MICROCOMPUTERS IN DEVELOPMENT:

IMPLICATIONS FOR AGRICULTURAL EXTENSION, EDUCATION, AND TRAINING

by

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A 21 minutes video brief has been produced by one of the authors (Bardini), and presents a summary of the written report as well as its main conclusions.

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EXECUTIVE SUMMARY

The objective of this report is to review and analyze the useful applications of microcomputers in agricultural development with implications for agricultural extension, education, and training, in order to identify the important lessons learned. We gathered three kinds of information about microcomputer applications: (1) a review of available literature on this topic, (2) a mailed surbey of 20 experts on microcomputer applications in agriculture, and (3) six case studies of projects underway that utilize microcomputers for development.

The main conlusions form the present study are:

1. Microcomputer technology is at its early stage of diffusion for agricultural development in Third World countries. The main reasons preventing a wider diffusion to date are cost, availability, infrastructure problems, and lack of specialized software.

2. Microcomputer present a great potential for administrative activities necessary to extension (record keeping, desktop publishing).

3. Farmers' use is almost inexistant in developing countries and still limited in industrialized countries. Direct farmers use is not to be sought in developing countries.

4. Microcomputers are widely used in agricultural research but not in extension. Wider use of microcmputers is to be promoted for extension, in order to create a better linkage between these two interdependant activities.

5. This linkage describes the creation of a more efficient interface between research and extension. It will require the development of a second type of application of microcomputers, such as data-base management and expert systems.

Chapter 1
INTRODUCTION

1.1 BACKGROUND

Microcomputers offer a potentially useful tool for agricultural extension and training, but in the decade or so of their widespread availability, applications of these promising technologies have only begun to be realized in certain nations and for certain purposes.

"What ought to be the role of extension in the Information Society of the 21st century?" Thus began the first national assessment of the U.S. Cooperative Extension Service in 1984, after more than 20 years of computer use by the agricultural extension services. In developed, industrialized countries such as the United States, the Information Society is already a reality. In agriculture, as in other sectors, applications of information technologies like microcomputers are becoming ever more extensive.

1.11 A Brief History of Computer Technologies

Since the invention of the transistor in 1947, computer power has increased at least a million-fold. Strategies for organizing and disseminating knowledge have changed dramatically. Paisley (1984) identified four major developments in the area of information creation, storage and distribution, during the past 25 years:

1) On-line information services became widely available, providing knowledge workers with large electronic data-bases and means of accessing them (in the early 1970s).

For example, in 1963, solid-state electronics replaced vacuum tubes, and IBM introduced magnetic disks to replace computer tape. In 1967, IBM developed removable disk packs that allowed the memory size of computers to be expanded, and to enable certain interchanges with other computers (Huskey, 1988).

2) Research on diffusion and technology transfer led to new knowledge networks combining the `high-tech' of electronic access to information and the `high touch' of interpersonal linkage (in the late 1970s).

"High-technology" development was paralleled by an evolution, perhaps as impressive as its technological counterpart, of the human communication paradigm. This paradigm grew out of contributions from scholars in social psychology, sociology, political science, mathematics, and electrical engineering.

3) Personal computers enabled knowledge workers to create and analyze information without the cost and other limitations of mainframe computers (in the early 1980s).

The current microcomputer, also called a "personal computer," took form in the late 1970s when the newly-introduced microprocessor on a silicon chip (invented in 1971) was combined with an IBM invention, the 8-inch flexible or "floppy" disk, which became available to users in 1973 (Dubbe and Richards, 1988). Personal computers are now available for less than $1,000 (Figure 1-1).

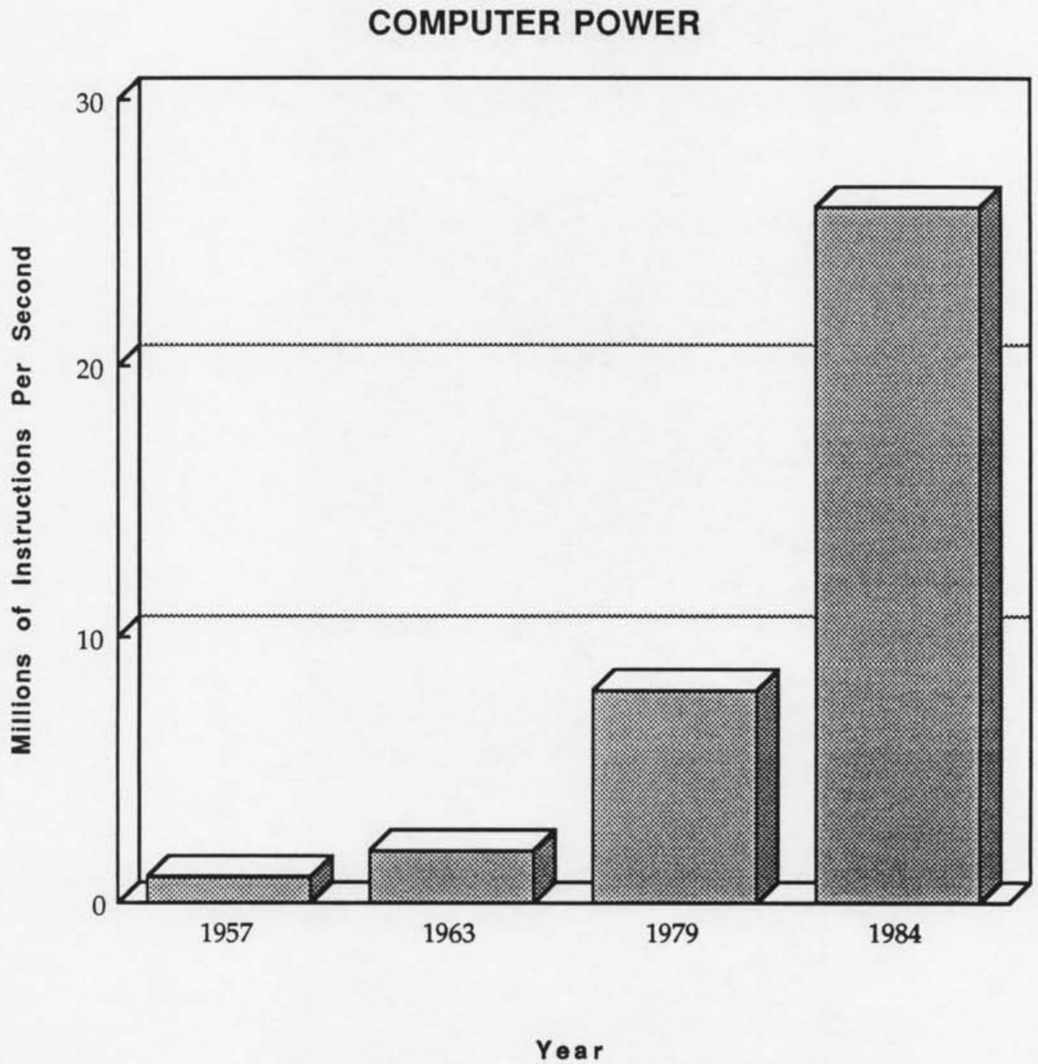

Figure 1-1. Computer Power Has Increased Sharply in Recent Decades.

4) Optical disks capable of storing `bookshelf' amounts of information at first paralleled the coverage of on-line databases and now provide both multi-media contents and enhanced functions (in the late 1980s).

The evolution of data-storage facilities moved from magnetic disks to optical disks, with higher capacities and lower costs (Figure 1-2). Magnetic disks have improved in performance and declined in cost. Half of all the microcomputers sold in 1990 used fixed rigid disk drives (or hard disks). Magnetic recording remains the universally accepted mass storage technology.

1.12 The Computerization of Agricultural Production

The applications of these successive computer-related technologies first began to play an important role in agricultural production in the developed, industrialized countries like the U.S. Today, microcomputers are used in the agricultural sector for functions ranging from data-gathering and analysis to decision aids.

In the U.S., Strain and Simmons (1984) compiled an inventory of agricultural software, including over 700 agricultural computer programs intended for use by farmers. Holt (1985) described the major public networks accessible by farmers, and also demonstrated the importance of the public R&D effort to achieve a widespread computerization of agricultural production.

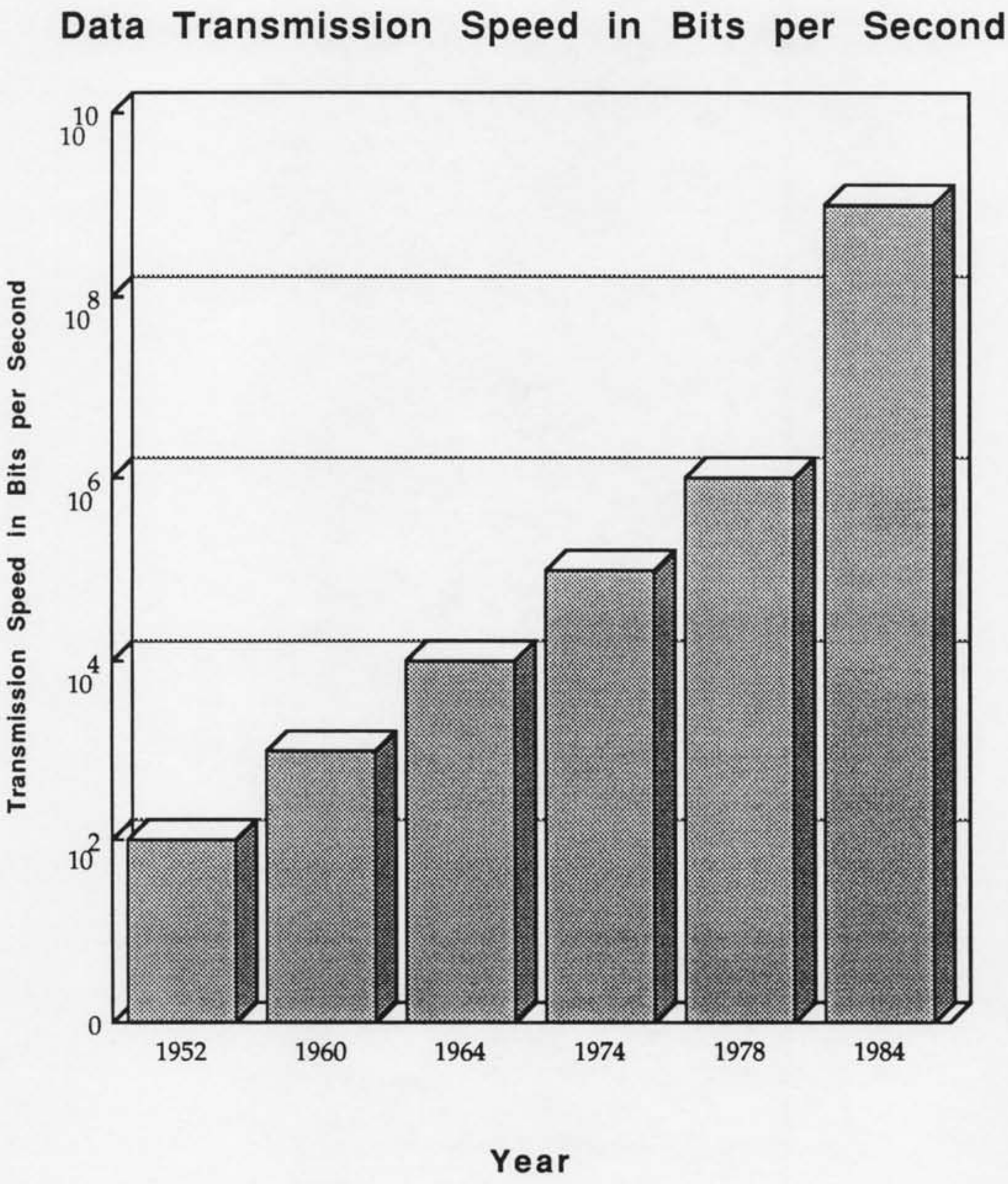

Figure 1-2. Increases in the Data Transmission Speed of Microcomputers.

Some recent evaluations of on-line information services (Miller and others, 1989; Case and others, 1981) show that providing updated market information is the most widely attractive service for U.S. farmers. Information, especially market information, has become an essential farming input, just like land, labor, and capital. The U.S. Department of Agriculture (1984) in a farmers' bulletin stated: "The computer will probably be as important a part of a commercial farmer's operation as the pickup truck."

1.13 Microcomputers and Development

Microcomputer use is quite different in the developing countries of Latin America, Africa, and Asia. The information revolution has been lately introduced in these countries, but seldom in agricultural production. Agricultural applications of microcomputers in developing countries were not thought to be a priority until recently. The first two publications about computer uses in development (United Nations, 1971; Taylor and Obudho, 1977) did not even mention agricultural uses. A change occured slowly during the 1980s, mainly with the help of certain development agencies and international institutions, who foresaw the potential of microcomputers in Third World development.

In a book published by the International Labor Office (ILO) (Bhalla and others, 1984), 76 separate applications in 33 developing countries were identified among the development projects of the U.S. Agency for International Development (US AID) and the U.S. Department of Agriculture (USDA). However, no sound data are available about the extent of diffusion of microcomputers in developing countries. The ILO book stated that, "The experience [of the ILO] with assessments of projects shows that very little if any systematic data-collection is done on a regular basis. This makes it very difficult, if not impossible, to evaluate the success or failure of the projects or experiments in the light of any systematic criteria or quantitative parameters."

1.2 OBJECTIVES

The present report will review and analyze the useful applications of microcomputers in agricultural development with implications for agricultural extension, education, and training, in order to identify the important lessons learned.

We seek to give a coherent review of microcomputer applications in agricultural extension, in order to identify lessons learned. We stress:

1. The successes and failures of development communication to date.
2. The opportunities for development provided by such new information technologies as microcomputers.

1.21 Success and Failure of Development Communication

> The crucial need to create the human and institutional capability for sustainable development and poverty alleviation is increasingly recognized, but the means for doing so are not in place in any developing country (Bernard Woods, 1990).

We here describe a communication perspective on development. The earliest notions of development considered communication as an important tool for achieving development outcomes, but as only one component in a technical development package. "Development is a special case of communication processes" (Narula and Pearse, 1986). This perspective implies that knowledge transfer, one of the main activities of most development agencies (Rogers, 1986), can be analyzed as a communication issue. Technology essentially consists of information, so technology transfer is a special case of the communication of information (Eveland, 1987).

This perspective enables us to understand the failure of development from a communication point of view, but should not lead us to consider development as only a communication problem. "Information alone is rarely a satisfactory solution to resource-based development problems" (Hornik, 1988).

Nevertheless, the communication perspective emphasizes the point that "development both requires and depends on appropriate learning" (Woods, 1990). Learning requires the exchange of information among participants in the development process, defining the ways of appropriate knowledge transfer. It is an oversimplification to think of knowledge transfer as a one-way, top-down process, as was often the case in the 1960s and the 1970s (Rogers, 1986).

1.22 A New Opportunity for Development

Woods (1990) identified four qualities of information transfer needed for sustainable development: (l) demand-driven, (2) individualized, self-paced, and interactive, (3) capable of two-way, vertical, and horizontal communication, and (4) available to all potential users and providing socially and culturally acceptable information about behavior change. New information technologies make such development communication possible. Microcomputers, along with other information technologies like video, satellites, FM radio receivers, etc., allow the creation of new communication systems. These new systems can be designed to be reliable, quick, and easily manageable.

But these new information systems will not be implemented in a vacuum. Implementation often consists of a necessary "blending of new and traditional technologies" (Bhalla, and others, 1984). This blending requires a comprehensive assessment of the needs and potential problems of people, as well as an extensive knowledge of the potential of the new technologies. An innovation can be introduced most effectively if its promoters fully understand the traditional knowledge and behavior of the intended audience for the new idea.

The present report reviews experiences with the blending of traditional and innovative systems. We analyze these experiences on the basis of the conceptual framework described in Chapter 2.

1.3 METHODS

> Applications of microcomputers in agricultural extension, education, and training will be identified and analyzed by a thorough search of the available literature, through correspondence with scholars and officials known to be experts on this topic, and by direct interviews in case-studies providing "living examples."

The general lack of systematic data-collection about applications of microcomputers for agricultural uses makes it difficult to identify the lessons that have been learned. In order to obtain the maximum possible information, we sought to identify three kinds of information:

I. The available literature on the topic of microcomputers in agricultural development, through a thorough computer-search, personal contacts with knowledgeable individuals, and by tracing the references cited in the set of publications that we originally located.

2. The personal experience of recognized experts on microcomputers in development, who were identified from the available literature and from other sources, and contacted by mail.

3. Case studies of selected on-going projects using microcomputers for development.

1.31 Analysis of the Literature

The available literature on this topic was identified (1) from materials available at FAO headquarters in Rome, and (2) by a thorough search of the published literature using a "snowball process." Each publication provided a bibliography with references to further work, which was then consulted for further citations to other work. We include here "gray literature" (e.g., unpublished papers, proceedings of conferences or workshops, etc.).

1.32 Mailed Questionnaires

We began our mailed correspondence with experts via a mailed questionnaire that was sent to experts identified in the available literature. We also used a snowball process, by asking the first set of experts for other individuals who were experts on microcomputers in development.

Fifty questionnaires were mailed, and 20 answers were received. The nonresponses were mainly due to inaccurate addresses. The mailed questionnaire and the list of persons contacted are included at the end of the present report. The results from the 20 responses are provided in our discussion of the conceptual framework (Chapter 2) and in the lessons learned (Chapter 5).

1.33 Case Studies

The authors conducted six case studies of the applications of microcomputers in development. These case studies describe the experiences of different actors (scholars, development officials, NGOs, entrepreneurs, etc.) in the microcomputer projects of study. Our six case studies include:

1. A modelling study of irrigation in Bali, Indonesia, by two university scholars, one an anthropologist and one a biologist.
2. A program, planning, and management project on fruit and vegetables marketing in India.
3. A poultry project in India.
4. An information networking project in India (CRISP and NICNET).
5. A data-base reference service via videotext in the U.S. (the Green Thumb Project in Kentucky).
6. A CD-ROM data-base in Mexico (the CGIAR-CIMMYT Maize Germplasm Data-Base).

Chapter 2
CONCEPTUAL FRAMEWORK

The present conceptual framework is presented to assess the potential uses of microcomputers for agricultural extension, education, and training. This framework takes into account past "biases" in understanding the extension education process, and is based on the premise that development requires appropriate learning of relevant activities. Such learning leads to new knowledge, perceptions, skills, attitudes, policies, and institutions, which in turn lead to the adoption of new ideas (Woods, 1988). **Development is the purpose of a system that generates, exchanges, and utilizes knowledge in order to improve people's quality of life.**

Through a historical analysis of agricultural extension models, we can understand the biases inherent in this model. This historical development is related to the research tradition of the diffusion of innovations. Knowledge of this research tradition, as well as its major criticisms, will help us avoid these bias in constructing an alternative framework.

2.1 DEVELOPMENT AND EXTENSION.

2.11 Historical Development of Extension Models

Three major legislative acts mark the origins of the U.S. agricultural extension model:

1. The Morill Act of 1862, which established the land-grant colleges (one in each state) in the U.S.

2. The Hatch Act of 1887, which authorized agricultural experiment stations as one part of state land-grant universities, to conduct research.

3. The Smith-Lever Act of 1914, which established Federal government funding of the extension services.

The land-grant college/extension model emerged gradually from these three legislative acts, as the "embodiment of public policy toward agriculture in the United States" (Flora and Flora, 1989). These policies led to the large-scale introduction of labor-saving agricultural innovations, which in turn led to the production of relatively low-priced food for urban populations of consumers. The land-grant college model provided the institutional framework for a policy of technological advance by integrating education, research, and extension activities in land-grant colleges.

The land-grant model is composed of eight main components (Rogers, 1986):

1. A critical mass of new technologies.

2. A research sub-system oriented toward utilization.

3. A high degree of user control over the knowledge transfer/ research utilization process.

4. Structural linkages among the research utilization system's components.

5. A high degree of client contact by the linking sub-system.

6. A spanable social distance across each interface between components in the system.

7. Evolution as a complete system.

8. A high degree of control by the system over its environment.

Rogers (1989) proposed eight generalizations about the agricultural extension model in the U.S:

1. The agricultural extension system model has changed considerably since its origin, to adjust to its changing environment.

