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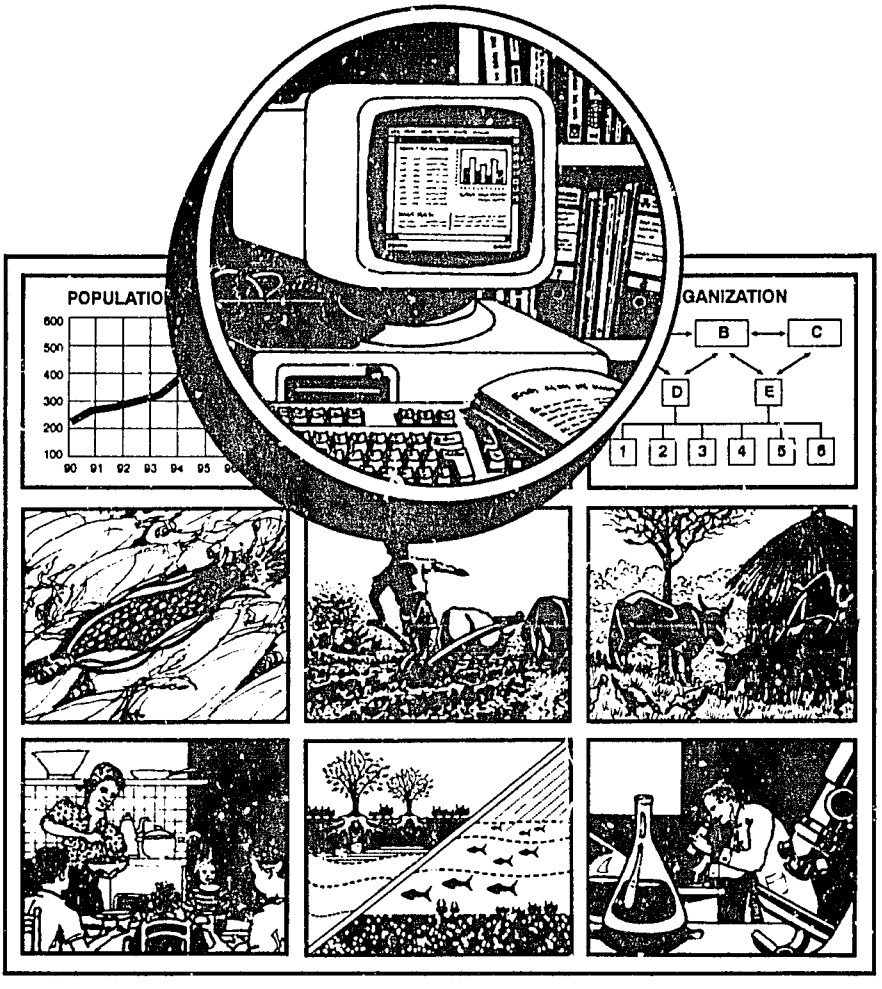
Managing the Flow of Scientific Information for Agricultural Research in Small Countries: An Issues Paper

Peter Ballantyne



isnar SMALL-COUNTRIES STUDY PAPER # 2

The International Service for National Agricultural Research (ISNAR) began operating at its headquarters in The Hague, the Netherlands, on 1 September 1980. It was established by the Consultative Group on International Agricultural Research (CGIAR), on the basis of recommendations from an international task force, for the purpose of assisting governments of developing countries in strengthening their agricultural research. It is a nonprofit, autonomous agency, international in character and nonpolitical in management, staffing, and operations.

Of the 16 centers in the CGIAR network, ISNAR is the only one that focuses primarily on national agricultural research issues. It provides advice to governments, upon request, on research policy, organization, and management issues, thus complementing the activities of other assistance agencies.

ISNAR has active advisory, research, and training programs.

ISNAR is supported by a number of the members of the CGIAR, an informal group of donors that includes countries, development banks, international organizations, and foundations.

