THE NEED FOR INFORMED CHOICE REGARDING INFORMATION TECHNOLOGIES: CASE STUDIES IN TELECOMMUNICATIONS

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INTRODUCTION

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 concept of information as a resource has been rapidly expanding into many other sectors besides research: government, policy-making, management, industrial development, and so on. The basic lessons learned in information science, principally through experiences with bibliographic information production and processing, have spread to many other applications and sectors. The concept of "knowledge industries" and "knowledge workers" is 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.

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 workers and users. Thus, to a large degree, it is not the electronic circuitry or the microcomputer system on their desk which is seen by information workers as the tool, but rather it is the software which provides the interface to their database or which manages communications which is the tool, the thing "used". It is all a matter of focus.

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Technology is relative. For example, writing is a technology, although it is so prevalent, at least within developed-country cultures, that it is scarcely considered as such. To this extent, a book may be considered an information tool: it acts to store information. The index at the back of the book is also a tool: it facilitates information retrieval. Although one scarcely thinks of cataloguing rules, thesauri, or information standards as technology-based, they are essential ingredients in both automated and manual systems, and they are based on a "technology" of information organization. Seen from the perspective of an information user in the decades to come, the telecommunications services or computers, with which everyone is so fascinated these days, will appear as commonplace and basic an element of technology as writing does today.

For most purposes, however, when one talks of "information technologies" one is referring to a particular class of technology-based tools. These are the "electronic" tools, which manipulate and communicate digital information. These tools collect, process, store, retrieve, and transmit the bits and bytes which represent information. In fact, these days, "information technology" and "computer technology" are sometimes taken to be synonymous. Data processing systems are now information systems. Communications is telecommunications. When one talks of information technologies one is really talking about computer-based tools. And even if one is not directly referring to computers, 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 electronic information tools inevitable? 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

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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 sectors 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 it 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.

Questions such as these are also relevant for a donor agency like the International Development Research Centre (IDRC) when it too examines new information technologies and their possible role in its programs. IDRC is a public corporation established by an Act of the Parliament of Canada in 1970 to support research activities for development in developing countries. At the time of its creation, the importance of information to support research was already recognized, and an Information Sciences Division was established. During its first decade of operation, experience was gained with the application of technology-based information tools based on a variety of classes of technologies: computerized bibliographic systems, remote sensing and cartography, and micrographics to name three. Certainly there were problems related to introducing and using such tools in developing countries -- problems often related to infrastructure and training -- but it seemed clear that such tools were indeed appropriate and necessary in many situations.

For example, in the late 1970s it became evident that telecommunications had an increasingly important role to play in information systems. But was this relevant to developing countries where the basic problem was lack of adequate infrastructure (a problem which IDRC could obviously not address

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with its limited resources)? It was not even clear in developed countries how some of the emerging tools could or would be used. IDRC decided to concentrate on exploring some of the new telecommunications tools to ensure an adequate base of experience with which to answer such questions. To be manageable, the focus would be on a limited set of tools: those related to data communications (as opposed to voice communications, for example) in support of research activities.

A number of case studies selected from the telecommunications program are presented in the rest of this paper to illustrate efforts to ensure that technologies have a chance to be tested and used before they are either rejected or selected. In fact, this program is still in its developmental stage (both within the world at large and IDRC), and it is difficult to draw definitive conclusions on the technologies per se. But the evidence strongly suggests to IDRC the need for research so that choices can be made intelligently.

COMPUTER-BASED MESSAGING AND CONFERENCING: AN OVERVIEW

One of the most promising telecommunications tools to appear at the beginning of this decade is computer-based messaging. In such systems, a user composes a message using a computer terminal, and then transmits it, along with addressing information, to a computer via telecommunications links. A host computer, with appropriate software, manages the message electronically. When the addressee signs on to that computer, he or she receives delivery of the message, along with any others that are waiting. These systems are similar to telex but are much less expensive, and provide additional facilities such as upper and lower case characters, individualized formatting, forwarding of messages, automatic acknowledgement, multiple addressees for a message, and so on.