2. The model is based on client participation in identifying local needs, program planning, evaluation, and feedback.

3. The linking function of the extension system is facilitated by utilization-oriented policy researchers.

4. State-level extension specialists are in close social and spatial contact with researchers and professors in their specialty, which facilitates their linking function.

5. The model has been more effective in the diffusion of agricultural production technology to farmers than in its latter-day diffusion of other subject matter to non-farm audiences.

6. Innovation-diffusion is only one component of a total research utilization system which institutionalizes means for orienting research activities toward users' needs.

7. The success of the model is related to its ability to adjust to environmental changes and to the strong support of the American Farm Bureau Federation and of elite farm leaders.

8. The extension service's emphasis upon production agriculture has invited criticism in recent decades for a lack of concern with rural social problems, some of which resulted from the increased agricultural production activities of the extension service.

Massive attempts to replicate the U.S land-grant college/extension model in Third World nations originated with the Point IV program, just after World War II. Important links in this transfer were formed through institutional ties, faculty consultations, and student training. For example, Cornell University agricultural experts in China from 1924 to 1931 (Flora and Flora, 1989), and in Venezuela in 1936-1937 (Arvanitis and Bardini, 1990), and U.S. agricultural missionnaries were active in the Allahabad Agricultural Institute in northern India after the 1940s.

From 1950 onwards, when the U.S. Congress authorized the Point IV Program for international development, major efforts were based on massive investments in infrastructure and in encouraging democratic institutions. Initially, grants were provided by such private foundations as Ford, Kellog, and Rockefeller to U.S land-grant universities for institution-building overseas. Thus versions of land-grant colleges and extension services were implemented in Third World countries.

Transfering the U.S extension model overseas faced various problems. In most cases, the newly-created extension services could not play the important role that they played in the U.S model. At least two major problems plagued the transfer process:

1. Manpower problems:

1.1 Extension budgets were often inadequate for implementing a sufficient ratio of extension workers/farmers (component #5 of the land-grant model, described previously, was thus missing).

1.2 The socioeconomic dissimilarity between the extension workers and their clients prevented effective communication from taking place between them (so component #6 of the extension model was missing).

2. The research/extension interface was often missing: The extension service was typically organized under a national ministry of agriculture, without an effective connection to agricultural universities (so components #2, #4, and #7 were missing or else incompletely organized).

The two main problems with the replication of the land-grant model overseas, inadequate farmer contact and an inadequate research/ extension interface, were acknowledged in the early 1970s. Daniel Benor, an Israeli consultant to the World Bank, proposed a solution to these problems: The Training and Visit System (Benor and Harrisson, 1977). Several related problems were identified in the then-existing extension services in developing nations:

1. Organizational: Lack of a direct line of technical support to farmers and a lack of administrative control by one agency.

2. Dilution of efforts: Multipurpose roles were assigned to the field-level extension workers.

3. Coverage: An inadequate ratio of extension worker/farmers and a lack of vehicles transportation for regular contact between farmers and extension agents.

4. Training: Inadequate and generally out-dated.

5. Lack of direct ties with research.

6. The low status of extension personnel.

7. Duplication of extension services by various organizations.

In order to solve these problems and to increase the efficiency of the extension service in its contacts with farmers, three basic principles guided the T and V (training and visit) system:

1. All agricultural extension activities should be combined into one unified extension service, in order to provide a "single modern extension service" to farmers.

2. Extension personnel should devote all of their time exclusively to professional agricultural extension work.

3. Extension work should be organized in a systematic time-bound program of training and visits, based on a manageable ratio of extension workers/farmers. At the field level, this ratio could be from 300 to 1,200 families per worker, depending on the physical dispersion of the population in an area.

The Training and Visit System was implemented in such countries as India, Brazil, Thailand, Nigeria, Bangladesh, Malaysia, and Sri Lanka. Over 75 T&V extension programs were underway in 1989 (Rogers, 1989). However, relatively few evaluations of the effectiveness of the T&V system have been conducted. The results show that the design of the T&V System clearly improves the efficiency of the extension services at the local level. Two solutions improve the extension/farmer link:

1. Increase the ratio of extension worker/farmer, and the quality of extension workers' training.

2. Improve communication between sub-systems by a careful selection of "contact farmers for their potential influence on other farmers and [their] willingness to collaborate with extension workers in following recommendations" (Cernea, 1981).

The T&V solution to the problem of the research/extension interface consists in training and in enhancing the roles of subject-matter specialists as liaison officers between agricultural researchers and local extension agents. This solution replicates the category of the state extension specialist in the land-grant model, but at a lower level (Figure 2-1).

2.12 The Diffusion Tradition and Its Critics

A historical analysis of the development of extension models designed for developing countries demonstrates a process of trial and error. They represent a progressive attempt toward building a comprehensive approach to the extension function within the knowledge dissemination process. After World War II, the first attempts were made to replicate the U.S land-grant system overseas. This "slavish copy" (Rogers, Eveland, and Bean, 1976) of the American model was generally unsuccessful. Further trials were made to adapt the agricultural extension model to the conditions of Third World countries, their institutions and social practices.

The most striking aspect of this history is the fidelity of the extension model in shaping agricultural development according to the diffusion of innovations tradition. Extension services are characterized mainly as functional units devoted to diffusing technological knowledge, from those who know it, to those who use it. A critical assessment of the extension service function therefore requires a basic understanding of the diffusion tradition, its main criticisms, and of its evolution.

Most extension services in developing nations continue to rely on an outdated version of diffusion theory, without taking into account its continuity later evolution. Among later developments of the diffusion tradition are the concepts of re-invention and of decentralized diffusion.

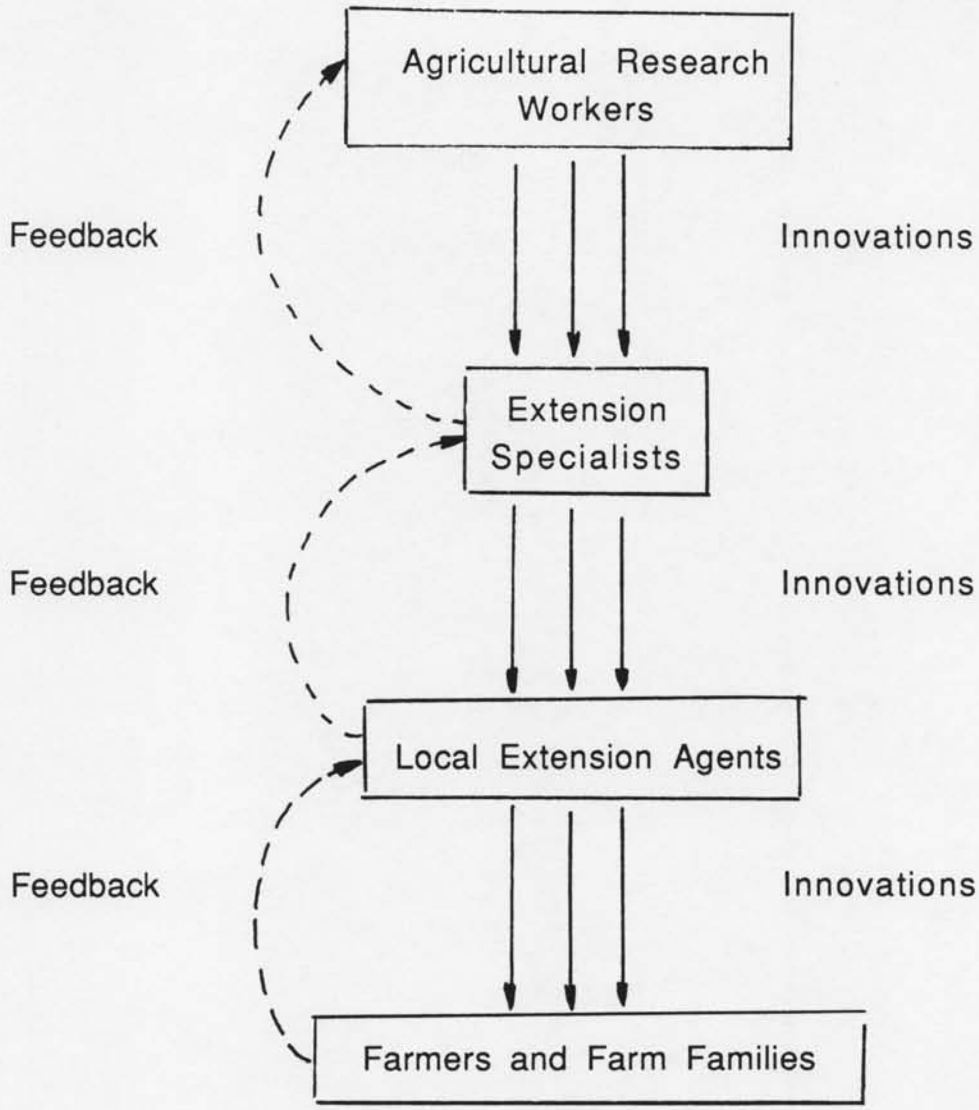

Figure 2-1. Various Roles in an Extension Service.

Re-invention is "defined as the degree to which an innovation is changed or modified by a user in the process of its adoption and implementation" (Rogers and Rice, 1980). Rogers (1983) acknowledged re-invention as a "mental breakthrough" for this research tradition: "...For the first 25 years or so of diffusion research, we simply did not recognize that re-invention existed. An innovation was regarded by diffusion scholars as an invariant during its diffusion process. Now we realize, belatedly, that an innovation may be perceived somewhat differently by each adopter, and modified to suit the individual's particular situation."

Acknowledgement of the possibility of re-invention is a way to avoid the **pro-innovation bias** in diffusion, which is defined as the "implication that an innovation should be diffused and adopted by all the members of a social system, that it should be diffused more rapidly, and that the innovation should be neither re-invented nor rejected" (Rogers, 1983, p.92). Giving up the idea that a technological innovation is perfect makes a strong argument for measuring adoption at the implementation stage, and for studying innovations in the making.

The dominant normative model of diffusion, exemplified by the agricultural extension model, has been called the "center-periphery model" (Schön, 1971). Schön's main criticism of this centralized model is that it may apply to certain classes of innovations "lying near the periphery," but that it fails to capture the complexity of innovations which may evolve as they diffuse, and that originate from numerous sources (for example, innovations which can be re-invented). This recognition led to the conception of an alternative between (1) centrally-managed information

Table 2-1. Characteristics of Centralized and Decentralized Diffusion Systems.

Characteristics of Diffusion Systems	Centralized Diffusion Systems	Decentralized Diffusion Systems
1. The degree of centralization in decision making and power.	Overall control of decisions by national government administrators and technical subject-matter experts.	Wide sharing of power and control among the members of the diffusion system; client control by local community officials/leaders.
2. Direction of diffusion.	Top-down diffusion from experts to local users of innovations.	Peer diffusion of innovations through horizontal networks.
3. Sources of innovations.	Innovations come from formal R&D conducted by technical experts.	Innovations come from local experimentation by nonexperts, who often are users.
4. Who decides which innovations to diffuse?	Decisions about which innovations should be diffused are made by top administrators and technical subject-matter experts.	Local units decide which innovations should diffuse on the basis of their informal evaluations of the innovations.
5. How important are clients' needs in driving the diffusion process?	An innovation-centered approach; technology-push, emphasizing needs created by the availability of the innovation.	A problem-centered approach; technology-pull, created by locally perceived needs and problems.
6. Amount of re-invention.	A low degree of local adaptation and re-invention of the innovations as they diffuse among adopters.	A high degree of local adaptation and re-invention of the innovations as they diffuse among adopters.

diffusion, and (2) user-shaped innovation diffusion, based on users' needs and problems (Table 2-1).

This alternative model of diffusion, the decentralized model, is defined as a diffusion system where power and control is widely shared among the members of the system (Rogers, 1983). The decentralized model emphasizes the role of horizontal communication within peer networks for the transfer of information. Most diffusion systems exhibit some characteristics of both centralized and decentralized models. In other words, the extreme centralized and decentralized ideal systems of diffusion are end-points on a continuum.

2.13 Consequences and Alternatives: New Approaches

We use the knowledge-base of two different academic disciplines in order to build a conceptual framework for studying microcomputer applications in agricultural development: (1) the social studies of science and technology, and (2) communication. The purpose of this conceptual framework is to assess the potential uses of microcomputers for agricultural education, extension, and training. We wish to avoid the pro-innovation bias that often characterizes information technologies when introduced in a Third World setting from a Western point of view.

Since Daniel Lerner's The Passing of Traditional Society (1958) and Wilbur Schramm's Mass Media and National Development (1964) much has been said about the "passing of the dominant paradigm of development" (Rogers, 1976). The acknowledgement of re-invention and decentralized diffusion systems during the 1970's helped in revising the one-way, linear model of diffusion, which was criticized for its source-biased, out-of-context, and persuasive-only conception of the communication process (Rogers, 1986). The passing of the dominant paradigm of development has been facilitated by a theoretical revolution in the conceptualization of the communication process itself, which puts emphasis on feed-back, interactivity, and convergence.

The convergence model of communication (Rogers and Kincaid, 1981) opened a new perspective for communication study. It considers communication as "a process in which the participants create and share information with one another in order to reach a mutual understanding." Communication is a progressive, never-completely-achieved process, as absolute understanding can not be reached due to the inherent uncertainty of the information that is created and exchanged (Figure 2-2). Communication implies a relationship, a mutual acknowledgement of the existence and condition of the other individual as an active subject.

At a methodological level, this theoretical development of convergence communication paralleled the development in communication studies of network analysis. The convergence communication process implied that when interactions become patterned over time, a communication structure, or network, emerges. Communication network analysis describes the component linkages defining this structure and therefore makes possible a holistic characterization of the communication process.

These important developments in the field of communication, however, do not completely change the prevailing conceptualization of development. Re-invention and synchronous developments in the field of

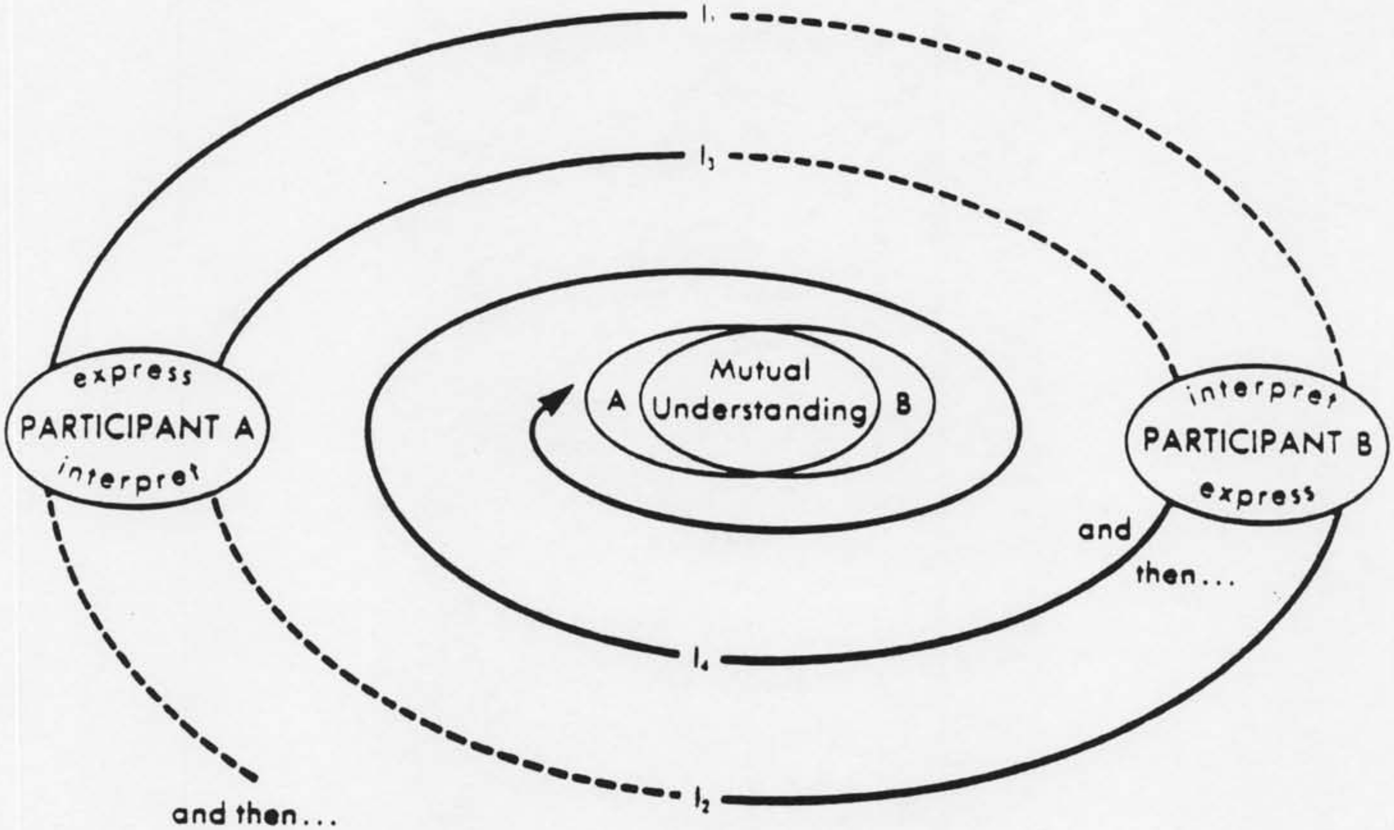

Figure 2-2. The Convergence Model of Communication,
Source: Rogers and Kincaid (1981).

communication are a limited "breakthrough" if the process of socially shaping the innovation is not questioned. To clarify this point, we review the constructivist program of scholars studying the social shaping of technology.

The social construction of technology (SCOT) is a strategic analysis methodology which describes the constitution of socio-technological networks, without making *a priori* distinction between what is social and what is technological. The technological qualities of an innovation are considered to arise as a result of social negotiations. The best expression of the social constructivist program is given by Woolgar (1991) in his assessment of the "turn to technology in Social Studies of Science:"

> Distinctions between the technical [scientific] and the social must be broken down. Social analysis should attend to the content of technology [scientific knowledge]. The role of the great individual engineer, inventor [scientist, discoverer] must be seen in social context. Technological [scientific] growth can no longer be thought of as a linear accumulation of artifacts [facts], each extrapolated from an existing corpus of technological achievement [scientific knowledge]. In short, technology [science] involves process as well as product, and technological artifacts [scientific facts] are to be understood as social constructs.

Several contributions to the social study of Artificial Intelligence (AI) have been made from a constructivist perspective (Woolgar, 1989). The controversy about the "strong program of AI" (Coulter, 1985), which states that the human mind can be adequately studied as though it were a computer, has been central for the social constructivist perspective, as well as for cognitive science in general. Woolgar (1987), however, demonstrated that the dispute based on the distinction between what is "cognitive" and what is "social" hides the problem of the relationship between (cognitive) science and technology (AI). According Woolgar, the difference between "strong" and "soft" versions of the AI program mirrors the difference between a hierarchical conception of the relationship between science (cognitive theory) and technology (AI).

The strong version on some occasions advances a symmetric view of this relationship, stating that both cognitive theory and AI are explicitly based on computational metaphors. On the other hand, the "soft" version tends to consider AI as a way to "mimic" human behavior (that is, performance). Woolgar's analysis suggests that "criteria of performance and mechanism are not unproblematically distinct." We use this example in our present conceptual framework, as a cornerstone for an assessment of the uses of microcomputers for agricultural development. The AI applications (expert systems, etc.) provide us with a representative example of what can be the future of intelligent applications of microcomputer technology for agricultural development.

We criticized the extension models for their use of an outdated version of the diffusion of innovations research tradition. New results and methods, both inside and outside of diffusion research tradition, teach us how these models can be updated. The concepts of re-invention and the decentralized diffusion model picture the user as a central character in the innovation process. The convergence model of communication and network analysis teach us how to consider the user in his/her social context. The reflexive example of AI applications show us how understanding of the user and his/her context should not be taken for granted in a purely behavioral conception of the user function in the innovation process.

The social construction of technology viewpoint, with which the present authors identify, tells us that a technological innovation like the microcomputer comes to exist, and then is perceived, through a social process of people talking to people.