CTA

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AGROVOC Descriptors

information services; management; research

CABI Descriptors

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ISNAR Small-Country Project

Introduction

In 1989, ISNAR began a global study of agricultural research systems in small, low-income developing countries with populations of fewer than five million people. Because of resource limitations and the inherent constraint of size that restrict the scale of the research effort in these countries, their national agricultural research systems (NARS) are small — often under 50 researchers. Nonetheless, these NARS have varied and complex tasks to perform in their respective countries.

The major goals of this study are to identify the strategic role of NARS in small countries and to determine how essential research tasks can be carried out in small research systems. Several cases are to be examined in depth, and for these, the study will assess the research capacity and resources that are currently available or needed to conduct agricultural research. This is examined in light of their mandates under the agricultural development policy of their respective countries, as well as requirements for conserving the country's natural resource base.

The project is funded largely by the Italian Government with additional support from the Rockefeller Foundation, the Danish International Development Agency (DANIDA), and the CTA (Technical Centre for Agricultural and Rural Cooperation, ACP-EC Lomé Convention).

Objectives

- To create and maintain a data base on 50 small countries, containing information on their agricultural research needs and national agricultural research systems.
- To devise means of measuring and classifying key factors related to agricultural research so that the NARS of small countries can be analyzed and compared. Such factors include agroecological zones, the scale of research systems (e.g., human and financial resources, sizes and types of institutes, types and quantity of local research programs), internal demand for technology, external sources of information on new technologies, and linkages to those sources.
- To identify suitable organizational models for NARS, as well as mechanisms and strategies for setting priorities and allocating resources to research.
- To evaluate national and regional research environments so as to help small countries exploit opportunities for acquiring new technologies from outside.
- To identify and assess mechanisms that enable NARS to manage their links with policymakers, local producers, and external sources of knowledge and technology.
- To identify the skills needed by small-country research leaders to manage the alternative strategies open to them.

Project Activities

A Global Data Base on NARS in Small Countries

Fifty developing countries are included in a global data base on agricultural research needs and the state of the NARS. These countries have populations of less than five million (1980 census) and meet at least three of the following four criteria:

- The economically active agricultural population is 20 percent or more of the total economically active population.
- Per capita income is less than US$2,000 (1980 US constant dollars).
- AgGDP per capita for the economically active agricultural population is less than US$2,000.
- AgGDP is 20 percent or more of GDP.

For each country, this information will be used to assess the national demand for research as well as existing national research capacity. The data base should provide cross-country indicators of common constraints, options, and trends.

Country Case Studies

Honduras, Jamaica, Sierra Leone, Togo, Lesotho, Mauritius, and Fiji have been selected for in-depth study. The studies cover institutional development, research organization and structure, external linkages, and information flows to the country.

Regional Studies

Regional studies will be conducted in parts of West Africa, the Caribbean, and the South Pacific. The goal of the regional studies is to assess research capacity in regions where small countries predominate. The regional studies will also identify mechanisms and strategies by which national systems can increase their effectiveness and efficiency and gain access to the information and technology they need. The studies will consider the division of labor between NARS in a regional context as well as the role of regional research organizations and collaborative networks.

Methods and Concepts

The ISNAR project will develop methods for analyzing research needs and capacity in small countries. These will identify key issues and employ the following concepts:

- **Scale:** the inherent research capacity of a national system: the combination of a NARS's human and financial resources, knowledge base, and infrastructure.
- **Scope:** the institutional agenda of a NARS, the set of research topics and objectives to which it is committed. Scope has two dimensions: the range of research programs and the level of sophistication of the research.
- **Technology Gradients and Information Flows:** the varying intensities and levels of complexity in technology generation among national systems and the network of information exchange. An analysis of structure and levels of technology generation and transfer in a region is crucial for guiding the flow of information to smaller research systems. The study of gradients and flows also examines the capacity NARS must have in

place to have access to the technology and information they need.

- **Linkages:** linkages to institutions and systems outside the NARS itself. The study will explore two key sets of linkages that are essential for the national agricultural research system. The first includes linkages to policymakers and to farmer knowledge systems in the country. The second includes linkages to external sources of knowledge, technology, and resources.