As an extension of this concept, systems designers developed what are now called computer-based conferencing systems (1), allowing many-to-many communications on specific topics. Such systems allow groups of people scattered around the world to discuss topics of common interest such as scientific issues or administrative matters, for example. The storage, retrieval, and processing

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capabilities of the computer, coupled with the appropriate software, permit the management and tracking of messages in a computer conference. A computer with conferencing software can manage many conferences simultaneously, in addition to allowing personal messaging and also, in some instances, other applications (e.g. database management). In effect, one can participate in what could be called the "plenary" session of a conference discussion while at the same time one can be engaged in "corridor chatter". Conferences can be structured as being public, open to all those with access, or private, open to only those who have been registered as participants. Some of these systems have additional features such as allowing joint authorship of papers, cross-referencing and selective retrieval of text, and even a voting facility for consensus gathering. In addition to handling textual information, some systems allow for transmitting data, producing tables cooperatively, and creating graphics.

Perhaps the key characteristic of these systems is their asynchronous nature. Certain advantages ensue as a result. Problems of communicating across time zones and the frustrations of making connections over the telephone disappear. One is able to participate in many electronic conferencing activities while at the same time conducting one's regular work. Individuals are able to ensure greater accuracy in their communications as they communicate while remaining close to their own data sources. Furthermore, the quality of communications is improved as individuals control the location, time, and rate of their communications.

AN IMPORTANT WORKSHOP ON COMPUTER-BASED CONFERENCING

It became evident at IDRC that these new communications techniques were being utilized more and more in the industrialized world, and there was concern that Third World institutions would be left out of the design, implementation, and use of the rapidly expanding networks. In order to explore the state of the art and receive advice on any potential role for donors, IDRC convened a week-long workshop in October 1981, entitled "Computer-Based Conferencing Systems for Developing Countries" (2). It was perhaps indicative of the need for that workshop that only isolated pockets of activity in this field could be found in developing countries.

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Experts from Brazil, India, international organizations involved in the informatics field, and those involved with existing systems discussed current and proposed systems, advantages and disadvantages, impediments to implementation, and possibilities for developing countries.

The telecommunications infrastructure and technology required to support computer conferencing is developing in many parts of the world. Even for relatively inaccessible regions of the globe, many of the technical solutions to communications problems exist. However, these may not be practical to implement because they do not appear to have a good cost/benefit ratio and they are not given sufficiently high priority by decision makers. The experts at the workshop were unanimous in stating that the greatest impediments to the implementation of international computer conferencing systems would be legal and regulatory, rather than technical. In many countries, national communications authorities do not look kindly on inexpensive digital communications techniques competing with the lucrative traditional communications monopolies they now manage. The compensating national benefits of allowing improved scientific communications via these techniques obviously need to be emphasized to these authorities.

It was the consensus of the workshop that these systems will be an integral part of the available communications options in the coming decade and that, unless the developing nations can participate in this electronic community of science and technology, they will suffer from disenfranchisement of a serious nature. This may take the form of a lack of access to the resources of the developed nations and the inability to gain timely access to results and techniques found in the developing countries themselves.

The participants in the meeting felt that there was a role for donors to play in this area and to that end they drew up a set of twelve recommendations. These recommendations included support for:

- information activities which increase the awareness of these technologies;

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- regional workshops for increasing awareness as well as eliciting national and regional needs and identifying individuals and projects which may require support;

- pilot projects utilizing computer conferencing;

- systems being utilized by developing-country institutions;

- feasibility studies relating to low-cost ground stations, satellite communications, and telecommunications infrastructures; and

- policy studies looking at the regulatory restraints.

In other words, the need for a sufficient base of knowledge and experience related to certain new information technologies was clearly identified.

THE COMPUTER CONFERENCE ON THE BIOCONVERSION OF LIGNOCELLULOSICS

One of the recommendations of the previously-cited Computer-Based Conferencing workshop was "that IDRC support a pilot CBCS [Computer-based Conferencing System] project involving both developed and developing nations". A suggested topic was the bioconversion of lignocellulosics (i.e. the conversion of waste products into energy sources and nutrients), an appropriate area for international cooperative research given the obvious priorities of fuel and food to developing countries. With the acceleration of biotechnology research developments and the ever-growing gap between the resources available to industrialized versus developing-country researchers, the need for linkages to support the free exchange of ideas and information among them was becoming increasingly obvious.

Following from this recommendation and with the stimulus of Dr. C. G. Hedén of the Karolinska Institute in Sweden, IDRC began organizing a computer conference on "Bioconversion of Lignocellulosics for Fuel, Fodder and Food needed for Rural Development in Poor Countries". The objectives of this exercise

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were as follows: on the scientific side, to explore the possible uses of the bioconversion of lignocellulosics for development purposes; on the technical side, to explore the viability of using computer conferencing to facilitate scientific research by a specific user group; and on a secondary level, to lay the groundwork for future applications of this technique, on a global basis, to more specific aspects of the subject. Because of IDRC's interest in the facilitation of the use of data communications techniques in support of research in developing countries, there were two additional objectives: to increase awareness in general; and to gain experience in the organization and operation of a computer conference on an international scale.