2.2 EXTENSION AND MICROCOMPUTERS: A FRAMEWORK

2.21 Indigenous Knowledge and Development

Extension services in developing countries involve "giving confidence" about modern agricultural methods (Western, science-based technology) to farmers, in a way that gives them as much confidence as they have in their traditions (Roher, 1986). In the early 1980s, a counter-proposition centering on the notion of Indigenous Knowledge Systems (IKS) was developed. Indigenous technological knowledge can be used for development purposes. Despite its notable successes in many nations, the Green Revolution illustrates the problems inherent in strategies which promote new technologies "from the top down" (Howes, 1980). The main idea of IKS is to encourage farmers' participation by blending traditional and modern agricultural methods.

The concept of blending modern and traditional technologies must take into account the differences in these two kind of systems. For instance, the type of rationality underlying these systems of knowledge should be considered. IKS scholars advocate the rationality of indigenous knowledge systems. They sometimes accept a utilitarian point of view, alleging that IKS are of direct practical use in development programs, and so have a practical kind of rationality, as opposed to theoretical rationality. Doing so may lead to replacing one "unacceptable dichotomy" with another unacceptable dichotomy (Howes, 1980). Seeking to demonstrate the rationality of IKS from a Western point a view leads to recognition of Western-type rationality (the utilitarian paradigm).

The problem of defining the "rationality" of indigenous knowledge systems corresponds to the central problem of defining who and what is "indigenous." Several words are used as synonymous with indigenous: Local, rural poor, traditional, native, primitive, savage, folk, etc, (Chambers, 1983). Sometimes, indigenous is defined according (1) to the land (such as those people living in remote/inaccessible/frontier areas), (2) to the mode of utilization of this land (nomadic/semi-nomadic/herders/hunters/ gatherers), (3) to an historical status (dominated/colonized/exploited), or (4) to a common cultural attribute (language/religion/ ideology).

The problem of defining indigenous rationality, or who is indigenous, can be seen as a special case of understanding the user in the diffusion process. The farmer is the user in most of the extension models based on the diffusion research tradition. According to the Indigenous Knowledge System perspective, indigenous knowledge is not only useful, that is of practical use for development purpose, but fundamental for any development process to occur. The development process needs more than farmers' participation. It requires the farmers themselves to define which type of development they want to engage in and sustain. In the specific case of microcomputer applications, microcomputers cannot be introduced for extension purpose without a clear understanding of the processes they will stimulate.

2.22 Which Literacy for Developing Countries?

Computer technology is a product of the Western world (Figure 2-3). This technology is able to ground various kinds of discourse, from the most optimistic ("a cultural revolution," or "a new era in human communication") to the most pessimistic. Computer technology represents all kinds of ideologies, and is a center piece in the constitution of modern identity.

A communication perspective on computer technology is provided by David Bolter's (1984) Turing's Man , and James Carey's (1990) Language of Technology. Both authors analyzed the strength of computer technology in transforming Western technological culture. Bolter uses the concept of defining technology: "A defining technology develop links, metaphorical or otherwise, with a culture's science, philosophy, or literature; it is always available to serve as a metaphor, example, model or symbol."

Carey (1990) said that "When technology functions as a master symbol, it operates not as an external and causal force, but as a blueprint: Something that makes phenomena intelligible and through that intelligibility sets forth the conditions of its secondary reproduction." How do microcomputers work as a "master symbol" of the present-day technological society.

Both Bolter and Carey insist on the special characteristics of the computer from a technological point of view. Their assessment of

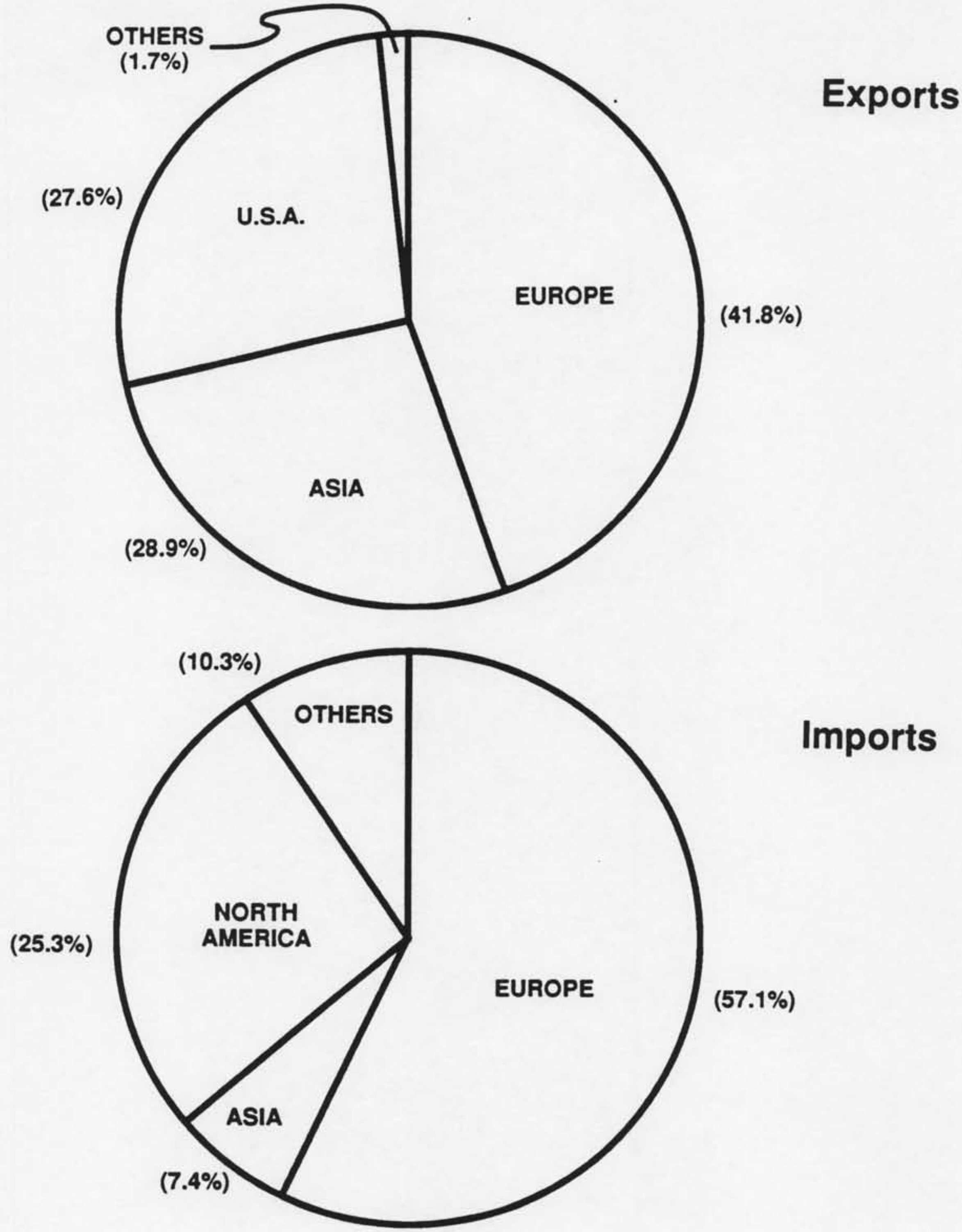

Figure 2-3. Imports and Exports of Automatic Data-Processing Equipment by World Region.

Source: UNESCO (1989).

computer technology relies on a technological analysis of what, and how, computers perform their duties. According to Bolter, computers work "As a calculating machine, a machine that controls machines," and according to Carey, "Like the telegraph, the computer does not work himself, a technology of control and command." These qualities or attributes of the computer then determine the possible social effects of the technology: "For us today, the computer constantly threatens to break out of the tiny corner of human affairs (scientific measurement and business accounting) that it was built to occupy, to contribute instead to a general redefinition of science to technology, of knowledge to technical power, and, in the broadest sense, of mankind to the world of nature" (Bolter, 1984).

This "threat" refers more to mainframe computers than to microcomputers. The "control and command" image is a direct allusion to the military origin of the mainframe computer technology, when microcomputers found their social origin in the social activism of their inventors in Silicon Valley in the late 1960s (Freiberger and Swaine, 1984).

Bolter (1984) distinguished between machine and tool: The computer is in some ways a machine in the Western tradition, and in other ways a tool-in-hand from the ancient craft tradition. The best way to encourage the human use of computers is to emphasize the tool over the machine. "A tool, unlike a machine, is not self-sufficient or autonomous in action. It requires the skill of a craftsman and, when handled with skill, permits him to reshape the world in his way" (Bolter, 1984). The social assessment of the technology therefore requires to consider the social definition of the "skill of the craftsman," that is the social definition of what "computer literacy" is.

Papagiannis and others (1987) ascribed three meanings to the concept of "computer literacy" in the U.S.: (1) employment preparation (i.e., technical familiarity and/or competence), (2) informatic (i.e., as part of an information policy), and (3) productivity-enhancement (i.e., learning to use computers in order to improve non-computer related activities). In Third World countries, the second perspective appears as the crucial step in order to avoid linear diffusion of an imported concept of "computer literacy." As Papagiannis and others (1987) stated: "The limited concept of computer literacy, as it has been used in the U.S., needs to be broadened and transformed into a conceptual framework that denotes how microcomputers can contribute to development." Four main computer functions constitute this framework: (1) organizational and institutional emancipation, (2) advancing self-reliance, (3) improving access to information, and (4) advancing local knowledge production.

2.23 Extension and Microcomputers: The Linkage

The paradigm shift (1) to the convergence model of communication, and (2) to the constructivist program of technology, includes a general theoretical movement toward the integration of the user in the innovation process. This theoretical movement toward a cognitive understanding of indigenous knowledge systems emphasizes the indigenous in a process of mutual understanding. The process of "translation" of a technology is central. Translating is understood as "the mechanisms and strategies

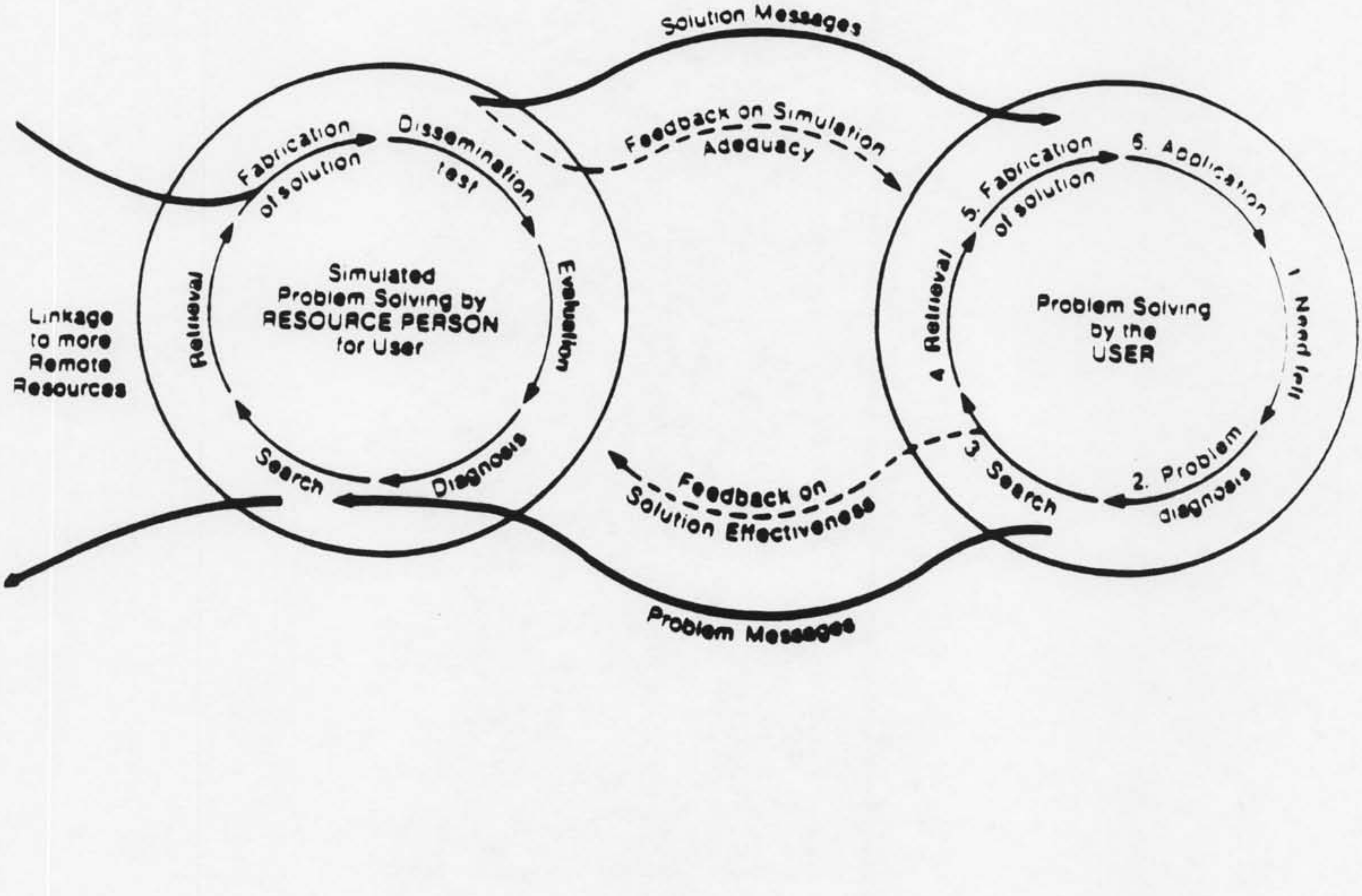

Figure 2-4. The Linkage Model of Knowledge Transfer,

Source: Havelock (1986).

through which an actor identifies other actors or elements and places them in relation to one another" (Callon and others, 1983). The concept of linking two or more systems of knowledge therefore appears as the cornerstone of this conceptual construction (Figure 2-4). The microcomputer application of linking indigenous knowledge system and development programs takes place at problem-solving process of the "user" and the "resource person." This "simulation" must go to the cognitive understanding of the knowledge system, further than just the illusion of performance. This flexible adaptation of microcomputing technology to development is a first step toward re-invention of a technology. Havelock's conception of "linkage" summarizes the arguments used here, and provides a conceptual framework to many challenging works in development (Röling, 1988; Warren, 1989).

One of the main important element in Rogers' (1986) analysis of the success of the land-grant system in the U.S. was the "high degree of control by the system over its environment." Information technologies are part of this revolution of control (Beniger, 1986) in the long range of the industrial revolution. Microcomputing technologies are an information technology for exchange and interaction, rather than just for a control perspective. Patton (1988) said that "The information-age extension model will not be able to exercise a high degree of control, though it will be proactive with regard to its environment. Rather than control, the information-age extension organization will depend upon mutual interests, negotiations, and shared values undergired by the movement of resources into and out of the system in ways that have visible impact on issue of critical public concern."

Chapter 3

ANALYSIS OF CASE STUDIES

Here we describe and analyze six case studies of computer use in agriculture. For each case, we present a description of the computer application, our analysis, and the important lessons learned.

3.1 BALI PROJECT: A MODELLING STUDY[1]

The Bali Rice Ecosystem Simulation Model was designed by Dr. J. Stephen Lansing and Dr. James Kremer, professors of anthropology and biological sciences, respectively, at the University of Southern California (USC). This application of microcomputer technology is mainly of a "problem-solving" nature. The model provides insights about conflict management in rice growing in Bali, Indonesia, by testing whether optimum local coordination exists for the efficient use of water and pest control. The Bali case shows the power of microcomputers as a communication tool in a conflictive social context.

3.11. Contextual Information: Historical Background of Rice Farming in Bali

[1] This section is based on personal conversations by Thiery Bardini with Dr. Steve Lansing of the the Department of Anthropology at University of Southern California, and with Dr. Jim Kremer of the Department of Marine Biology at University of Southern California.

The Traditional System

Traditionally, the Balinese farming system is composed of two rice crops per annual cycle, with a fallow period of approximately 35 days (one Balinese month) between them. The first crop is a long maturing variety of rice (*padi del*) that is slow-growing (200 to 210 days) but nutritious. The second crop (*padi cicih*) is usually a nonphotosensitive rice variety which has an average growing period of about 120 days.

The climate of Bali consists of a dry season and a rainy season of more or less equal length (Table 3-1, Figure 3-1). The traditional farming system is arranged so that the first crop harvest occurs in mid-summer, when the danger of rainfall is minimal and sunlight is assured for ripening of the rice. The fallow period is fundamental for pest control in the traditional farming system of Bali: the fallow period interrupts the food supply and/or life cycle of the major rice pests. Therefore, it is critical that this fallow period extends over a wide geographical region, to prevent the migration of pests from one rice field to another. This traditional system requires a high degree of coordination in order to optimize management of the fallow period for water and pest control (Lansing, 1987).

The Farming System in Bali and the Green Revolution

From 1978 to 1984, the government's Bali Irrigation Project promoted a new farming system, following the Indonesian government's push for self-sufficiency in grain production, which was called the "Green Revolution." The national government of Indonesia and the Asian Development Bank spent $24 million in introducing high-yielding rice

Table 3-1. The Climate of Rice-Growing Areas in Bali, Indonesia.

	Zone I	Zone II	Zone IV
I. Yearly mean rainfall			
1. Low rain	1,800	1,750	1,350
2. High rain	2,310	2,000	1,850
II. Dry season			
1. Low rain	May-Sept.	May-Oct.	May-Nov.
2. High rain	June-Sept.	Aug-Sept.	June-Oct.
III. Mean Days of sunshine	60%	76%	50%

Source: Lansing (1987).

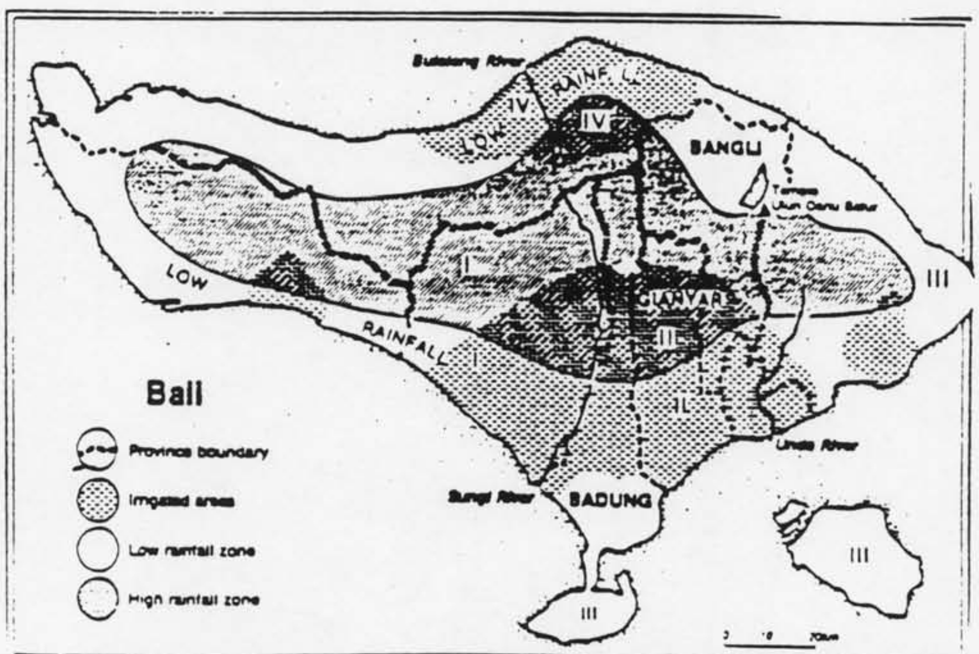

Figure 3-1. Map of the Island of Bali showing the three regions previously defined.

varieties, and in building larger dams and canals in selected watersheds. The new rice varieties grow relatively fast (90 days), allowing three harvests a year. One consequence of the Green Revolution was to break down the region-wide fallow period, in order to keep each rice field in continuous production. The government's Bali Irrigation Project (BIP) and the Asian Development Bank thought that the changes induced by the Green Revolution could be resolved by farmers purchasing increased commercial inputs of pesticides and fertilizers.

The introduction of the new farming system lead to increased resistance to pesticides by rice pests in Bali after several years. The previously balanced ecosystem broke down. The heavy applications of pesticides killed fish and eels, as well as the pests (and, sometimes, farmers). Rice yields and the number of cropped areas declined from 1982 to 1985, and farmers began to return to the traditional rice farming system, rejecting the Green Revolution farming system.

