group, IDRC itself has also been involved in software development, mainly involving its **MINISIS program**, with results that have proven useful for many developing countries. MINISIS is a generalized information storage and retrieval system developed, disseminated, and supported by IDRC. The computer software operates on the Hewlett Packard 3000 family of minicomputers. The MINISIS Package provides for the design of relational database structures; data entry and modification; information retrieval using phrases, keywords and Boolean operators; SDI profile execution; multi-level sorting; flexible formatting for printed output; arithmetic calculations; and the exchange of information in the ISO 2709 format. Since MINISIS became operational in 1978, it has been installed in over 300 organizations, with more than 160 in developing countries. Although MINISIS was originally developed to manage bibliographic data, it is general enough to support a large variety of textual applications. Some examples include: project information systems, mailing lists, registries of correspondence, directories of consultants, inventory systems, historical and museum artifact data banks, meteorological information services, and chemical toxicology databases.

The MINISIS software operates in a variety of languages and permits users to manage information stored in different character sets. Through the use of discrete dialogue files, it is possible to operate MINISIS and process data stored in a combination of Roman-based languages, as well as Arabic, Greek, Thai, Korean, and Chinese. In addition, the multilingual thesaurus capabilities of MINISIS make it possible for searchers to find information indexed not only in the language of the

search but also in either language equivalents. MINISIS is an important part of the Information Sciences Division's program to transfer information technology to developing countries. It is a tool which provides developing countries with the capabilities to manage their own information more effectively and to easily exchange information with others.

IV. CONCLUSION

As can be seen from some of the examples I have given, information technologies can play an important role in a wide variety of development-related information applications, even though they are at relatively early stages in their development and applications. The evidence which they provide is by no means conclusive, either in absolute terms related to the ultimate utility of the technologies involved or in relative terms related to the appropriateness for developing countries. Although these activities have been carried out, in part, to ensure that the interests of developing countries are considered at the early stages in technology development, clearly there is further testing to be done. However, basic information and experience have been gained to enable better planning by developing countries. New technologies and tools bring with them an immensely complex range of issues -- social and economic, as well as technical. Developing countries are demanding relevant information upon which to base their decisions. The need for experimentation, open discussion, and information dissemination has never been greater; and that is why organizations like IDRC support initiatives such as those described this morning.

The international community has an important role to play in keeping the dialogue open and active between developed and developing countries, as well as among developing countries themselves. However, it is through the work carried out by others in both the developing and developed world -- that significant, long-term progress will be made in harnessing information technolgoies for development.