Over 100 researchers from many countries participated in this open, eight-month conference (which was held from May to December 1983), with the majority, as expected, participating from industrialized countries. Off-line participation modes were provided for those unable to participate on-line. The conference ran on two computer systems: Electronic Information Exchange System (EIES) at Newark, New Jersey and COM at Stockholm. Participants participated on either EIES or COM and texts were transferred between the two systems. Following the conclusion of the conference, extensive evaluations were carried out. The results of these are to be published by IDRC in 1985.

From a technical perspective, this computer conferencing exercise was very useful, with the host systems and communications networks largely meeting the participants' requirements. As was anticipated, however, the central technical problem proved to be the difficulty (or in some cases impossibility) of gaining reliable access to the international data networks by scientists located in developing countries.

A number of conclusions can be derived from analysis of the technical aspects of this activity:*

(1) the host systems and data networks were generally reliable and facilitated participation, except for the difficulties generally experienced by participants from developing countries;

* Extract from contribution by J. B. Black to International Computer-Based Conference on Biotechnology: A Case Study, edited by D. Balson, to be published by IDRC, Ottawa, 1985.

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(2) expansion of access to international data networks from developing countries is essential if scientists in these countries are to be able to participate fully in future information exchange and transfer activities of this type;

(3) equipment and facilities for participants (terminals, modems, microcomputers, software, communications links, etc.) must be close at hand if scientists are to integrate these activities into their normal research and scholarly communications process;

(4) ready access to good support systems for participants (training, manuals, "colleague advisors", etc.) is essential to the successful application of computer conferencing to research communications in the future.

It is interesting to look at the conference from the point of view of participants from a developing country. In order to participate on-line, researchers at the Instituto Centroamericano de Investigacion y Tecnologia Industrial (ICAITI) in Guatemala City had to overcome problems related to modems (standards), cables, and microcomputer communications software packages. Without local access to international data transmission networks, on-line participation, when finally possible, was expensive via regular voice channels. Despite these problems, these researchers felt that computer conferencing made sense, especially in light of high travel costs, the scarcity of foreign currency and related restrictions, and the future expansion of the international data transmission web. On the scientific side, certain benefits accrued from participation in the computer conference: their knowledge of current research activities was updated; they discovered research activities in laboratories new to them; they received confirmation that their research was on track; and they found some of the scientific discussions interesting and useful. As scientists in developing countries, they saw computer conferencing as an excellent tool for communicating ideas and exchanging know-how internationally.

Although participants from developed countries found the scientific content of the conference to be less useful than those from developing countries, in general, the technique of computer

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conferencing was accepted as a viable medium for facilitating scientific research. Of those particpants who responded to a questionnaire, only 6% would not participate again in a computer conference on a subject of interest to them. Along with the advantages gained from having a written record, the inherent characteristics of asynchronous computer conferencing (i.e. participation at a time and rate of one's own choice, proximity to one's data sources, and being able to contemplate answers to questions before responding) were cited as the most important benefits.

For the developing-country participants, the greatest impediments to participation were related to access to terminals, reliable telecommunications links, access to the international data transmission networks, and the costs of participating. For the most part, participants from industrialized countries valued the exercise more for the experience in using computer conferencing rather than for the scientific discussions themselves. For them, drawbacks to this computer conference were predominately information related: too many repetitious comments, unwillingness of other participants to share new information, and lack of response to their contributions.

Perhaps the most valuable outcome of this activity has been the lessons learned concerning the use of computer conferencing. It seems apparent that this technique of communicating is best suited for dispersed groups working towards common goals with a need for regular communications. Convenient access to terminals and the existence of reliable telecommunications links is of course essential. To ensure greater participation of researchers in developing countries, improvement of the local telecommunications infrastructure and the encouragement of the expansion of the international data transmission networks will obviously be necessary. Although the Computer Conference on Bioconversion of Lignocellulosics was not a complete success, it did open a window on a new technology for a large group within the biotechnology community. But, being a relatively novel experiment, with an uninitiated user group, it has served a very useful purpose in defining those areas which require further work.