The Green Revolution in Bali was a failure. In many other nations of Asia, Latin America, and Africa, the Green Revolution was very successful, frequently doubling or tripling rice and wheat yields, and turning countries like India from being grain-importers to grain-exporters. Why did the Green Revolution fail in Bali?

Traditional Versus Modern Farming Systems

A rapid shift from traditional to modern farming systems occured in Bali, caused by government development agencies. Development of a computer-based model of rice growing in Bali goes back to 1983 when Dr. Steve Lansing began working on the role of water temples as a system for scheduling irrigation, planting, and harvesting during the rice-growing season. Lansing (1987) suggested that "Irrigation is centrally organized by a system of water temples, separate from the state." Water temples are located at the upstream boundary of the water system that they control, linking the physical features of irrigation systems to the social units according to a logic of rice production (Figure 3-2). The Balinese calendars and water temples show a link between the management of irrigation water and the centralization of power.

Officials of the Asian Development Bank felt that the Hindu priests in Bali did not "exercise any active role in irrigation-related activities." Two kinds of assessments explain this position:

1. Specialization of the Bali Irrigation Project staff: When a socio-anthropologist consultant was contracted by the Project, his work concerned the "human aspect" of the problem, such as conflicts about water (B.I.P., 1988).

2. Because of its anthropological nature, Steven Lansing's (1987) study cannot answer the question of the technical rationality of the traditional system of irrigation water management.

Religious factors are generally considered irrelevant to development. Likewise, technical solutions are often not taken into full account in solving social problems, and are therefore considered irrelevant by social scientists of development. But in certain cases, religious institutions play a key role in development (Niehoff, 1964).

In 1985, rice yields in Bali had decreased, and farmers were returning to the traditional rice farming system. The government's Bali Irrigation Project had not recognized the role of the water temples in the rational management of irrigation water.

Figure 3-2. Map of the Study Site for the Bali Model: The Oos River and the Petanu River in the Region of Gianyar, with the Catchment Basins, Irrigation Systems, and *Subaks* Shown in Relation to the Water Temples.

3.12 Objectives of the Simulation: Toward a Scientific Rationality[2] of Traditional Farming Organization

A comparison of traditional and modern farming systems requires an integrative approach combining technical and religious factors. The Bali Rice Ecosystem Simulation Model puts the traditional and modern farming systems in an ecological perspective, attempting to give scientific rationality to a complex reality. Human and natural factors in human organization are analyzed in order to further understanding of the irrigation system of Bali.

The underlying idea is that "in Balinese rice terraces, water is used to create an artificial ecosystem" (Lansing, 1987). Water management not only consists of bringing water to the rice crop, but it also transforms the entire ecosystem. Understanding the rationality of this farming system transformation requires measuring its impact on the entire ecosystem, not just its consequences on rice yields. The main idea of the modeling research project at the University of Southern California was to understand the process of transformation in farming systems, not just to analyze the in/output balance of rice production.

The Balinese ecosystem was too complex to be modeled in all of its dimensions. The fundamental step in this computer modeling began with the definition of a "ground hypothesis". This ground hypothesis identifies the objectives of the theoretical model and the conditions of the specific setting that is modeled. Steve Lansing sought to demonstrate the rational achievements of the water temples in the management of irrigation from

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[2] Rationality is the degree to which the most effective means are chosen to reach a given goal (Merton, 1957).

a technical point of view. Lansing found that "two irrigation-management institutions coexist on the island [that is, Bali], institutions so fundamentally dissimilar that they are all but invisible to each other" (Lansing, 1987). The main objective of the computer model was to make these two institutions meet and communicate with each other.

3.13 The Model: From Idea to Realization

Formulation of the Computer Model

The design strategy for specifying the model was based on the viewpoint that "empirical relevance was more desirable than scientific precision, and we had to deal with information appropriate to the intended audience" (Kremer, 1989). The model was reduced to two criteria: (l) use of water, and (2) pest control. The reasons were:

1. These two criteria were fundamental because "they are the criteria the priests use" (Lansing).

2. This reduction was acceptable because it made the model "attractable and relevant" (Kremer).

The main steps in formulating the model were:

1. An empirical, statistical description based on the Bali Irrigation Project hydrology report was used to define the relationship between rainfall and river flow.

2. For each of the five crop options consisting of the three rice varieties, fallow, and vegetables, data were obtained on growth rates, the potential effect of severe pest damage on yields, and water stress.

3. Water demand was provided by the Bali Irrigation Project. The remaining parameters come from "anecdotal information" (Kremer).

4. The fractional water stress[3] deficit is assumed to reduce the calculated rice growth toward full harvest on a linear basis.

5. The pest population is modeled in terms (l) of the reduced rice yields that it causes and (2) the changes it causes in pest growth and migration. Local growth is assumed to be exponential but food dependant, and migration is computed as a linear diffusion through space (Kremer, 1989).

"The key to the present application of the model is the choice of management scenarios." Finding whether an optimum regional coordination in water use and pest control exists is obtained by running different scenarios that "span the range of coordination among the 172 *subaks* [4] of the model from all following the same schedule, to 172 different schedules." Seven choices are provided, which "assume that the *subaks* plant and harvest together in group that parallel to various degrees the subdivision of [water] temple hierarchy" (Kremer, 1989).

Features of the Computer Model

The communication interface was written in a high-level programming language, HyperCard, for the Apple Macintosh computer. This model package introduces the user to the geographical boundaries,

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[3] <u>Water stress</u> is the degree to which adequate amounts of water are not available to a plant.

[4] A *subak* is the Balinese word for a local farmers' association, operating as a water user group. The invisibility of the water temple system comes from the fact that "irrigation development plans invariably assumes that the individual *subaks* are the highest-level traditional Balinese institutions concerned with irrigation" (Lansing, 1987).

conceptual framework, simulation options, and then displays the results. All computer programming is in three languages: English, Indonesian, and Balinese.

Human resources were required in addition to Drs. Lansing and Kremer. Formulation of the model required the technical assessment in computer programming by Tyde Richards and the Project Jefferson team of the Center for Scholarly Technology at the University of Southern California. Approximately six weeks were required to conceive and execute the model design. Then, using HyperCard, the first draft of the communication interface was roughed out in three days.

The research project was funded by a $100,000 grant from the (U.S.) National Science Foundation. In addition, the faculty salaries of the two main researchers were paid by USC.

A videotape, "The Goddess and the Computer," has been produced by the project team for broadcast in the *Nova* series of educational television programs in the U.S. The videotape was produced by Andre Singer of the British Broadcasting Corporation, who is also an Adjunct Professor of Visual Anthropology at the University of Southern California. Considerable press coverage, including articles in Newsweek magazine, also helped spread the Project's result.

3.14. Results and Lessons

Results: The Traditional Rationality

The first results of the computer simulation suggest that an intermediate scale of coordination in balancing water use and pest control is optimum. This degree of coordination corresponds to that provided by the network of water temples in Bali (Kremer, 1989). Further results showed:

1. The priests and the village elders in Bali considered that the computer model was an approximation of reality, and showed great interest in its further development. The Bali Irrigation model on an Apple Macintosh computer was taken to Bali by Dr. Lansing, and provided to the priests and village elders for a demonstration.

2. The Asian Development Bank and the Bali Irrigation Project acknowledged the model's results. The Project Performance Audit Report (B.I.P., 1988) stated: "The substitution of the `high technology and bureaucratic' solution in the event proved counter-productive. While administrators and *subaks* have now returned to a lower rice cropping intensity and to a more coordinated rotation, the cost of the lack of appreciation of the merits of the traditional regime has been high."

Lessons Learned

The social success of the introduction of the computer model is explained by several key factors (Figure 3-3):

1. Control of a major source of uncertainty. The efficiency of an intermediate scale of coordination of water management and pest control was fundamental to the 1985 failure of the Bali Irrigation Project's attempt to introduce the high-yielding Green Revolution rice varieties.

2. The uncertainty caused by the mutual invisibility of the two irrigation management institutions. The power of the microcomputer is that the model can be made to speak a language understandable to the technicians and specialist staff of the Bali Irrigation Project.

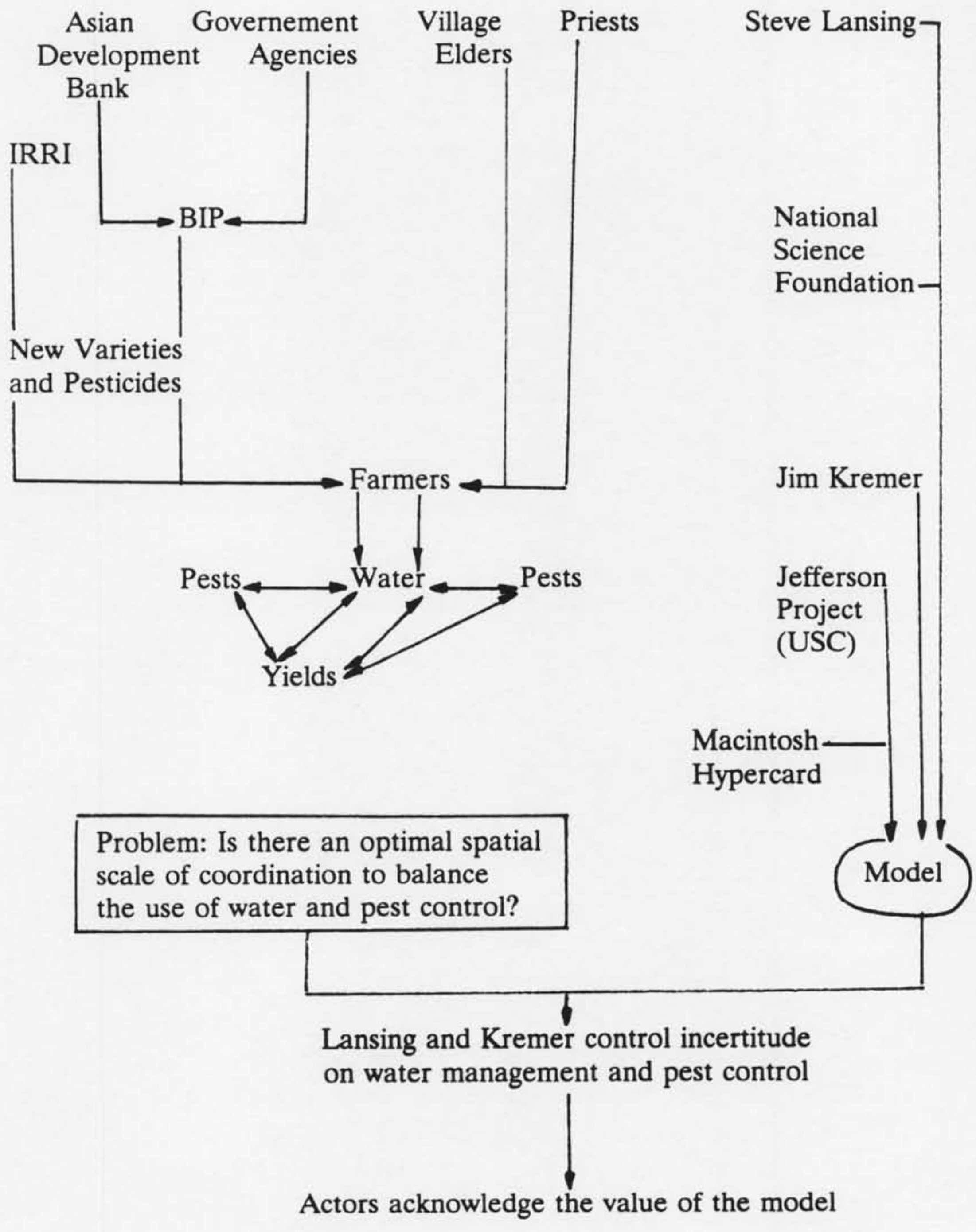

Figure 3-2. Analysis of the Bali Rice Ecosystem Simulation Model.

The success of the microcomputer in this case can be explained by the fact (l) that it answers a problem raised by the actors themselves, and (2) that this answer is given to them in a language that they understand and value.

This case study provides us some important lessons about the use of microcomputers for agricultural extension, education and training:

1. The microcomputer can be used as a communication tool to overcome some obstacles to communication between different actors of the development. The simulation appears as the process of making these actors communicate via the computer.

2. This type of application requires relatively little resources, and can be considered as a preliminary phase in projects involving conflictive rationalities and/or representations of the problem.

3. The replication of this type of project on a larger scale (extension) is, in fact, the process of diffusion of the research results. It requires training of extension workers to computer use as considered as a communication tool. Therefore, the emphasis should not be put only on the computer technology, but on the technology as a means to reach communication goals.

3.2 NDDB'S FRUIT AND VEGETABLE PROJECT IN INDIA

The Fruit and Vegetable Project (FVP) in New Delhi, India is a spectacular example of a fruit and vegetable procurement and marketing system that is integrated by a computer system. FVP's mission is to serve the interests of both fruit and vegetable producers and consumers.

Producers are insured a regular market for their produce to encourage greater production. Consumers are assured of a continuous supply of fresh fruits and vegetables at affordable prices. Information flows via the computer system to connect the farmer/producer of the fruits and vegetables with the urban consumer in the Delhi metropolitan area, through an information network stretching across hundred of miles.

Many thousands of farmers, distributors, and consumers are linked via this computer-based system. The computer plans the production and procurement of 2,500 varieties of farm produce from thousands of farmers every day; monitors the storage of some 125,000 kilograms of diversified types of produce; markets the produce through about 145 retail outlets; and monitors the economics of individual produce items. The Fruit and Vegetable Project is a function of the National Dairy Development Board (NDDB), headquartered in Anand, India, a small city in Gujarat State, India.

The National Dairy Development Board[4] (NDDB) was founded in 1965 to replicate a highly successful cooperative, the Kaira District Cooperative Milk Producers' Union (AMUL) throughout India. Resources for this expansion of the cooperative system came from the sale of dairy commodities donated by the World Food Program and the European Economic Community (EEC) which were combined into fluid milk in India. This imported milk helped establish a market for dairy products in major cities for the India-produced milk which followed. This campaign, called "Operation Flood," increased the consumption of milk from 104 grams per

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[4] This section is based on written corresspondance with Thomas R. Carter, dated December 6, 1990, and a personal discussion with Everett M. Rogers on January 9, 1991, in New Delhi.

person per day in the mid-1960s, to over 170 grams per capita per day today. The EEC imports of milk products stopped in 1988, and today India exports nonfat dried milk.

The NDDB seeks to enable milk producers to gain greater control over returns from the dairy resources that they create. Such efficiency is fostered through vertically-integrated cooperatives that support production, processing, and marketing. Thanks to NDDB, India today has over 60,000 cooperatives with more than 7.5 million members.

To follow-up on its success in dairy cooperatives, the NDDB seeks to replicate the Anand pattern in oilseeds, trees, salt production, and fruit and vegetable. The Delhi Fruit and Vegetable Project is one attempt by the NDDB to transfer the Anand-style dairy cooperative idea to another enterprise. In early 1991, the NDDB was evaluating ten other Indian cities in which to launch fruit and vegetable projects.

3.21 Contextual Information: Computer System and Integrated Management

Figure 3-3 shows that the FVP includes transportation, price-setting, sorting and packaging, storing, distribution, and retailing functions. All of these interrelated functions are controlled by the project's computer system. In fact, one might think of the Fruit and Vegetable Project as a computer system that also has attached to it the means of buying, processing and selling food products.

The microcomputer-based system of the FVP is ubiquitous. When it is time to procure the produce, the computerized crop plans identifies areas in India where fresh fruits and vegetables are available. Produce from individual farmers and cooperative societies are logged on the computer system. A payment list is printed by the computer, as are the payment checks for farmers. Advice on seed multiplication, crop management, and increased production are also provided to Indian farmers by the computer (Achar, 1990).

When the produce arrives in FVP's trucks at the central warehouse facility in Mongolpuri (on the outskirts of New Delhi), one of the largest in Asia, the computer again takes charge. The trucks pass over a weightbridge which calculates the exact weight of the produce. The computer allocates storage space for the produce in atmosphere-controlled cold-rooms specifying the most appropriate temperature and humidity conditions for each type of produce. When it is time for produce withdrawal, a series of decisions are made by the computer, based on produce's perishability limits, first-in-first-out, quality parameters, etc. The demand of the produce items are compiled by the computer based ondaily requisitions received from FVP's 145 retail outlets and the 46 institutions which it serves.

The computer identifies the best transportation route and prepares invoices based on the existing sales prices (Gosh, 1990).

The FVP computer's marketing module consists of demand forecasting for produce, demand and sales analysis, sales accounting, retail prices fixation, monitoring expenses of retail outlets, etc. Stores, purchase, and inventory functions are completely on-line. An electronic cash-book is maintained and such accounting documents as balance sheets and profitability statements are computer-created. Personnel and administrative functions such as employee attendance, overtime, leave, payroll, appraisals and promotions, security, etc. are all computer-

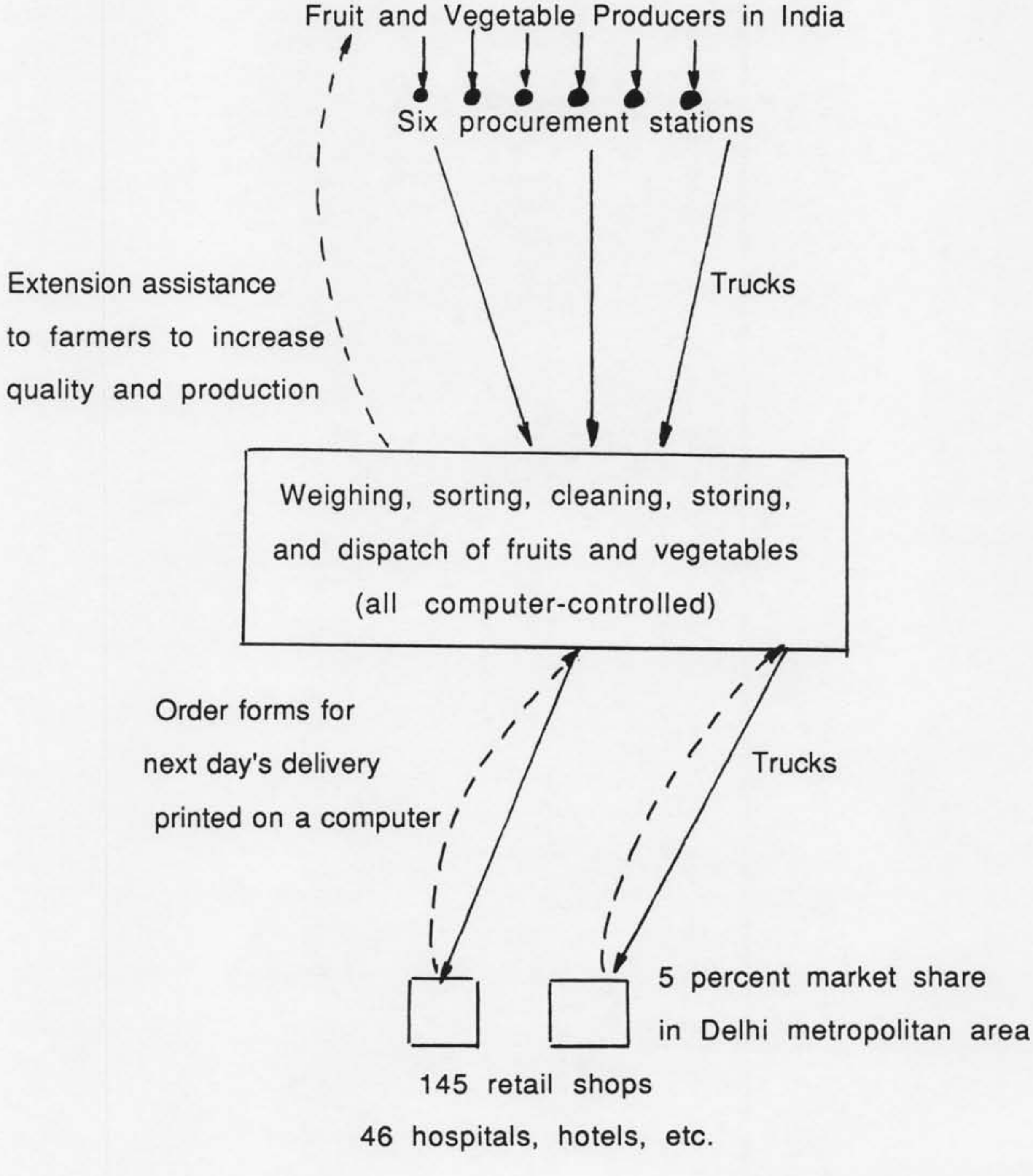

Figure 3-3. Diagram of the Fruit and Vegetable Project (FVP) in New Delhi, India, Showing the Key Role of the Computer System.

controlled. An integrated office automation package provides word-processing, spread-sheet, and electronic mail services. The FVP is well on its way to a completely paperless office.