Managing Scientific Information

In collaboration with the CTA (Technical Centre for Agricultural and Rural Cooperation, ACP-EC Lomé Convention) and agricultural research information specialists from developing countries, a study is underway to explore the management of scientific information in small research systems with limited resources.

Access to scientific information that is relevant to the development of objectives and appropriate to the conditions of developing countries is crucial for agricultural research systems. It is particularly critical in small countries because the resources to do all the research that farmers need are not always available. The scope of research in a country can be increased through effective information management. Information can also be used to supplement or replace some kinds of research, releasing scarce resources to be used for programs that must be conducted locally.

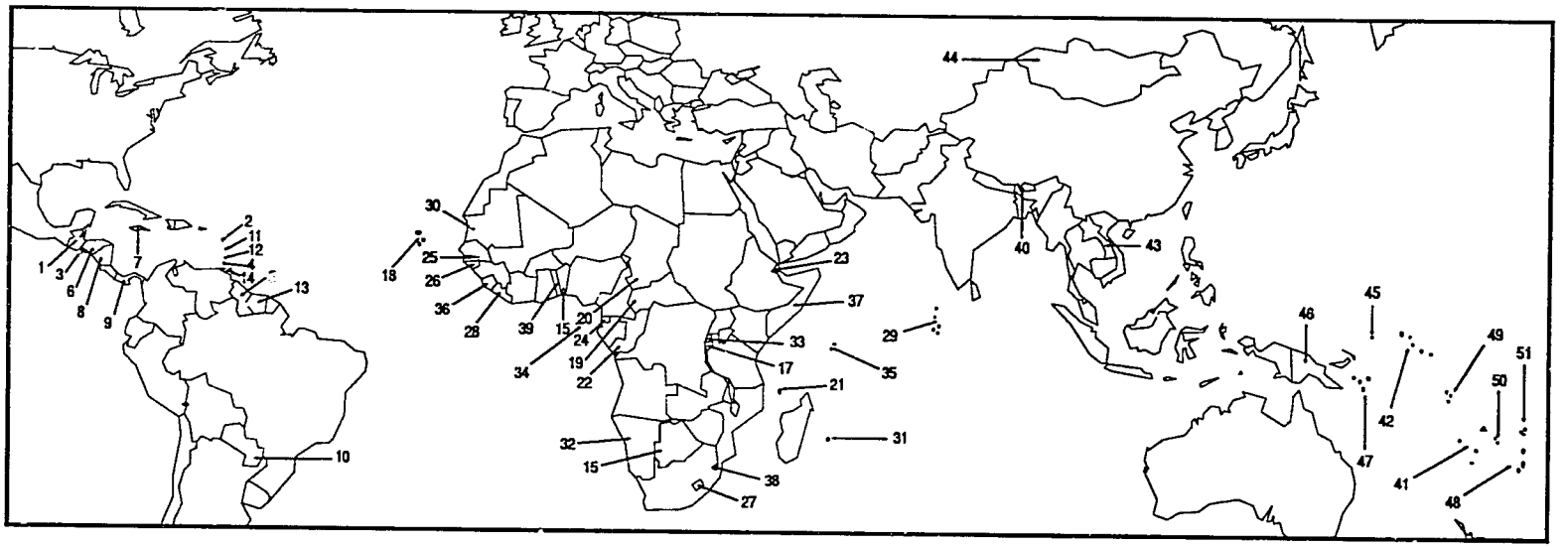
NARS in small countries are often limited in their ability to identify and receive the information they need to conduct adaptive and resource management research. This study will assess and propose mechanisms for identifying and obtaining scientific information for research programs in small countries. It will then focus on mechanisms of managing this information.

Dissemination of Results

Seminars/Workshops: Workshops are the key to disseminating the results of this study. The first workshop, held in The Hague in January 1990, reviewed project methodology and began implementation of country and regional studies. When the main phase of the study is complete, a global workshop of research leaders from small developing countries will be held. At this workshop, the conclusions of the study will be validated and applied.

Advisory Service and Training: In collaboration with national and regional agricultural research organizations, the methods developed in the study will be used for strategic planning and to produce improved management techniques for small research systems.