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CGNET: COMMUNICATIONS FOR AGRICULTURAL RESEARCH

The Consultative Group on International Agricultural Research (CGIAR) is an international consortium sponsored by the World Bank, the United Nations Development Program, and the Food and Agriculture Organization of the United Nations, dedicated to supporting research programs with the purpose of improving the quantity and quality of food production in the developing world. These programs are carried out by thirteen autonomous international agricultural research centres (IARCs).

In 1982, with conventional communications costs rising, budgets restricted or shrinking, the need for international scientific and administrative communications increasing, and the recent availability of a number of technical solutions, the CGIAR system decided that the time was ripe to explore the technical, legal, administrative, and economic feasibility of the implementation of a data transfer network for the IARCs. Two earlier studies had made initial recommendations, but for a variety of reasons these had not been pursued.

Following a meeting of CGIAR Centre Directors in 1982, a study was commissioned to look first at a system to handle inter-centre communications needs. During the first phase of the feasibility study, the consultants concluded that the primary services of a CGIAR data transfer network should be computer-based message services and gateway facilities from the computer-based messaging system to on-line database services. It was also determined that the prospects of a full implementation of a CGIAR data transfer network would be enhanced if a pilot project were established. Such a project would maintain and strengthen the momentum within the CGIAR system toward the implementation of new communications technologies. Since there were existent international computer-based messaging services, some, but not all, of the Centres could participate with little or no acquisition of equipment or technology. This would give the Centres and the associated Secretariats exposure to some of the practical problems and implications of establishing an operational system. They would have the opportunity to contemplate the managerial and financial

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implications resulting from the use of computer-based messaging services. As such, they would have a stronger basis for judging any eventual recommendation regarding full network implementation.

In addition, the consultants recommended that the original target group to be studied, the thirteen IARCs and two Secretariats, should be expanded to include some of the important remote research sites. As a result, a project was initiated to conduct a feasibility study on the implementation of a data transfer network for the CGIAR system which would include sites involved in a major share of information flow to and from the centres but which were not located at any of the 15 primary sites, and to establish, administer, monitor, and evaluate a small computer-based message system pilot project for the CGIAR system.

The project was completed in 1984, resulting in an operational network, CGNET, linking ten of the fifteen major sites along with some of their remote sites and many other institutions with which they conduct business and research. A commercial US-based messaging/conferencing system acts as the host system for the network.

The next logical step would be to expand the network to include those sites without ready access to the international data transmission networks. One of the IARCs, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in Hyderabad, India, experimented during the project with participation in the network via a relay computer located in the United States. Even with this more complicated routing, ICRISAT became one of the system's heaviest users. Telex interfaces could also be employed on an interim basis by those institutions in countries without easy access until the time when the international network is more comprehensive geographically.

As CGNET matures, user groups will expand, applications will be tried and implemented if appropriate (including computer conferencing, bulletin boards, telex-refiling, database access, data transfer, etc.), and new locations will be added to the network.

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Projects such as this one can provide lessons which, although not novel, warrant mention. For the successful use of asynchronous communications networks, a critical mass of regular users is required to ensure that it is worthwhile for any one user to log on to the system. As with most technologies, training, both initial and ongoing, is probably the single most important investment. Related to training, with new information/ communications technologies there appears to be a conditioning process required whereby resistance to change must be overcome. This can be accomplished by sensitization workshops, hands-on experience, encouragement by peers and supervisors, and the demonstration of effectiveness of the technologies. Finally, it is very difficult to implement a variety of applications of a technology simultaneously. A step-by-step approach is usually advisable. For each application, an individual with the appropriate technical, organizational, and personal skills, is required to blaze the trail.

PACSAT: PACKET SATELLITE COMMUNICATIONS

At the Computer-Based Conferencing workshop in 1981, one of the participants, Dr. S. Ramani of the Tata Institute for Fundamental Research in Bombay, India, proposed the concept of a low-orbiting communications satellite dedicated to computer-based messaging for international development purposes. Dr. Ramani, in concert with Dr. R. Miller, who was then with Infomedia Corporation, developed this concept into a full paper which was presented at the International Conference on Computer Communications in London, England in 1982 (3). The concept was well received. At approximately the same time, Dr. Yash Pal, Secretary-General of UNISPACE '82, stimulated by this, presented a document on the idea to the Secretary-General of the United Nations with the recommendation that the UN should explore such a satellite's applicability to its own operations (4). One of the resolutions of the UNISPACE '82 conference also recommended pursuit of this concept.