The Fruit and Vegetable Project is large in size, representing about 5 percent of market share for fruits and vegetable sales for the eight million people living in the Delhi metropolitan area. The Project is also extremely wide in geographical scope, with purchases of fruit and vegetables from producers in many distant parts of India. Figure 3-3 shows the flows of extension information (depicted as dotted lines) from the Project to the farmers producing fruits and vegetables in India. About 60 extension workers with advanced educations in horticulture are employed by the Project to advise farmers when to plant and harvest their crops, how to achieve higher yields, and how to improve the quality of their products so as to meet the needs of Delhi consumers.

3.22 Objectives: A Computer System for a Cooperative Ideal[5]

The idea for launching the NDDB's Fruit and Vegetable Project originated in New Delhi, in 1983, in a meeting between then-Prime Minister Indira Gandhi and Verghese Kurien, Chairman of the NDDB. Gandhi asked Kurien why the cauliflower that she grew on her Mehrauli farm on the outskirts of Delhi sold for one rupee per kilogram to the local

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[5] This section is based on personal conversations by Dr. Arvind Singhal with Ms. Amrita Patel, Managing Director (Operations) of the NDDB, and with Dr. Verghese Kurien, Chairman of the NDDB, in Anand, India, on August 1, 1990.

vegetable trader, while her household chef bought the same cauliflower for four rupees per kilogram in the local market in New Delhi.

Kurien told her about the heavy profits which "middlemen" made at the expense of farmers. Gandhi said, "You eliminated the `middlemen' in milk and oilseeds procurement and distribution. Why can't you do the same for fruits and vegetables?" Already overburdened by the milk marketing projects and by the oilseeds marketing projects, Kurien was not enthusiastic about yet another project on fruit and vegetable marketing.

But three months later, when Indira Gandhi's Cabinet Secretary called Kurien to enquire about what progress the NDDB had made to empower fruit and vegetables farmers, Kurien agreed to look into the matter. Kurien was dismayed that while India had several agricultural research institutes and government horticulture departments, these organizations played no role in empowering fruit and vegetable farmers to earn higher prices for their produce. Deciding that he did not have much to learn from these government agricultural/horticultural units, he decided that the NDDB would independently organize a fruit and vegetable marketing cooperative.

In 1984, NDDB built 10 fruit and vegetables retail shops in Delhi, in order to learn more about procuring, distributing, and marketing fruits and vegetables to consumers. In 1985, an expert group composed of NDDB officials and Canadian and U.S. consultants studied the feasibility of a Fruit and Vegetable Project. In 1986, the F&V Project was approved by the government of India, and shortly thereafter construction began on the warehouse storage facilities in New Delhi that would be needed to begin operations.

3.23 Computerization of the FVP[6]: From Idea to Realization

History of the FVP

NDDB wanted all their fruit and vegetable transactions to be completely on-line (in other words, to have a "paperless" office). Deepak Tikku, General Manager of the FVP in Delhi, championed the F&V Project's computerization, with blessings from his boss, Verghese Kurien, Chairman of the NDDB, in Anand, India.

The NDDB conducted feasibility studies of a completely on-line computer system for the F&V Project. Data-processing needs were ascertained, and computer companies were asked to bid for the computerization project. ORG Systems won the contract for several reasons. The NDDB had faith in ORG System's expertise, as ORG Systems had previously computerized part of NDDB's "Mother Dairy" milk procurement/distribution operations. Further, ORG Systems had built an excellent track-record in implementing on-line computer projects for horse-racing "turf" clubs, airlines, and several travel agencies. ORG Systems represented to NDDB a "total solution" company, capable of meeting the F&V Project's hardware, software, maintenance, and manpower training requirements.

Features of the Computer System

ORG Systems Engineers developed the software for the F&V Project using Oracle, a powerful data-base management system. Even though it is

[6] This section is based on personal conversations by Dr. Arvind Singhal with Mr. Hari Dave, General Manager, ORG Systems, and Mr. Deepak Ruchandani, data-processing consultant in New Delhi, in July-August, 1990.

complex in design and development, Oracle presents several advantages to users.

A super mini-computer (networked with about 50 microcomputers) was implemented with a modular capability for expansion in case data-processing needs grew. The hardware could be expanded from one to eight CPUs (Control Processing Units). In the past two years, the hardware capability of the Project's computer system has been expanded and enhanced to cope with higher data-processing inputs.

ORG Systems' engineers integrated several third-party devices into the on-line computer system. Examples are the road-weight bridge for the F&V Project trucks when they arrive or depart the F&V complex in New Delhi; the electronic employee attendance recorder (for enhancing punctuality and discouraging absenteeism); and the door-mat weigh bridges for crates of fruits and vegetables as they enter or depart the cleaning/storage area. Such integration of third-party devices into the F&V Project's on-line computer was complex to implement, but tremendously beneficial to more efficient operations.

ORG Systems engineers completely trained F&V employees to use the new computer system. ORG Systems felt that if the F&V Project began with a completely on-line computer system, resistance to computer use on the part of the F&V Project's employees would not be a serious problem.

The F&V Project's computer has a tremendous capability. ORG Systems engineers insured that the computer system would not be "down" at any time by building in a high degree of redundancy.

ORG Systems completed the computerization of the F&V Project in about six months at a cost of about 5,000,000 rupees ($300,000).

3.24 Results and Lessons Learned[7]

NDDB's Fruit and Vegetable Project in Mongolpuri, a suburban area of New Delhi, represents a "learning laboratory" for NDDB officials in the fruit and vegetable markets of other Indian cities. The Project is scheduled to expand to ten other Indian cities in the 1990s. What has been learned to date?

1. FVP's computer technology helps harmonize the best interests of farmer/producers and consumers. Producers are ensured a regular market which in turn induces them to produce more, and consumers are assured of high quality fruits and vegetables at an affordable price.

2. The FVP computer serves as an invaluable decision-aid for framers, FVP managers, and retailers. For instance, it optimizes supply and demand for produce, provides advice on cropping patterns, and manages the complexity of procuring, storing, and distributing over 2,500 produce items every day to some 145 retail outlets. Such a task would be impossible to carry out without the FVP computer system.

3. The F&V Project is highly capital-intensive. NDDB will not build as large a storage facility in the ten other cities as they did in New Delhi. The New Delhi facility is presently under-utilized.

4. In comparison to other vegetable vendors, NDDB's overhead costs are relatively high, so competing with small retailers is difficult.

5. The processing and packaging of food is prohibitively expensive in India. Consumer attitudes in India toward processed and packaged foods,

[7] This section is based on a personal conversation by Dr. Arvind Singhal with Ms. Amrita Patel, Managing Director (Operations), NDDB, in Anand, on August 1, 1990.

while changing, are still generally unfavorable. In order to be commercially viable, the NDDB must fully exploit the emerging processed/packaged food market in India.

6. The F&V Project is highly complex, with a wide variety of fruit and vegetables being handled, and with various quality levels of each fruit and vegetable. This complexity presents important problems for efficient marketing operations. In the long term, the NDDB FVP needs to supply uniform-quality seeds to farmers in order to achieve uniform production. For example, some types of Indian tomatoes get bruised by the FVP's French-made cleaning machines.

7. The F&V Project needs to supply improved seeds to farmers, and to improve the procurement, distribution, transportation, packaging, and marketing of fruits and vegetables. All of these functions must be coordinated effectively. So the F&V Project represents a difficult management challenge.

3.3 THE DEEJAY POULTRY PROJECT IN INDIA[8]

While the average-sized farmer will not use a microcomputer for on-farm analysis and record-keeping (even in industrialized nations like the United States), very large-scale agricultural enterprises in Third World countries are utilizing computers currently as an important part of their operations. One such example is the Deejay Poultry Project headquartered in Bangalore, India. Deejay is a very large enterprise indeed.

[8] The present case-study is based upon Galfar (1985) and Jaikumar (1989), and on personal interviews by Everett M. Rogers and Arvind Singhal with Dr. G. B. Pattannaiah, Manager of Technical Sewrvices; and Dr. M. Morton, Technical Services; and Mr. John Xavier, Manager of Costs and Systems, Computer Division, all of Deejay Enterprises.

In mid-1990, Deejay had 10.9 percent of the market share for broiler chickens in India and 13.4 percent of the market share for layers. The company did $22 million of sales in 1989, making it the second-largest poultry enterprise in India. From a modest start with 10,000 chickens in 1969, the Deejay Group of companies has grown to include:

1. 19 breeding farms, with 400,000 laying hens, and 11 hatcheries.
2. A production of 3,000,000 eggs, 670,000 layer chicks, 1,600,000 broilers and 3,000,000 baby chicks per month.
3. Sales of baby chicks to 12,000 farms.
4. A new poultry-processing plant in Bangalore that processes and freezes 10,000 chickens per day.

In addition to its poultry enterprises, the Deejay Group has expanded in recent years into the following ventures:

1. The sale of poultry equipment (like chicken waterers and feeders, sand disinfectant).
2. Coconut breeding through hybridization, in order to breed faster maturing and shorter trees (only about 10 feet tall).
3. Rabbit-raising to produce angora wool for export sale.
4. Shrimp-farming along the coast of Karnateka state.
5. Coffee production.
6. Flower production (mainly orchids and anthuriums).
7. Farm equipment manufacturing.

One measure of the rise of the Deejay and other companies in the poultry industry in India is the much higher consumption of eggs and poultry meat. However, India's egg consumption of 19 eggs per capita per year is in marked contrast to 320 in the United states. The peak in demand for eggs occurs in India around Christmas time, when eggs are used for making cakes. Peaks in demand necessitate that egg production be adjusted accordingly, a task that computers are uniquely capable of carrying out, as a way of integrating production with consumption.

The president of the Deejay Group is David J. "D.J." Lobo, whose initials give the company its name. Mr. Lobo got his start in the poultry industry 20 years ago, as a $40 per year employee on a poultry farm. Then, from 1971-1977, Lobo was a franchisee of Venkateshwara Hatcheries of Pune (commonly called "Vinki's"), which had been founded by Dr. B. V. Rao as the first large commercial poultry enterprise in India. After gaining valuable experience with Venki's, Lobo split off from the parent company to establish Deejay's poultry company in 1978. South India is becoming a major poultry-producing area, and the state of Andhra Pradesh has become the "egg bowl" of India. It has been necessary for Deejay's to breed special chickens for the tropical and semi-tropical conditions of South India.

In mid-1990, Deejay's had grown to over 800 employees. The company has a unique organizational culture in that all of the employees are encouraged to call President Lobo by his first name, David. Deejay's boasts that it has a participative management style, with employees having a say in company decisions. Each workday at Deejay's begins with a prayer.

Computers have been used by Deejay poultry enterprises almost since the company was founded in 1978. Deejay officials say that because the company is so large today, it could not operate efficiently if it did not use computers for administration, farm management, and marketing. For example, the Deejay Group uses specialized computer software for production forecasting, flock performance reporting, least-cost feed formulation, and resources management.

Deejay's began using computers for accounting purposes in 1980, when they were one of the first companies in India to computerize (Jaikumar, 1989). The company started with a microcomputer, and as computer use grew, Deejay's acquired a computer workstation system. Today, in addition, Deejay's has an IBM PC AT and two PC XT's and printers for each of the seven regional offices that are located in South India. In mid-1990, the computer system was being further decentralized to 18 out-stations, which are tied into a company-wide network through the exchange of floppy disks among the company's various computers.

Deejay's computer system is used to forecast egg and poultry production for the Deejay farms. Egg production must be scheduled long in advance of demand. A baby chick grows to the point of beginning to lay eggs at 20 weeks, and will be culled one year later at an age of 72 weeks, when the bird is expected to have laid 300 eggs.

A newly-hatched chick can only survive for about 36 hours without feed and water, so they are an extremely fragile product. If Deejay's chicks are not sold within the 36-hour period they must be destroyed by drowning, the most economic alternative. The Deejay's computer system performs a crucial function in predicting the demand for baby chicks.

Twenty-five years ago, most egg-producers in India were small farmers. Then the commercial poultry industry began to get underway. Today poultry producers include engineers, medical doctors, and a variety of other individuals who engage in poultry farming as a profitable sideline. Deejay's uses a computer program to predict whether or not an individual should go into poultry production. This program identifies hidden costs, calculates expected profits and losses and cash flow for the next five years, provides customized blueprints for poultry shed design and construction, and calculates the financial analysis demanded by Indian banks for making a loan.

Deejay's does a great deal of diagnostic work and other extension education with poultry farmers who buy Deejay's chicks. Some 20 local extension offices are staffed by Deejay's veterinarians and other employees. They make on-farm visits; provide advice about sanitation, nutrition, and other poultry management problems; and offer a variety of computer-analysis services. Training courses for poultry farmers are regularly provided by Deejay's.

3.4 NICNET AND CRISP: USING COMPUTERS FOR DEVELOPMENT IN INDIA[9]

With 80 percent of its people living in some 600,000 villages, the Indian government has accorded a high priority to rural development programs. In the past three decades, various anti-poverty programs such as the Integrated Rural Development Program (IRDP), the National Rural Employment Program (NREP), and the Rural Landless Employment Guarantee (RLEG) were launched (Department of Rural Development, 1989). In order to evaluate these programs, development officials in India generated a plethora of data about various rural development activities.

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[9] The present case study draws upon Banerji and Gosh (1989), Sharma (1989a, 1989b), Sharma and Jaikumar (1989), and upon Dr. Arvind Singhal's personal conversations with Dr. N. Seshagiri, Director of the National Informatic Center in New Delhi in July ,1990, and with Anantha Padmanabha, a former CRISP official, in Anand, India, in August, 1990.

However, given the lack of a management information systems (MISs) to analyze these data, local development officials could not effectively plan, monitor, or implement these rural development programs (Sharma, 1989b).

Two management information systems are now available in India, in which computers are being used to promote socioeconomic development: (l) NICNET, a computer-based communication network of the National Information Center (NIC), New Delhi, and (2) CRISP, the Computerized Rural Information Services Project. The first system was initiated as a top-down computer system, and the later as a bottom-up system. NICNET and CRISP represent efforts of the Indian government to encourage information flows horizontally and downwards.

3.41 Contextual Information: Two Levels of Action

NICNET: The Computer-Based Communication Network of the NIC

The National Information Center (NIC) was established in New Delhi in 1977, funded jointly by the Indian Department of Electronics (DOE), the Electronics Commission, and the United Nations Development Program (UNDP). In 1982, when India hosted the Asian Games (a mini-Olympiad), NIC created the Computerized Asiad Information System (CAIS), networking 17 stadia in New Delhi by on-line computer services. Results of over 215 athletic events were instantaneously provided to all 17 stadia and to the press. Comparisons were also made with past performances (NIC, 1983). CAIS helped bestow prestige on NIC's mission.

NIC established NICNET, a satellite-based computer communication data network which connects India's 440 local districts, the 30 state capitals and union territories, and NIC's four regional centers (Delhi, Pune, Bhubhneshwar, and Hyderabad) with the central facility in New Delhi. Hailed as the world's largest government-run computer network, NICNET's purpose is to provide decision support system to enhance central planning by the government of India (Varma 1989a).

In 1987, NIC was transfered from India's Department of Electronics to India's Planning Commission. NIC develops software standards for data-collection, compilation, and dissemination, creates data-bases for key sectors of the Indian economy, and provides computer training to government officials. As one of India's largest computer organization, NIC employs 3,200 individuals, of which 2,900 are scientists, engineers, or technicians (Sharma and Jaikumar, 1989).

The Karwar District Experiment

Mr. Sanjoy Dasgupta, the Development Commissioner of Karwar District in India's Karnataka state, purchased a microcomputer in 1983 by diverting funds that had been allocated to purchase a new jeep. He was frustrated by the necessity of making arbitrary decisions for his district based on unorganized information. Dasgupta thus laid the foundation for what later became the Computerized Rural Information Service Project (CRISP) in India.

With a simple-to-use 8-bit, 64-kilobyte microcomputer, Dasgupta computerized data on Karwar District's 1,334 villages, so that he could monitor the activities of the 20,000 beneficiaries covered by the district's rural development programs (Banerji and Ghosh, 1989). In the first year after adopting the microcomputer, Karwar District moved up from 18th to 3rd rank among the districts in Karnataka state in its degree of success in implementing development programs (Singhal and Rogers, 1989). Karwar District soon gained public attention for its use of the microcomputer to monitor its development loans, land records, and other data about development programs.

In 1985, Mr. N. J. Kurian, the Director of the Department of Rural Development (in the national government in New Delhi) visited Karwar District, and was very impressed with Dasgupta's use of the microcomputer for rural development. Kurian then recommended that microcomputers be implemented in other Indian districts. In 1986, the Indian Planning Commission approved the Computerized Rural Information Systems Project (CRISP). Dasgupta was named Project Director of a pilot project covering 10 Indian districts.

3.42 Objectives: Computers for Organized Decision-Making

Both NICNET and CRISP were launched to overcome the cumbersome, time-consuming, and often inefficient task of manually compiling data for purposes of administrative decision-making (Sharma, 1989a). India's government administrative structure includes a center (New Delhi), 30 states and union territories, 440 districts, and 5,000 blocks[10] .

A paper trail typically originates in a block, where records about the progress of village-level development projects are maintained. Block records are consolidated at the district level, district records at the state level, and state records at the national level (Figure 3-5). Manual compilation of data is highly inefficient, as there can be little horizontal

[10] The block is an administrative unit of government within a district. Each block includes a large number of villages.

#4. Center (New Delhi)

#3. State Capitals and Union Territories

(N=30)

#2. Districts

(N=440)

#1. Blocks

(N=5,000)

People

(N=880,000,000)

Figure 3-5. Administrative Levels at which Data Are Collected and Consolidated by the Indian Government.

or downward mobility of the data. To overcome this problem, NICNET and CRISP utilize computers for information-gathering and processing, and a MIS (Management Information System) to enhance administrative decision-making. While computer technology is central to both NICNET and CRISP, the two projects differ in various ways:

1. While NICNET is designed to provide decision-support for the national government, CRISP serves a similar purpose at the district level (Sharma, 1989a). NICNET serves the national government by gathering data from state governments, who in turn gather data from district officials. In the CRISP system, each district gathers data from blocks and villages. So NICNET is centralized (controlled by the national government in New Delhi), whereas CRISP is relatively decentralized (controlled by district officials).

2. While NICNET was created to provide decision support services for the entire gamut of Indian administrative sectors (industry, agriculture, energy, transportation, etc.), CRISP's primary task is to plan, implement, and monitor rural development programs in districts (such as the Integrated Rural Development Program, the National Rural Employment Program, etc.).

3. While NICNET cost the Indian government over $200 million by 1990, CRISP only cost $5 million. So NICNET and CRISP differ in terms of their scope, size, implementing agency, and costs.

3.43 Implimentation of NICNET and CRISP: From Ideas to Realization

History of the Computer Projects

In the mid-1980s, the Rajiv Gandhi government of India provided a thrust to implement NICNET on a national level. Championed by Dr. N. Seshagiri, Director General of NIC, the NICNET project was given a boost in 1987, when NIC's mother earth station (MES) was commissioned in New Delhi. NIC's MES uses the INTELSAT V satellite to communicate with state and district administrations (Figure 3-6). By 1990, all of India's 440 districts were connected by NICNET. NIC plans to spend another $225 million to extend the network to India's 5,000 blocks by 1995.