Publications: The data base, case studies, and issues papers will be published and made available to agricultural research managers, scientists, and development agencies concerned with agricultural growth and sustainability in developing countries.



Small Countries (as Defined by this Project)

Latin America and Caribbean:

1 Belize
2 Dominica
3 El Salvador
4 Grenada
5 Guyana
6 Honduras
7 Jamaica
8 Nicaragua
9 Panama
10 Paraguay
11 St. Lucia
12 St. Vincent
13 Suriname
14 Trinidad and Tobago

Africa and the Indian Ocean:

15 Benin
16 Botswana
17 Burundi
18 Cape Verde
19 Central African Republic
20 Chad
21 Comoros
22 Congo
23 Djibouti
24 Equatorial Guinea
25 Gambia
26 Guinea-Bissau
27 Lesotho
28 Liberia
29 Maldives
30 Mauritania
31 Mauritius
32 Namibia
33 Rwanda
34 Sao Tome e Principe
35 Seychelles
36 Sierra Leone
37 Somalia
38 Swaziland
39 Togo

Asia and the Pacific:

40 Bhutan
41 Fiji
42 Kiribati
43 Laos
44 Mongolia
45 Nauru
46 Papua New Guinea
47 Solomon Islands
48 Tonga
49 Tuvalu
50 Vanuatu
51 Western Samoa

Preface

This paper is part of a joint ISNAR and CTA Project entitled "Managing Scientific Information in Agricultural Research Systems in Small Countries." Its objectives are to identify mechanisms and strategies which can be used by agricultural research systems in small countries to gain access to relevant scientific information.

This paper discusses the major issues and factors that influence the flow of scientific information in small countries and provides a framework for analysis by managers and information specialists in small countries. It does not provide solutions or recommendations for specific situations; these must be developed by individual institutes and countries to suit their own needs.

Four case studies of national experiences in Trinidad and Tobago, the Seychelles, Swaziland, and Mauritius have been commissioned by the project. They provide a description and a basis for discussion of information approaches to support for agricultural research in each country. The cases will be discussed at an international workshop in 1992, and the conclusions of the workshop, together with other experiences from national systems, will be the basis for a synthesis document. This will provide research managers in small countries with practical guidance on information management issues and suggest appropriate uses for different information mechanisms.

Acknowledgements

The ideas and approaches in this paper had a long gestation period and benefitted immeasurably from critical discussion with many people. Maritza Hee Houng of the Ministry of Food Production and Marine Exploitation in Trinidad and Tobago was involved at a very early stage and provided thoughtful and useful comments and the benefits of her wide experience in the Caribbean. She further provided the perfect introduction to the research system in her country. In Trinidad and Tobago, my discussions with Dr. Sam Howard and his staff at Centeno, with Dr. T. Carr at Caroni Research Station, and with Mr. F. Neckles at the Sugarcane Feeds Centre provided significant input at a critical period.

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At ISNAR I received constant and often over-enthusiastic support from Pablo Eyzaguirre and his colleagues in the small-countries team. N'Guetta Bosso, Doug Horton, Byron Mook, and Barry Nestel gave valued comments on earlier drafts, and Kathleen Sheridan corrected my editorial excesses. Thanks especially to Sandra Gardner in the ISNAR library who allowed me to take time off for this project.

Financial support from the CTA enabled colleagues from four small countries to be involved in the project, and this opportunity, together with professional support from CTA staff is gratefully acknowledged.

Abstract

The resources available to conduct agricultural research in small countries are limited, and not all the necessary research can be carried out. New approaches to research and its organization are needed to deal with these constraints. One strategy is to "borrow" knowledge from sources outside the research system, using the results and methodologies developed elsewhere to solve local problems that could not otherwise be addressed. This requires an information-based strategy that builds on knowledge of local information demands, scans and assesses external sources for useful information, and adapts promising technologies to local conditions.

Key issues identified for small countries in this paper include the following: Information management should be recognized as an essential function of a research institute and its staff, and the demand for information in the research system must be identified and understood before mechanisms to acquire information are implemented. This requires information about the present and planned research program, priorities and resource allocations, and strong linkages between researchers and the information intermediaries who will search out and obtain information.