Late in 1982, two groups, Volunteers in Technical Assistance, Inc. (VITA) and the Radio Amateur Satellite Corporation (AMSAT), in part sparked by this series of events, began a collaborative effort to

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demonstrate how an innovative low-cost communications satellite system based on packet-radio technology, called PACSAT (5), could improve the quality and speed of technical information transfer to and from developing countries. PACSAT would demonstrate the cost-effectiveness of using low-cost and relatively unsophisticated ground station technology while providing reliable high volume information transfer. An average ground station configuration in today's dollars for off-the-shelf components would cost approximately USD 1 600, and would consist of a transmitter/ receiver, a crossed dipole antenna, a portable computer, and a terminal node controller. Due to its independence from land-based telecommunications systems, PACSAT would open up communications links to previously inaccessible locations. Wherever the need for low-cost, timely, asynchronous, reliable information transfer on a local, regional, or global basis existed, PACSAT should be applicable. Regional information networks in locations where conventional communications media are poor or unavailable are obvious prime users of this technology.

PACSAT is planned as a small, low-earth orbiting satellite, covering every point on the globe at least twice daily. Acting as an "electronic mailbox", it will receive messages, store them and then deliver them to the intended addressee(s) at a later time. Real-time messaging will also be possible for ground stations which are simultaneously within the satellite's footprint. Connections between PACSAT and ground-based packet-switched networks will be available.

As part of this research effort, in March 1984, UOSAT-B, a satellite built by the University of Surrey in the United Kingdom, was launched carrying an experimental Digital Communications Experiment (DCE) which is a scaled-down version of PACSAT's "brains". In order to test the PACSAT concept in field conditions and to expose this technology to a wider audience, IDRC funded a Canadian non-governmental organization interested in this technology, Inter Pares, to manage a PACSAT experiment using the DCE at the Pacific Telecommunications Council's Conference (PTC '85) in Honolulu in January 1985.

Two-way communications exchanges had taken place in advance of this conference between stable environments at the University of Surrey

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and the home of the PACSAT project manager in Los Angeles. This was to be the first true field experiment. There were, of course, a number of technical difficulties and unanticipated problems. Furthermore, UOSAT-2 had not been originally designed for PACSAT-like applications, and certain accommodations had to be made for this. In the end, however, the demonstration was successful: messages were loaded into the computer on UOSAT-2 and others were received from both California and the University of Surrey, including one in response to a question loaded from Hawaii on the first orbit over Honolulu 100 minutes earlier.

Besides having exposed this concept to a wide audience, the technical team learned some valuable lessons concerning equipment requirements in the field and has started to incorporate these lessons in new hardware and software. For example, it is now expected that the electronic equipment, including the computer, will be transportable in a single airline carry-on bag. The antenna will be designed to be shipped in a tough plastic tube, which will also function as part of the mount.

PACSAT is to be launched in the spring of 1987 via a "Get-Away-Special" on the US-NASA space shuttle. AMSAT is responsible for the technical design, construction, testing and launch of the satellite while VITA is managing the administrative side (funding) and will provide test applications.

PACSAT represents a new information technology in the making. It is still at a very tenuous stage in its development, especially since much of the work is being done by volunteer labour. It is not even certain that all of the conditions will fall into place for its operation. But it does seem clear that it holds great potential for remote developing-country applications, and it is important to ensure that their needs are considered from the start.

In addition, there are certain problems associated with PACSAT: how to avoid legislative hurdles against its use over various countries; in what manner will particular user groups be able to avail themselves of this service; how can unauthorized use be prevented, and so on. These questions are being considered and solutions are being defined. On the other hand, with current studies showing the importance of telecommunications to

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development, the benefits to be gained from having access to alternative communications services appear to outweigh the difficulties involved.

CONCLUSIONS

The examples given in this paper relate to new information technologies and tools at relatively early stages in their development and application, especially with respect to developing countries. 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, significant testing in developing-country environments to meet developing-country needs has not yet taken place. This is clearly the next step. However, basic information and experience have been gained to enable better planning of this next step 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. That is why organizations like IDRC support initiatives such as those described in this paper; even if they do not always work out or provide the best solution, at least they have been tested, and with developing countries in mind. And that is why vehicles for bringing technology-related issues to decision-makers, such as the ATAS Bulletin, are important. In the Information Age, informed decisions are imperative.

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