Seshagiri justifies NICNET's high investment costs by arguing that NICNET will save India $700 million between 1990 and 1995 through on-line project monitoring by drastically reducing cost over-runs on projects (Varma, 1989). The several private networks of large government organizations (such as the National Thermal Power Corporation, Steel Authority of India Limited, and others which ride piggy-back on NICNET) also save the Indian government several million rupees every year (Sharma and Jaikumar, 1989).

CRISP's 10 pilot districts were chosen from India's 440 districts to represent different levels of development, agro-climatic conditions, and administrative cultures (Banerji and Ghosh, 1989). The task of Dasgupta's team was to develop a user-friendly software program for use in planning, monitoring, and evaluating rural development programs (such as IRDP, NREP, and RLEG). By early 1987, the CRISP software was installed in all 10 districts, and a further extension of CRISP to India's 440 districts began.

The microcomputers are installed in the office of the District Rural Development Agency (DRDA), which was given responsibility for procuring

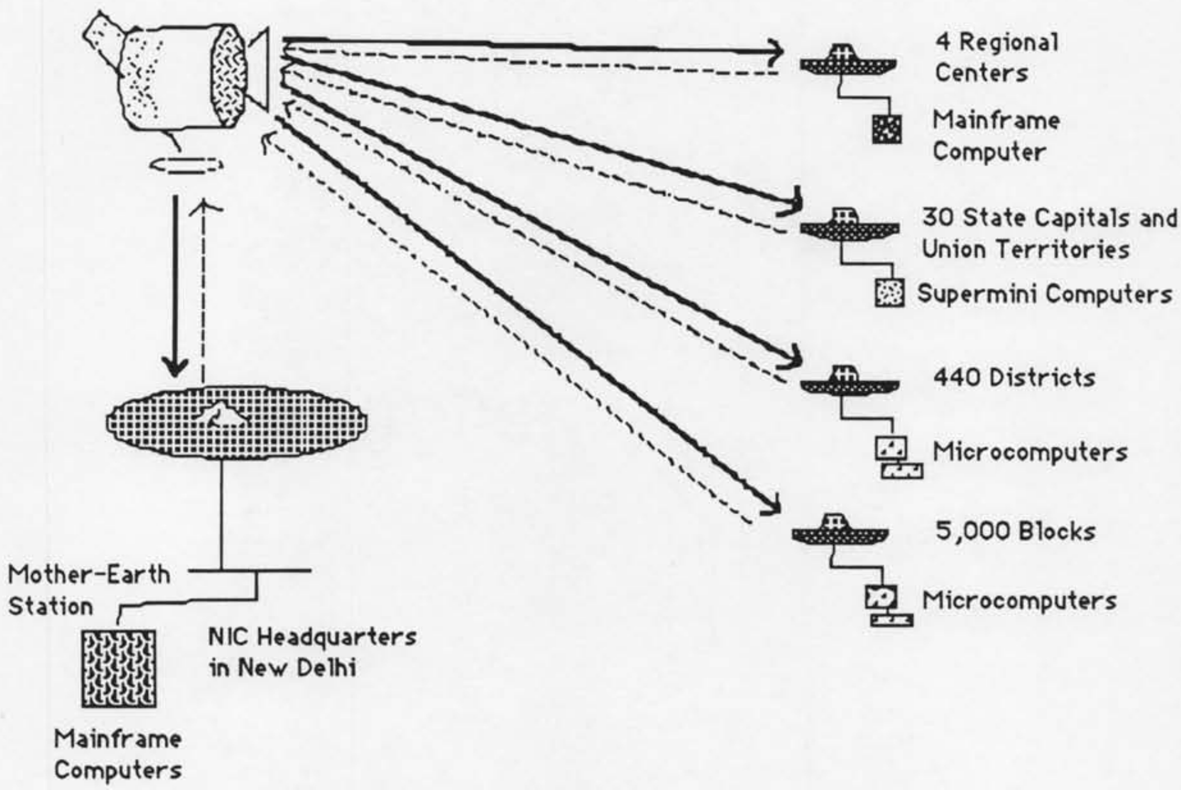

Figure 3-6. NICNET Links the Center (New Delhi), 4 Regional Centers, 30 State Capitals and Union Territories, and 440 Indian Districts via a Communication Satellite (by 1995, NICNET will expand its network to link India's 5,000 blocks).

Source: National Informatic Center (1989b).

an IBM PC-AT compatible microcomputer. Four members in each of India's 440 DRDAs were trained on CRISP. The CRISP software team prepared a user's handbook and provided training to the officials of several DRDAs with the help of state-level computer-training institutions. By 1990, some 400 DRDAs in India had adopted CRISP. CRISP's total cost is only about $5 million, because it uses a relatively inexpensive hardware and software configuration.

System Features

A key element of NICNET is DISNIC, the District Information System of the NIC. Through DISNIC, each District Informatics Center (DIC) monitors the implementation of development projects in its district, and develops data-bases for 27 key economy sectors: agriculture, animal husbandry, employment, industry, health, and others (NIC, 1989b). Functional components of DISNIC, like natural resources management, district revenue administration, district development administration, etc., are shown in Figure 3-7. NIC expects that DISNIC will improve the efficiency of district administration and will provide data-bases for the state and national government in planning and decision-making.

A micro-earth station, an IBM PC Super-AT with four terminals, and a heavy-duty printer are provided to each District Informatics Office (NIC, 1989a). The microcomputer has 300 megabytes of hard disk memory, and an eight-megabyte on-board memory. Micro-earth stations (produced by Indian Telephone Industries in collaboration with Equatorial Satcom of the U.S.), each costing about $18,000, provide a highly reliable, interactive, on-line data link with the various NIC nodes (see Figure 3-7).

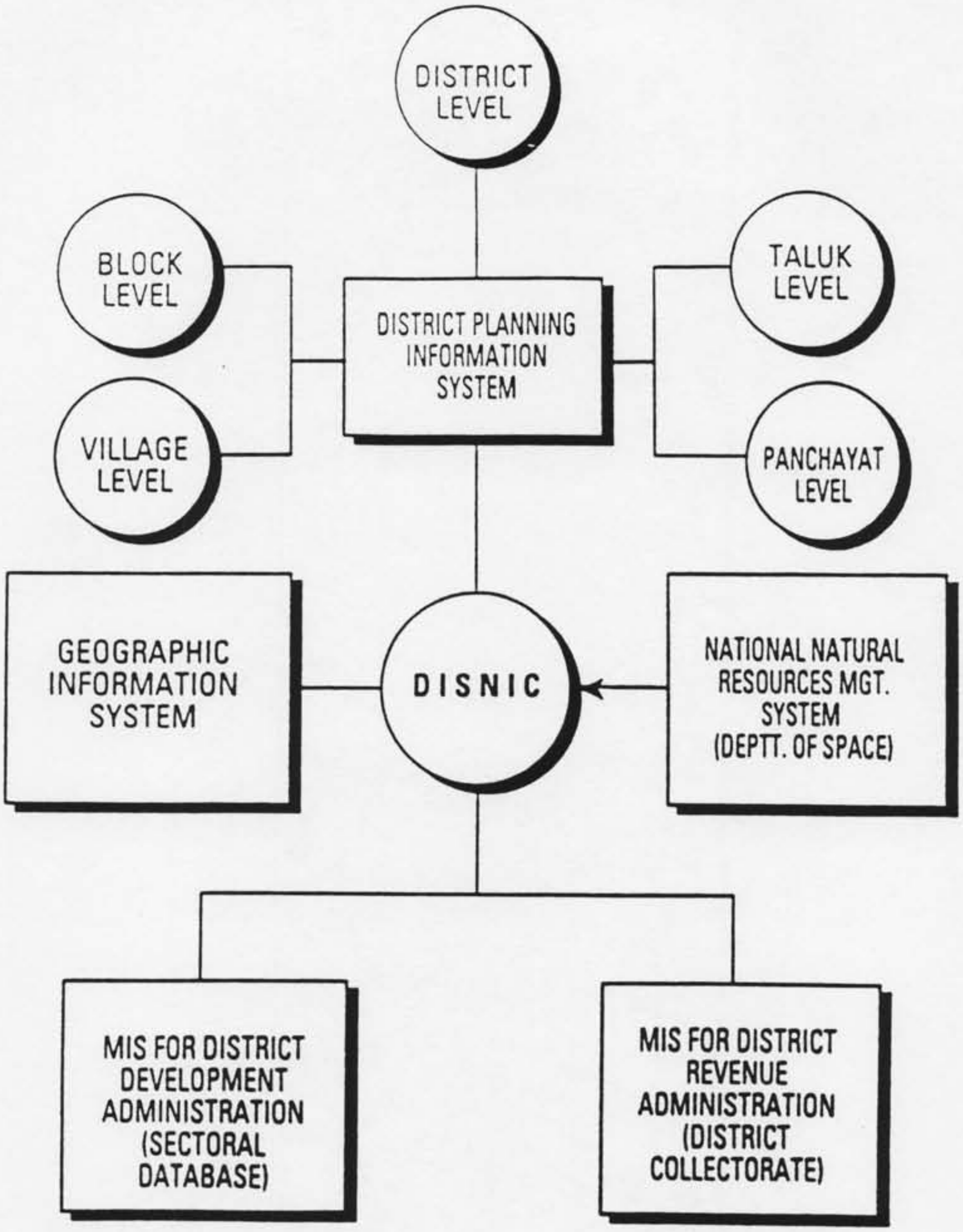

Figure 3-7. Functional Components of the District Information System (DIS) of the National Informatics Center (NIC).

Source: National Informatics Center 1989b.

A six-person CRISP software team, headed by Dasgupta, spent about 50 work-months developing the basic CRISP 1.0 software. CRISP 1.0 was especially designed to monitor and implement four governmental rural development programs: The Integrated Rural Development Program (IRDP), the National Rural Employment Program (NREP), The Rural Landless Employment Program (RLEG), and the Rural Drinking Water Scheme (RDWS). The challenge was to develop software that was capable of monitoring extensive rural development programs, was user-friendly, and could be standardized for India's 440 districts (Banerji and Gosh, 1989). The six-person software team conducted extensive fieldwork in CRISP's 10 pilot districts, learning about the needs and requirements of administrators and the problems of beneficiaries.

CRISP is available on two 1.2 megabyte floppy discs, and runs on IBM PC-AT compatible microcomputers. CRISP contains 40,000 lines of computer software code in 40 files, and was developed in dBase III. Basic data-files can store up to 15,000 records of data, and data-retrieval is instantaneous. CRISP 1.0 is easy to install and has a built-in software demonstration package. The menus and sub-menus are user-friendly. The delete option is unavailable in the main menu so as to prevent unauthorized data-tampering. Area maps can be generated on the microcomputer screen using the four arrow keys. The help menu is highly detailed.

When CRISP 1.0 was demonstrated at a 1989 conference on Applications of Information Technology for Decentralized Development, in Islamabad, Pakistan, a virtual stampede occured to procure CRISP's demonstration copies. In 1990, a CRISP 2.0 version characterized by a multi-user, multi-tasking environment became available. The new version of CRISP allows networking and data-communication between districts and state capitals through modems and satellite-based micro-earth stations, which are now available in district headquarters, thanks to NICNET.

3.44 Results and Lessons Learned

The DRDA office in Narnaul, the headquarters of Mahendergarh District in India's Haryana state, has used CRISP to improve its Integrated Rural Development Program (IRDP). Data on 13,500 beneficiaries of IRDP (mostly farmers) are categorized by village, block, and development program. These data are constantly updated and monitored by local development officials.

For example, on the 25th of each month the microcomputer provides a list of new beneficiaries to the DRDA officer and to the local bank. Within a week, the bank disburses the loan (or subsidy) to the beneficiary, and the next day the new beneficiary information is updated in the DRDA microcomputer. Within a few more days (by the 7th day of the next month) a detailed list of monthly activities (broken down by village, block, development program, bank, etc.) is generated which shows how well the district is faring in implementing the IRDP. District officials can now identify bottlenecks and implement timely solutions (Banerji and Gosh, 1989).

In addition to making the district administration more efficient, the microcomputer system has enhanced employee accountability in the DRDA and in the local bank. To Gopla Singh, a data-entry clerk at Narnaul, the microcomputer provides a welcome respite from the onerous task of sifting through heavy paper registers of data.

While CRISP enjoys widespread popularity with district and state officials, NICNET was initially looked upon with suspicion by officials of several state governments, who felt that New Delhi was interfering with state affairs. These state officials were reluctant to part with sensitive information about administrative activities, and resisted signing a memorandum of understanding with the national government for the free exchange of information. However, when the national government agreed to pay for all equipment and computer networking costs, state officials eventually agreed to provide the data (Sharma and Jaikumar, 1989).

The Deodhar Committee, established by the Indian government to evaluate NICNET, commended NIC for putting the computer hardware equipment in place but was concerned about inadequate use of this equipment. India's government departments generally lack computer culture, and computer phobia is still widespread. A multiplicity of languages and administrative cultures in India present problems in standardizing data for NICNET. The numerical coding of data was suggested as one way to overcome the multiple language problem. On-going training and the maintenance of NICNET hardware were also identified as potential problems. While CRISP faces similar challenges, its relatively decentralized nature and somewhat limited focus make it more manageable and less subject to criticism.

To what extent are the NICNET and CRISP computer projects integrated? Unfortunately, not very. Both NICNET and CRISP function independently, and tensions sometimes run high between CRISP officials and NIC officials. Dasgupta, the creator of CRISP, contends that "NICNET represents an overkill of technology" (quoted in Sharma, 1989b, p. 32). N. Seshagiri, Director General of NIC, argues that with NICNET's DISNIC, "CRISP has become redundant" (quoted in Sharma and Jaikumar, 1989, p. 29). Such are the problems that can occur in a nation when one computer network starts at the national level and spreads toward the local level, and another computer network starts at the district level and spreads upward toward the national level.

3.5 THE GREEN THUMB PROJECT IN KENTUCKY

The Green Thumb Project (GTP) is an information clearing-house project that provided data to farmers via a videotext system. The "Green Thumb Box Project" was an extension service-oriented videotext trial carried out with 200 Kentucky farmers in 1980-1981, and evaluated by communication scholars from Stanford University (including one of the present report's coauthors).

3.51 Contextual Information: Videotext and the Extension Service in the U.S.

U.S. farmers are exposed to a wide variety of agricultural information from public and private sources. The Cooperative Extension Service ranks as one of the principal suppliers of information to U.S. farmers. The extension service has four missions: knowledge dissemination, change inducement, information validation, and capacity-building (USDA, 1980).

During the 1980s, a new videotext system was launched to provide information to U.S. farmers. Videotext is a computer-based system which supplies a nonspeech information service displayed on a television set (Bloom et al.,1980). Videotext is an interactive system because its use involves a "dialogue" between the user and a computer-based information system, as the user requests a specific frame of information which is then provided from the data-base via a telephone line (or a television cable) and displayed on the user's television screen.

The Green Thumb Box Project (GTB) was a trial of a videotext information-delivery system for farmers carried out by the Cooperative Extension Service of the state of Kentucky, the Federal Extension Service of the U.S. Department of Agriculture (USDA), the National Weather Service (NWS), and the U.S. Department of Commerce. Two hundred GTB videotext terminals were provided to farmers in two counties in Kentucky for 16 months from March 1980 to July 1981. The GTB menu in an average month offered 250 frames of weather, market, crop, livestock, and home management information, as well as certain local news (Paisley, 1983).

The 200 farmers who participated in the Green Thumb Project were selected by a voluntary process: a committee of state-level extension specialists selected the two Kentucky counties, and in each county a committee of local farm leaders chose 100 volunteers to represent a diversity of farm size and farming conditions in their county (Clearfield and Warner, 1984). Compared with a sample of nonusers, the GTB users had more years of formal schooling and operated larger farms (Tables 3-2 and 3-3).

3.52 Objectives: The Videotext Trial

Table 3-2. Farm Size of the Green Thumb Users in Kentucky.

Farm Size	Percent of Green Thumb Users (N=200)
1. Less than 180 acres	18%
2. From 180 to 500 acres	43%
3. More than 500 acres	39%
Total	100%

<u>Source</u>: Clearfield and Warner (1984).

Table 3-3: Characteristics of Users and Nonusers of the Green Thumb Videotext System in Kentucky.

	Users of the Green Thumb System		Nonusers of the Green Thumb System
	Shelby County (N=97)	Todd County (N=97)	(N=76)
1. Average number of acres farmed	499	752	361
2. Mean acres of:			
(a) Corn	105	206	84
(b) Wheat	42	126	44
(c) Pasture	153	87	70
(d) Soy Beans	69	284	103
3. Mean number of:			
(a) Cow and bulls	40	37	21
(b) Feeder cattle	19	32	44
(c) Hogs and pigs	105	182	25
4. Age (in years)	45.4	42.9	47.7
5.%. Percent of income earned of-the-farm	22%	17%	28%

Source: Case and Others (1981).

The increasing complexity of both farming practices and market structures in the U.S. means that farmers need more precise, more up-to-date information. Information is an essential farming input just as land, labor, and capital are (Chartrand and others, 1982). The GTB was important because it provided one of the first tests of a videotext system in agriculture (Clearfield and Warner, 1984).

All other videotext trials in the U.S. had been sponsored by private firms which charged for this information service. By including farmers of different socioeconomic status in the Green Thumb trial, it was possible to investigate the relative utility of this information service, independent of what the videotext system would have cost each farmer (Case and Rogers, 1987). Thus the usual socioeconomic bias of access to an expensive information technology was removed.

An evaluation of this videotext trial was conducted by communication scholars from Stanford University (Case et al, 1981), with a supplementary in-house evaluation by a University of Kentucky team of Extension Service specialists (Warner and Clearfield, 1981). The evaluation study's objectives were:

1. To test videotext technology in a field trial in Kentucky.
2. To compare this videotext service to other sources of information available to U.S. farmers.
3. To assess the potential role of videotext for agricultural extension.

3.53 The Green Thumb System: From Idea to Realization

History of the Green Thumb Project

The main events in the history of the Green Thumb Project (Case et al., 1981) are:

1976: The concept of a rural electronic text system was proposed by Howard Lehnert of the USDA and Harold Scott of the NWS.

1977: The Lehnert-Scott proposal came to the attention of Senator W. "Dee" Huddleston from Kentucky, who become a champion for the project. Senator Huddleston's legislative aide, W. Seal, began to work with Scott and Lehnert in seeking acceptance for the proposal.

November, 1977: The main features of the Green Thumb system were decided upon, and several committees were appointed by the USDA to assess the technical feasibility of the GTB. Out of these assessments came a decision to also provide farm marketing information and weather information.

September, 1978: An agreement for the videotext trial was signed by the USDA's Federal Extension Service with the Kentucky Agricultural Extension Service.

October, 1978: A Green Thumb Seminar attracted the participation of 53 advanced technology companies. A technical committee composed of representatives of the USDA, the NWS, and the University of Kentucky drafted detailed specifications for the videotext system.

March, 1979: A request for qualification was issued, following a second industry seminar (in February).

March, 1979 to March, 1980: Production of the videotext boxes (by Motorola Semiconductor Division) and provision of the two local microcomputers (by Western Union). Selection and training of the farmer-users was conducted.

March, 1980 to July, 1981: The field phase of the videotext trial was conducted in Shelby and Todd Counties, Kentucky.

June, 1981: Evaluation of the Green Thumb system was carried out by means of personal interviews by the Stanford University researchers.

System Configuration and Funding

The main minicomputer, a Hewlett-Packard 3000, was located in Lexington, at the University of Kentucky's Agricultural Data Center. One microcomputer was located in each of the two counties. Upon a user's request, information was downloaded into one of the 200 Green Thumb boxes, which decoded and stored it for viewing on a farmer's television set. Telephone lines linked the Lexington minicomputer with a local farmer's Green Thumb Box (Figure 3-8).

Funding. The Green Thumb Project was funded as following:

$400,000 by the USDA.

$100,000 by the NWS (National Weather Service).

$350,000 by the University of Kentucky.

$35,000 by the USDA for the Stanford University evaluation study.

The total funding for the Green Thumb Project was about $885,000.

3.54. <u>Results and Lessons Learned</u>

Technical Weaknesses

Telephone lines were a deficient delivery system, as downloading to

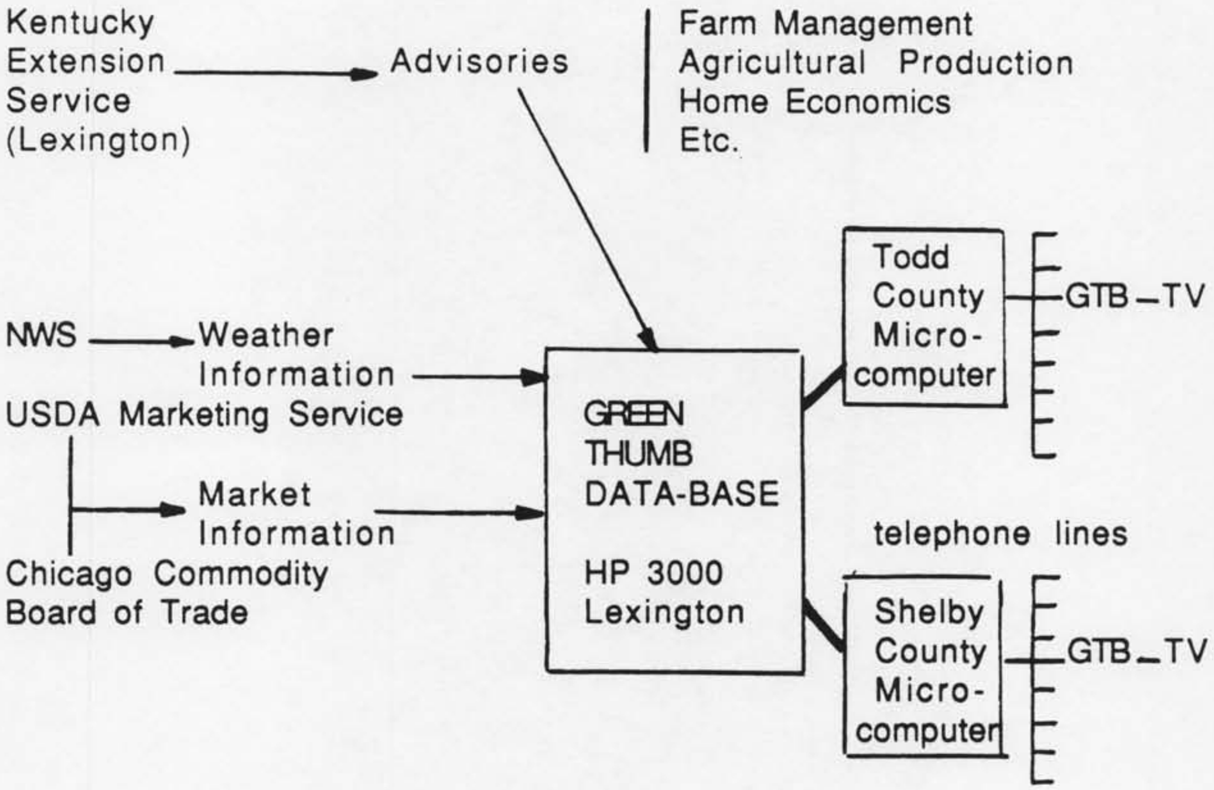

Figure 3-8. Configuration of the Green Thumb Box System.

a farmer's Green Thumb Box was a rather slow process. Each frame that was requested required more than 15 seconds to load into a farmer's Green Thumb box, which could not be viewed until all of the requested frames were loaded. Farmers typically requested four or five frames at a time, so this meant waiting 60 seconds or more. Further, the lack of an automatic procedure for converting information into videotext frames, except for weather and marketing information, prevented the Extension Service from up-dating the bank of frames on a regular basis. Farmers soon perceived that much of the data-base of information was outdated. Only the weather and marketing information were updated regularly.

These technical weaknesses essentially reshaped the GTB service into a special purpose weather and marketing information system (Paisley, 1983). Other technical information provided by the Kentucky Extension Service on agronomy, horticulture, soils, etc. was soon out-of-date, and hence was relatively unused. Further, several of the Green Thumb Boxes got "fried" in the early months of the field trial, when lightening struck telephone lines and caused a power surge. Unfortunately, the Green Thumb Boxes had been designed without an electrical overload fuse.

Ranking of Information Sources

Compared to other sources of information, the GTB ranked fourth (to the 200 farmers) as a source of market information, behind newspapers, radio, and agricultural buyers, and third as a source of weather information, after radio and television (Clearfield and Warner, 1984). The GTB did not change the information-seeking behavior of the Kentucky farmers who used it in a major way.

Widening the Information Gap

Framers who operated larger-sized farms and those who had adopted more agricultural innovations were heavier users of the Green Thumb system, even though use of the videotext service was free to all of the 200 selected farmers (Table 3-4). Thus the widening of the information gap between high and low socioeconomic status farmers was due to differential use of the Green Thumb system, not to problems of access or adoption (Case and Rogers, 1987).

3.6 CGIAR/CIMMYT: CD-ROM MAIZE GERMPLASM DATA-BASE IN MEXICO[11]

CIMMYT (Centro Internacional de Mejoramiento de Maiz y Trigo), the International Maize and Wheat Improvement Center, located near Mexico City, and CGIAR (Consultative Group for International Agricultural Research) have used a CD-ROM data-base. We focus here on the information function of these two institutions, both pioneers in the development of information technologies for agricultural purposes in developing countries.

The present section illustrates one side of the agricultural extension service function as a two-way communication process between researchers and producers in agriculture. We stress here the problem of the distribution of scientific information (about the results of

[11] This case study is based on personal conversations by Thierry Bardini with Russell Cormier, Head of Systems and Computing Sevices, Maximino Alcala de Stefano, Head of the International Wheat Testing program, Patrick F. Byrne, Maize Breeder, at CIMMYT, Mexico, December 5, 1990, and with Dr. William Paisley, Vice-President of Knowledge Acess International, and Dr. Georg Lindsey, President of CGNET Services, in Palo Alto, California, February 8, 1991.

Table 3-4. Degree of Use of the Green Thumb System by Farm Size.

Farm size	Uses of the Green Thumb System per Month							
	Less than 10		10 to 19		More than 20		Total	
	N	%	N	%	N	%	N	%
1. Less than 251 acres	21	36	25	43	12	21	58	30
2. From 251 to 750 acres	29	37	21	27	29	37	79	41
3. More than 750 acres	16	28	15	26	26	47	57	29
Totals	66	34	61	31	67	34	194	100

Source: Case and others (1981).

agricultural research) in an international perspective. The extension workers' depends on the channels of information between researchers and the extension workers, and from them to farmers.

The technology used here is CD-ROM (Compact Disk Read Only Memory), an optical storage technology whose main advantage is the low cost of production of the disks once the the data has been transferred onto a glass master disc using lasers (Frierson and Lindsey, 1990). Our case addresses the issue of **access to information resources** from the CIMMYT Maize Germplasms Data-Base.

3.61 Background

CIMMYT, IRRI and the Green Revolution.

CIMMYT's organizational development presents three important phases from the early 1950s to the present:

1. The first phase was a pioneer project between Mexico's Department of Agriculture and the Rockefeller Foundation in the 1950s.

2. The second phase was a transition to the present CIMMYT. Greater attention was given to international research issues, toward developing improved varieties suited to the production conditions in other countries (besides Mexico) of Latin America and Asia. The earlier example of the International Rice Research Institute (IRRI) at Los Baños in the Philippines inspired this transition in the early 1960s.

3. CIMMYT began its third phase in 1966 as a legally chartered, non-profit agricultural research and training institution, responsible to an internationally elected board of trustees (CIMMYT, 1985).

Genetic information is the basis of the Green Revolution in rice and wheat varieties, and is the major result of three decades of research. Access to this genetic information is a main challenge for extension services in this century.

The CGIAR Preservation and Dissemination Project

With the impressive achievements of IRRI and CIMMYT, and increasing concern for development issues, the need for an expanded international agricultural research system aimed at addressing the food production problems of the developing world surfaced within the United Nations community about in the late 1960s.

These discussions led in 1971 to the creation of a network of international agricultural research centers under a unique donor organization, the Consultative Group for International Agricultural Research (CGIAR). The Food and Agricultural Organization (FAO), the United Nations Development Program (UNDP), the World Bank, national governments, and private foundations support CGIAR as a mechanism for funding research and training activities at 13 autonomous agricultural research centers around the world.

For CGIAR and its 13 international research centers, the problem of access and distribution of scientific information is a crucial issue. In 1984, a request for proposal to undertake a project to create and distribute "compact libraries" of the CGIAR centers' literature was issued. After positive reactions to the 13 research centers and a feasibility study the Preservation and Dissemination Project was launched (Frierson, 1987).

The Project is divided into two phases:

1. Analysis of the potential use of optical storage technology, for the identification, collection, cataloguing, indexing, and physical processing of a retrospective collection of research-based literature.

2. Production and distribution of the retrospective collection of "compact libraries."

The question of the storage medium was, from the beginning of the project, a crucial issue. It was first assumed that the "compact libraries" would be produced as sets of microfiches. By 1986, however, optical storage technology became available and made the Preservation and Dissemination Project the first international-scale test of this technology for agricultural purpose (Table 3-5). The pioneering experience of the CIMMYT Germplasm CD-ROM Data-Base was a result.

3.62 Objectives:The Dual Role of the CIMMYT Maize Germplasm Bank

The CIMMYT Maize Germplasm Bank contains a majority of landacres[12] which contribute to make the world's oldest and largest collection of maize (corn) seeds (12,500 collections, of which 10,174 have been successfully regenerated and accessioned). The collection was established in the 1940s with materials gathered by cornbreeders who were then sampling the genetic variation of maize in Mexico (1943-1947), the Caribbean (1946-1947), and Guatemala (1948-1949).

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12 "A landrace is a genetic aggregate that over years of local selection has become adapted to a particular region... there is a considerable genetic diversity among the many landraces that together make up one of the maize races" (CIMMYT, 1986).

Table 3-5. The Twenty International Agricultural Institutes Participating in the Preservation and Dissemination Project.

Abbreviation	Name
AVRDC	Asian Vegetable Research and Development Center, Taiwan, Republic of China
CIAT*	Cento Internacional de Agricultura Tropical, Cali, Columbia
CIMMYT*	Centro Internacional de Mejoramiento de Maiz y Trigo, Mexico D.F. Mexico
CIP*	Centro Internacional de la Papa, Lima, Peru
IBPGR*	International Board for Plant Genetic Resources, Rome, Italy
IBSRAM	International Board for Soil Research and Management, Bangkok, Thailand
ICIMOD	International Centre for Integrated Mountain Development, Kathmandu, Nepal
ICARDA*	International Center for Agricultural Research in the Dry Areas, Aleppo, Syria
ICIPE	International Center of Insect Physiology and Ecology, Nairobi, Kenya
ICLARM	International Center for Living Aquatic Resources Management, Manila, Philippines
ICRAF	International Council for Research in Agroforestry, Nairobi, Kenya
ICRISAT*	International Crops Research Institute for the Semi-Arid Tropics, Hyderabad, India
IFDC	International Fertilizer Development Center, Muscle Shoals, Alabama, USA
IFPRI*	International Food Policy Research Institute, Washington, D.C., USA
IITA*	International Institute of Tropical Agriculture, Ibadan, Nigeria
ILCA*	International Livestock Centre for Africa, Addis Ababa, Ethiopia
ILRAD*	International Laboratory for Research on Animal Diseases, Nairobi, Kenya
IRRI*	International Rice Research Institute, Manila, Philippines
ISNAR*	International Service for National Agricultural Research, The Hague, Netherlands
WARDA*	West Africa Rice Development Association, Monrovia, Liberia

* CGIAR supported institutions

Two main primary functions are given for the Bank:

1. Conservation: It is crucial that the storage conditions of the Bank prevent as much genetic drift, or changes in the genetic composition of the accessions, as possible.

2. Distribution: The Bank is not a museum, and its ultimate value lies more in the use of the accessions than in their storage. Seeds are provided free to more than 80 countries upon request (CIMMYT,1986).

These two main functions are in reality the translation of the two senses of information flow between CIMMYT and the users ("cooperators" in CIMMYT terminology): The users request seed for their national breeding program (distribution) and provide feedback to the Bank about reactions of the provided seeds in field trials. Seeds are provided with the passport information suiting the request, that is, the local conditions of the field trial to be held. Feedback from cooperators is essential for the evaluation of the accessions' performances under local conditions, leading to more accurate knowledge of the accession.

Therefore, a secondary function is essential for the efficiency of the Bank: The promotion of the free flow of information about the performance of the Bank material. An efficient processing of information is also required. The computerization of this process has been a crucial step forward increasing this efficiency (Figure 3-9). Further, the process of such quantities of information would be now nearly impossible by manual procedures.

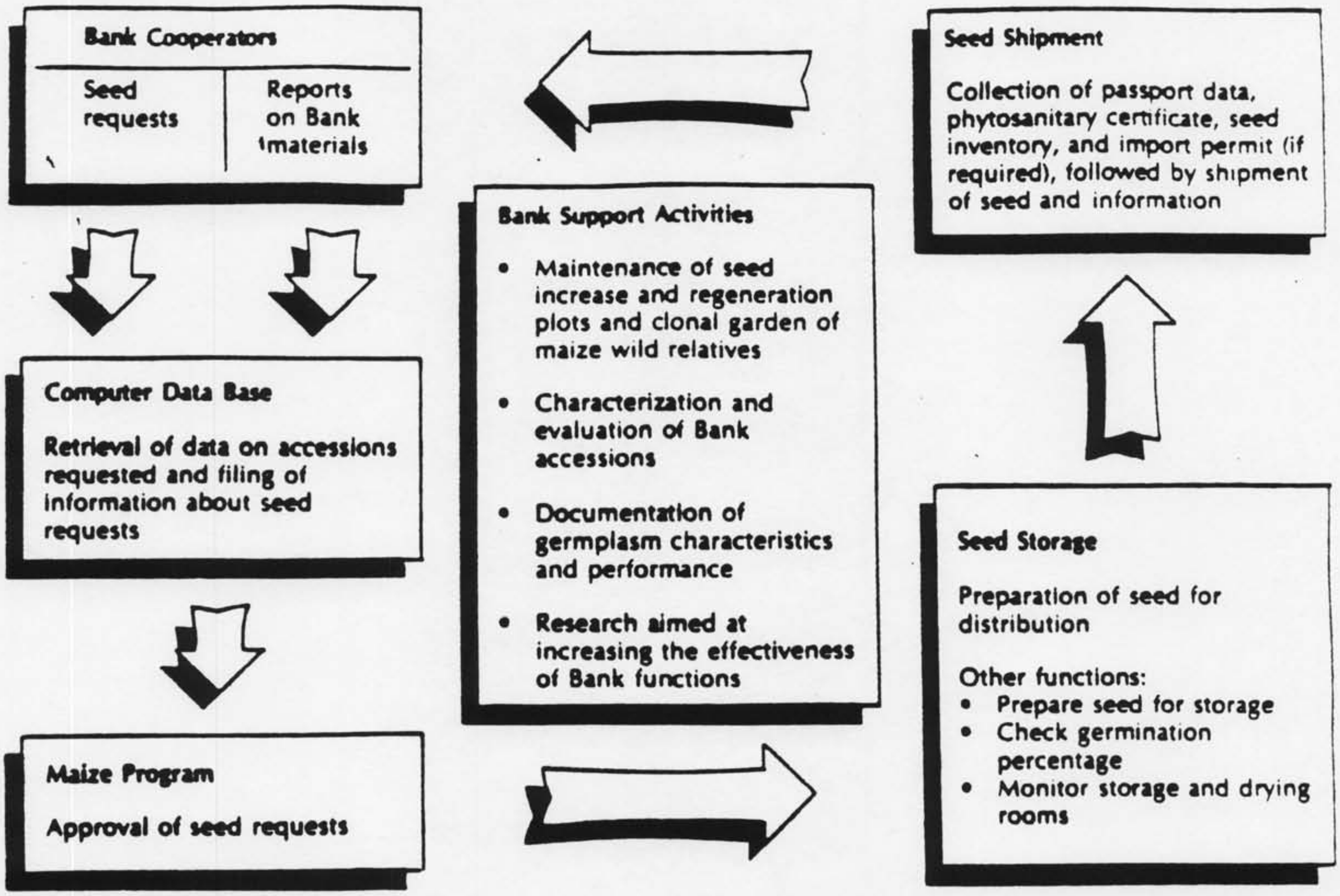

Figure 3-8. The Path of a Seed Request to the CIMMYT.

A last function can be attributed to the CIMMYT experience: It served as a trial of CD-ROM and computer technology for agricultural purposes. The results of this experience opened the way for the CGIAR Preservation and Dissemination Project. The CIMMYT experience can be considered as the first step in the constitution of an international network promoting information technologies for development purpose.

3.63 System Development: From Idea to Realization

Network of Expertise

We describe here the main lines of the network involved in the CIMMYT Germplasm CD-ROM Data-Base experience. The main actors/institutions were:

1. CGNET. The studies that led to the development of CGNET, the Consultative Group Network, started in 1982. Today CGNET links most of the agricultural research centers with each other and with the secretariats. There are now CGNET nodes in more than 40 countries. The network has operated for more than five years. In 1985, CGNET led to the constitution of CGNET Services International, a company in charge of managing the network. CGNET produced the CD-ROM of the Germplasm Data-Base (Woolston, 1990).

2. CTA. The Technical Centre for Agricultural and Rural Cooperation (CTA) in Wageningen, the Netherlands, funded the project (approximately $25,000). CTA will also distribute about 100 copies of the CD-ROM, along with the necessary disk readers, to selected locations in developing countries.

3. Knowledge Access International. This private company in Mountain View, California, headed by Dr. William Paisley, provided consultancy and premasterization of the optical disk for the CIMMYT experience. K.A.I. is also involved in producing CGIAR prototype CD-ROMs for the Preservation and Dissemination Project of CGIAR.

4. CIMMYT Information, systems and computing services. The design and production of the CD-ROM Data-Base is the result of the expertise of CIMMYT's own services. CIMMYT also contributed $25,000 to the funding of the Project.

System Configuration

The purpose of the CD-ROM Data-Base is to help the user search through accessions (approximately 10,500) to locate the few seeds that suit his/her needs. The basic steps are as follow:

1. Expression of the seed requirements using selection criteria screens: The inquiry system provides 4 screens, presenting 4 types of criteria (race and location, grain type, geography and climate, and growing conditions), for a total of 29 criteria.

2. Counting the number of accessions that meet the specifications.

3. Modifying the criteria to refine the request.

4. Review selected accessions on screen (quick list or full details).

5. Print a report of the selected accessions.

To use the Maize Germplasm Bank Inquiry System, the following system hardware features are required:

(1) An IBM-PC or compatible microcomputer with 640 Kbytes of main memory installed.

(2) A CD-ROM drive using the standard High Sierra Disk format.

(3) A printer (recommended).

A MS-DOS operating system version 2.0 or higher is the only software requirement, as the Inquiry System is provided on disk (CIMMYT, 1988). The hardware and software needed for running the system are now available for less than $ 5,000.

3.64 Results and Lessons Learned

Operational Results

Different factors affect the speed of the search process:

1. A CONFIG.SYS File in the DOS boot disk increases the speed by storing recently used information from the disk.

2. The speed depends also on the processor chips used in the microcomputer: The IBM AT will run from 7 to 12 times faster than a IBM PC or a IBM XT, and a IBM 386, 10 to 16 times faster.

3. The speed of access of the CD-ROM player is also very important: This device is now available with speed access from 350 milliseconds (very fast) to 1,000 milliseconds (very slow).

The combination of these different factors can create differences of from 1 to 6 or more seconds for the total time of access. The friendliness of the system also depends on these choices.

Training

One of the main result of the CIMMYT experience is to understand its implications for training. Training appears to be the most important limiting factor for such a program, assuming its low cost. Therefore, recognition of training needs is a crucial step in the entire process, with different kinds of actors (system operators, users) and their different functions (set-up, maintenance, use). Use of documentation (manuals, brochures) and on-screen help messages must be designed appropriately.

Information Access and CD-ROM.

The main argument for using CD-ROM is its promise to free developing country institutions from the expense of making telecommunication connections, always hazardous and onerous in such contexts.

The most important data-bases now offered on CD-ROMs are:

1. AGRICOLA, produced by the U.S. National Agricultural Library.

2. AGRIS, by FAO.

3. SCISEARCH, by the Institute for Scientific Information.

4. KIT ABSTRACTS, produced by the Royal Tropical Institute in the Netherlands.

5. SESAME, by the Centre d'Information et de Documentation des Regions Chaudes (CIDARC).

Chapter 4
CONCLUSION

The main conlusions form the present study are:

1. Microcomputer technology is at its early stage of diffusion for agricultural development in Third World countries. The main reasons preventing a wider diffusion to date are cost, availability, infrastructure problems, and lack of specialized software.
2. Microcomputer present a great potential for administrative activities necessary to extension (record keeping, desktop publishing).
3. Farmers' use is almost inexistant in developing countries and still limited in industrialized countries. Direct farmers use is not to be sought in developing countries.
4. Microcomputers are widely used in agricultural research but not in extension. Wider use of microcmputers is to be promoted for extension, in order to create a better linkage between these two interdependant activities.
5. This linkage describes the creation of a more efficient interface between research and extension. It will require the development of a second type of application of microcomputers, such as data-base management and expert systems.

The following lessons have been provided by the answers to our mailed questionnaire:

1. User-friendliness and access

1.1 Computer should be usable with little or no instruction.

1.2 Installation of computer technology should include provision for short-term trouble-shooting, system upgrades, and long-term maintenance.

1.3 Site specific instructions are needed for computer uses.

1.4 Training on resolving computer problems locally must be provided.

1.5 Success in computer applications to development is associated with intense small group training in the computer application.

2. Communication perspective

2.1 Data-base access by extension workers is more feasible on commercially produced CD-ROMs than online, due to cost and problems with telecommunications.

2.2 Microcomputers can be networked for communication purposes, and their functions are enhanced if transport and communication systems link the users.

2.3 Microcomputers should be considered in isolation from broader knowledge and information infrastructures, on which they depend.

3. Development

3.1 Keep microcomputer applications simple if development success is to be achieved.

3.2 Conduct pilot testing and compare computer-based solutions with others for appropriateness and cost-effectiveness.

3.3 Develop internationaly recognized data-storage, retrieval, and transmission standards for computer applications.

3.4 A support organization is required for efficient and cost-effective computer software development.

3.5 Computer use is often limited by a lack of subject-matter knowledge.

3.6 Computer applications should be directed toward problem-solving situations.

The following lessons have been provided by our casae studies:

1. Microcomputers can be used as a communication tool to overcome certain obstacles to communication among individuals involved in agricultural development.

2. Considered as a communication tool, microcomputer application requires relatively few resources.

3. The replication of research-oriented applications of microcomputers on a large-scale by extension requires adequate computer training of extension workers.

4. Microcomputer applications are one part of a broader extension package, and therefore depend on their integration in this package and with other extension techniques.

5. Microcomputer applications should be oriented to problem-solving oriented and therefore suited to the needs of the user.

6. Inadequate usage of equipment, lack of a computer culture, and computer phobia are potential problems in implementing microcomputer applications.

7. Lack of training and maintenance of computer hardware represent potential problems.

8. Technical weaknesses of the communication media and of microcomputers application can lead to a re-invention of the technology or to its non-adoption.

9. When microcomputer applications compete with existing communication media, their success depends on such comparative advantages as content, quality of delivery and speed.

10. The potential of microcomputer applications depends on such special conditions of use as the widening of the information gap between high and low socioeconomic status users

11. Training appears to be the most important limiting factor in many microcomputers applications.

12. CD-ROM can to free developing country institutions from the expense of making telecommunication connections.

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John Loder (1987), "Secondary Services," paper presented at the CTA Course on Agricultural Information Sources, Lilongwe, Malawi, 15-26 June.

E. J. Mann (1985), "Past, Present and Future Developments in Agricultural Information Transfer," paper presented at the Seventh World Congress of the IAALD, Ottawa, June.

William Paisley (1989), "Optical Disc: Already a Breakthrough in Knowledge Utilization," presented in the session on "Knowledge Utilization: Implications of the New Information Technologies" at the Third Annual Meeting of The Howard R. Davis Society for Knowledge Utilization and Planned Change, Los Angeles, April.

J.H.W. Van Hartevelt (1987), "Advantage of CD-ROM for Local Access to Computerized Data Bases in developing Countries in Comparison with Traditional Bibliographic Services: Suggested Pilot Projects," Abstracts on Rural Development in the Tropics, Vol.2, 2: 9-18.

John E. Woolston (1990) Scientific and Technical Information in the CG International Agricultural Research System, World Bank, CGIAR Secretariat.

Appendix A

ANNOTATED BIBLIOGRAPHY ON MICROCOMPUTERS AND THIRD WORLD DEVELOPMENT

Pamela Q. J. Andre (1990), "In the Field of Agriculture, CD-ROM Delivers," CD-ROM EndUser, 2 (3): 26-27.

This article gives examples and evidences of the interest of CD-ROM technology for "harvesting information" on agricultural topics all over the world. It explains why CD-ROM is a "distribution medium par excellence:" huge storage capacity, total flexibility regarding data type, compact size and standardized products.

Donald Case and Everett Rogers (1987), "The Adoption and Social Impacts of Information Technology in U.S. Agriculture," The Information Society, 5: 57-66.

This article describes certain aspects of the adoption and social impacts of the adoption of new information technologies in U.S. agriculture. The technology studied is videotext, an interactive information service that allows users to request frames of information from a central computer via telephone lines for reviewing on a home television set. The Green Thumb Project (GTB) was a videotext designed for farmers, provided by the Federal Extension Service of the USDA, the University of Kentucky's Extension Service, and the National Weather Service. The following lessons can be learned from the GTB: (1) Farmers who operated larger-sized farms and/or the more innovative were heavier users of the system; (2) The main reason why farmers applied for the videotext was to obtain information, especially farm marketing and weather information; (3) For both kind of uses, lack of adequate, accurate, reliable and up-to-date information was reported to be the first source of dissatisfaction, along with technical problems relative to the inadequacy of a telephone-line-based system.

Geoffrey Cowley (1989), "The Electronic Goddess," Newsweek, March 6: 50.

This article describes the history and the main results of a modelling study, the "Bali Rice Ecosystem Simulation Model," designed by John S. Lansing and James N. Kremer, both researchers of the University of Southern California (USC). The application of the microcomputer is mainly "problem-solving" in this case, as the model deals with conflicting management goals in rice cropping. The hypothesis tested was whether an optimum scale of regional coordination existed to balance efficient use of water and pest control. It demonstrated the ecological control of the ecosystem that allows the traditional water temple system. It confirmed that the priests exercise an important and active role in irrigation-related activities. These results enable development agency experts to understand better the advantages of the traditional system, and to build a solid basis for a further collaboration with the water priests.

Devres, Inc. (1983), "Use of Microcomputers in Preparing Agricultural Resources Assessment in Africa."

This note describes a contractual relationship between a U.S. private company (Devres, Inc.) and three international development agencies: The U.S. Agency for International Development (AID), the Institut du Sahel (INSAH), and the Southern African Development Coordination Conference (SADCC). To carry out a survey and assessment of agricultural research resources of 16 African countries, Devres, Inc. created a databank on a microcomputer (an IBM PC XT), using available software (dBase II, Statpac, etc.). This experience illustrates international cooperation to provide information on a large-scale dimension within an international R&D system.

Eleanor G. Frierson, William Paisley (1990), "From Paper to CD-ROM - Information Dissemination to Help Feed the World's Hungry," CD-ROM EndUser, 2 (3): 34-37.

The Consultative Group for International Agricultural Research (CGIAR) is an association of 40 donor agencies. It was established in 1971 to support a system of agricultural research around the world (20 International Agricultural Research Institutes). The CGIAR Preservation and Dissemination Project is creating an integrated library on CD-ROM, the "Compact International Agricultural Research Library," which will include 5,000 titles of the most important center publications. Although the cost of converting texts and tables to computer-readable form is considerable, CD-ROM is considered as a valuable solution: documents can be easily updated and republished, with less dependence on on-line searching. Because of its innovativeness, this project is very challenging for the future of CD-ROM use for development.

Eleanor G. Frierson, Pauline A. Zoellick (1990), "Information Needs in Agriculture and Markets for CD-ROM Products - Results of a Joint Market Study," IAALD World Congress, 28-31 May, Budapest, Hungary.

A market study was conducted by the CGIAR Secretariat and Digital Publications, Inc. in the Summer of 1989 to assess agricultural information needs in developing and developed countries, and to relate these needs to the potential for CD-ROM products. This study concludes on the interest of CD-ROM, but also on the problematic development of its market: up front investment costs in product, marketing and training are high, and the market development timetables are long. Nevertheless, the authors still believe that "there is indeed a market for such products."

Lalith Goonatilake (1989), "Appropriate Computer Education for Industrial Growth in Developing Countries," Computers in Industry, 12: 59-65.

This paper expresses the author's viewpoint on computer education. His main recommendation is a more application-oriented computer education, with the emphasis put on production management. Furthermore, Goonatilake criticizes computer education in developing countries. Most personnel are trained purely to use specific packages developed by computers vendors, rather than creating a pool of properly trained computer professionals with a diverse knowledge base. This paper insists on the importance of a local competence, based on practical knowledge, by computer professionals in developing countries.

K. L. Heong (1984), "Computer-Aided Pest Surveillance in Malaysia," in Workshop on Microcomputers Applications in Agricultural Research, September 24- 28, Los Baños, The Philippines, IRRI, and Ottawa, Canada, IDRC.

This abstract describes the main results of a rice pest surveillance program in Malaysia. It describes the organization of data-collection and treatment from the field to the headquarters, where, after feeding the data-bank, reports are produced and discussed, and policy decisions are taken. The main problem of the system is reported to be the long turn-around time of data from the field to the computer: an improved organization would involve regional computer centers at the local level. An important lesson about microcomputer use for extension purpose is the compatibility of data-collection systems by an extension system before the introduction of microcomputers.

David A. Holt (1985), "Computers in Production Agriculture," Science, April 26: 422-427.

This article is written by an American extension professional, and is one of the richest and most detailed articles about microcomputer use for farming in developed countries (in this case, the U.S.). The author describes the collective efforts required to bring information to farmers. This effort requires a complex system involving different types of actors and locating the development of computer use for farming in the agricultural research and development (R&D) system. The U.S. case shows the importance of collaboration between the public sector (research and extension agencies and universities) and the private sector (e.g., software companies). Microcomputer use in farming requires a clear agricultural R&D policy.

Rosalind L.R. Ibrahim (1985), "Computer Usage in Developing Countries: Case Study Kuwait," North Holland Information and Management, 8: 103-112.

This study is an examination of the position of computing technology in Kuwait, at the time a developing country in a favorable financial position, with a scarcity of human resources and an innovative outlook. This article is not concerned with agriculture. Nevertheless, we can accept its main conclusion: "A developing country can acquire computing technology at a high level and apply it to realize benefits." For most developing countries, foreign dependency on hardware is absolute, but local competence in software development is an achievable objective.

C. King (198?), "Of Rice and Men."

This short article provides an example of microcomputer agricultural use in developing countries: modelling water management in Bali. An anthropologist, Dr. John S. Lansing, and an ecologist, Dr. James N. Kremer, created this model to demonstrate the rationality of the traditional water temple system to balance efficient use of water and pest control. A communication interface developed on Macintosh Hypercard enables the two researchers to explain the role of the agricultural rituals to the development agencies and to foreign experts. The misunderstanding of this role had previously led them advise a Green Revolution-type transformation of the farming system which broke up the ecosystem and decreased rice yields. In this case, the microcomputer application was mainly for communication problem-solving.

Georg Lindsey, Ken Novak (1990), "Seeds of Change," CD-ROM EndUser, 2 (3): 38-39.

In 1987, the Technical Center for Agricultural and Rural Cooperation (CTA, Wageningen, The Netherlands) funded a program to disseminate databases on CD-ROM. The maize database of the International Maize and Wheat Improvement Center (CIMMYT, Mexico) inaugurated this effort by creating the "CIMMYT Maize Germplasm Data Base." This prototype demonstrated how CD-ROM technology particularly fits the needs of international agriculture information dissemination.

W. W. Miller et al. (1989), "Farmers Use On-Line Info Services," Journal of Extension, Winter: 26-27.

This brief note provides the main findings from a survey of farmers subscribing to Agri Data Network, an U.S. agricultural databank network for farmers. The purpose of the survey was to know how farmers use on-line services. The main results are: (l) Farmers use the service most frequently in order to obtain information about the agricultural markets; (2) they rated commodity information and agricultural news as most important; and (3) they rated frequently updated information, an always accessible telephone line, and modest cost as important features of the information system. These results show that individual microcomputer use by farmers in developed countries is mainly a way to obtain necessary information for more successful farming.

Geoffrey Murray (1982), "Hoe, Hoe, Hoe: Robots and Computers Take Up Farming," The Christian Science Monitor, December 23.

This article illustrates the individual use of microcomputers and robots for farming in Japan. Microcomputers use in Japan is caused by: l) The rapidly advancing age of Japanese farmers 2) the effort to make Japanese agriculture competitive in international markets, without heavy government subsidies. Cost is an important explanation of the relatively slow diffusion of microcomputers among individuals. Hope is expressed for future widespread use.

National Research Council (1986), Microcomputers and Their Applications For Developing Countries: Report of an Ad Hoc Panel on the Use of Microcomputers for Developing Countries, Boulder, Westview Press.

In 1983, the Bureau for Science and Technology of the U.S. Agency for International Development asked the Board on Science and Technology for International Development (BOSTID) of the National Research Council to convene a series of symposia to assess the implications of microcomputers for development. Microcomputers and Their Applications is the first report to be published. The book provides numerous examples of microcomputer applications, ranging from agriculture (Ch. 3) to health (Ch. 4), energy (Ch. 5), and municipal management (Ch. 6). This report assumes that agricultural applications are limited, "because the needs of farmers vary from place to place." Nevertheless, it provides applications and examples of microcomputers in agricultural management and research, statistical analysis, irrigation and food processing control, and modelling.

No author (1984), "Computers Move Onto the Cowherd's Patch," New Scientist, 3, May.

This short article provides an example of a possible use of microcomputers for agricultural production in a developed country: Dairy farms in England. As a management tool, microcomputers are supposed to increase the efficiency of management by saving labor and by managing great quantities of information. For that purpose, microcomputers are for individual use, and hence are affordable only for large-scale farms ("top-farmers"). In developed countries, microcomputer use follows the usual patterns for the diffusion of an expensive innovation. Considering the cost of microcomputers for individual farmers, they are highly unlikely to be used in developing countries. However, microcomputers could be used by agricultural development agencies in developing nations.

No author (1984), "Computers Improve Crop Planning," Data Processing, Summer: 6-7.

This article presents the main facts about the development of a software package by the Australian National University. The system, called MULBUD (for MULticrop multiperiod BUDgeting), provides a simple, straightforward tool for researchers and planners to analyze the economic potential of agroforestry systems in developing countries. After a successful test on agricultural systems in a wide range of countries (Papua New Guinea, Tonga, Thailand, Sri Lanka, Costa Rica, and New Zealand), and a field trial in Kenya, the emphasis was placed on the applicability of the package to field conditions. MULBUD forced researchers to put down their assumptions very explicitly about likely outcomes, and to then undertake very rapid analysis of these assumptions under field conditions.

No author (1985), "Apple Computers Donates 150 Microcomputers to Development NGOs," U.N. Development Forum, Vol. XIII, No 4, May.

This short article gives an account of an experience of collaboration between two types of actors involved in the use of microcomputers in agricultural extension and training in developing countries: Apple Computer, and PACT, a consortium of NGOs. Some 150 Apple microcomputers were donated for a to-be-created R&D system for the use of microcomputers in agricultural extension and training in developing countries.

William Paisley (1983), "Computerizing Information: Lessons of a Videotext Trial," Journal of Communication, 33 (Winter): 153-161.

This article suggests how content, audience and delivery system could be matched in future electronic systems. The Green thumb trial illustrates how a videotext system, designed to serve a wide range of needs, finally failed because of its design. There were about 250 frames in average month in the system, but except for weather and marketing, there was no automatic procedure for converting information into frames. Downloading was a slow process; each frame requested took more than to 15 seconds to load in the receiver, and the first frame could not be viewed until all frames were loaded. For these reasons, a broadcast-based teletext would have met all the designers objectives more simply and reliably.

William Paisley (1989), "Optical Disc: Already a Breakthrough in Knowledge Utilization," presented in the session on "Knowledge Utilization: Implications of the New Information Technologies" at the Third Annual Meeting of The Howard R. Davis Society for Knowledge Utilization and Planned Change, Los Angeles, April.

This article argues that CD-ROM is no longer just a future possibility but in daily use in knowledge utilization. A short history of CD-ROM applications provides three types of applications: - First, as a replacement technology, CD-ROM became a viable distribution medium; - Second, as a mass storage for distribution; - Third, smarter discs provide "post retrieval" functions that allow the user to work on the information without leaving the retrieval program. From these applications, the author sees in the future a progression of six types of discs:

1. Low-cost storage and distribution.
2. Enhanced search and retrieval.
3. Versatile printout and disk transfer
4. Computation and graphing.
5. Text, image and sound.
6. Expert system features.

To conclude, the author states that "there is no plateau in sight for either microcomputer or optical disc technology."

W. Ralph (1986), "Computers in Farm Management," Rural Research, 132: 24-25.

This article describes an Australian example of microcomputer use in simulations of farming systems. Different uses are demonstrated for better crop management: Insect management for cotton crops (SIRATAC), water management for irrigated wheat (BIRAGCROP), and grazing systems management (GRAZPLAN). The Australian experience provides another example of the integration of national agricultural R&D system for efficient microcomputer use: CSIRO centers and divisions, agricultural departments, and extension committees. Collective efforts are needed to bring information to farmers.

David H. Rothman (1984), "A Computer Hackers' Peace Corps? Solve the Third World's Problems on Your Home PC", The Washington Post, February 5.

The idea proposed here is for an "Electronic Peace Corps" that could directly provide information to Third World computer users. Implementation of this idea would require overcoming many practical and political problems.

D.R.F. Taylor and R.A. Obudho (1977), The Computer and Africa. Applications. Problems. and Potential, New York, Praeger.

This study analyses the process of development and transfer of computer technology for Africa, and distinguishes three main areas of use: Administration, academic, and business. Nothing is said about agriculture. As a matter of fact, African computer systems were then used for routine tasks, mainly in public administration.

United Nations, Department of Economic and Social Affairs (1971), The Applications of Computer Technologies for Development, New York, United Nations Publications.

On December 20, 1968, the General Assembly of the United Nations adopted Resolution 2458 (XXIII), calling upon the Secretary General to prepare a report dealing with the needs and prospects for the use of computers in developing countries. The four conclusions and eleven recommendations of this report provide the outline of a general computer policy for developing countries. Although the recommendations suggest positive action, this report raises more questions than answers. Nothing is said about the agricultural uses of computers.

Appendix B

SAMPLE QUESTIONNAIRE

NAME : ....

1. How are you involved in the use of microcomputers in agricultural extension and training?

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2. Do you have any experience in the use of microcomputers in agricultural extension and training **in developing countries**?

NO [ ]

YES [ ]

<u>IF YES</u>: When was this? ....
Could you describe this experience in a few lines?

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YOU MAY USE AN EXTRA PAGE IF YOU WISH

3. What are the main lessons derived from your experience in microcomputer use for agricultural extension and training?

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4. What is your point of view on the future next ten years of microcomputer use for agricultural extension and training in developed <u>and</u> developing countries? Please include both (1) the use of microcomputers by extension workers themselves (such as for consulting data-bases), and (2) the role of extension services in helping farmers and others use microcomputers.

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YOU MAY USE AN EXTRA PAGE IF YOU WISH

5. What are your main ideas about the need for adaptation of microcomputers for agricultural extension and training uses in developing countries?

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6. Could you give us any especially useful references to publications and/or contacts (i.e., individuals) on the use of microcomputers for agricultural extension and training?

(1)...

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(2)...

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YOU MAY USE AN EXTRA PAGE IF YOU WISH

8. Do you have any other comments that might be helpful to us?

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THANK YOU IN ADVANCE FOR YOUR HELP

Thierry Bardini

Everett M. Rogers

Appendix C

LIST OF EXPERTS ABOUT MICROCOMPUTER APPLICATIONS IN AGRICULTURAL DEVELOPMENT

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