Small countries must also pay close attention to the different patterns of information flow that determine its availability, quality, and usefulness, and they must select appropriate mechanisms or combinations of mechanisms for obtaining information to suit local requirements. Not all are equally appropriate for different types of demand, for different purposes, or for all sources of information. Changes in the roles of information centers, information specialists, researchers, and research managers in small countries will require new working relationships and different training.

Résumé

Les ressources disponibles pour mener la recherche agricole dans les petits pays sont limitées, et toutes les recherches nécessaires ne peuvent pas être réalisées. De nouvelles approches pour la recherche et son organisation sont nécessaires, pour agir à l'intérieur de ces contraintes. Une des stratégies consiste à "emprunter" les connaissances à des sources extérieures au système de recherche, utilisant les résultats et les méthodes développés ailleurs afin de résoudre les problèmes locaux qui ne peuvent être abordés autrement. Ceci exige une stratégie basée sur l'information à partir des connaissances des demandes d'information locales, qui analyse et évalue les sources d'informations utiles extérieures, et adapte les technologies prometteuses aux conditions locales.

Dans cette présentation, les points principaux suivants ont été identifiés pour les petits pays : reconnaître la gestion de l'information comme fonction essentielle d'un institut de recherche et de son personnel; identifier et comprendre les demandes d'information dans le système de recherche avant d'établir les mécanismes d'acquisition de l'information. Il faut avoir de l'information sur les programmes de recherche, les priorités et les allocations de ressources, et des relations solides entre les chercheurs et les intermédiaires de l'information qui vont chercher et obtenir l'information.

Les petits pays doivent aussi faire très attention aux différents modèles de flux de l'information qui déterminent leur disponibilité, leur qualité et leur utilité, et sélectionnent les mécanismes ou combinaisons de mécanismes adéquats afin d'obtenir et de satisfaire les besoins locaux en information. Tous les modèles ne sont pas appropriés d'une manière égale pour toutes sortes de demandes et d'objectifs, ou pour toutes sources d'information.

Les changements de rôle des centres d'information, spécialistes en information, chercheurs et directeurs de recherche des petits pays, exigent de nouvelles relations de travail et une formation différente.

Resumen

Los recursos disponibles para la investigación agrícola en países pequeños son limitados, y como consecuencia no es posible realizar toda la investigacion que necesita el sector. Para superar las limitaciones impuestas por la economía y estructuras relativamente pequeñas,es necesario adoptar un nuevo enfoque para organizar y realizar la investigación.

Un estrategia prometedora es de utilizar información proveniente de fuentes externas al sistema de investigación. Los resultados y metodologías producidas al exterior se pueden aplicar para solucionar problemas locales. Esta estrategia se basa en el conocimiento de la demanda local de información y tecnología nueva, y en los sondeos y evaluaciones de las fuentes de información externas para identificar la información mas útil y adaptar las tecnologías prometedoras a las condiciones locales.

Este documento identifica los siguientes temas que asumen una importancia mayor en el caso de los países pequeños. El manejo de la información se debe reconocer como una función esencial del instituto y sus investigadores; la demanda de información en el sistema de investigación debe ser identificada y analizada antes de establecer mecanismos para adquirir la información. Los especialistas en el manejo de información deben desarrollar una mayor comprensión de los programas y prioridades de investigación, y de la distribución de recursos. Esto requiere una colaboración más estrecha entre los investigadores y los intermediarios responsables de identificar y obtener la información necesaria.

Los sistemas de investigación agrícola en países pequeños deben reconocer la existencia de diversos modelos de flujo de información, que determinan su accesibilidad, calidad, y utilidad, y deben establecer mecanismos para obtener información que sea aplicable a las condiciones locales. No todos los mecanismos son apropiados o útiles para satisfacer los diversos tipos de demandas, u objetivos o para acceder a las diversas fuentes de información.

Lograr los cambios en los roles de los centros de información, los especialistas del manejo de la información, investigadores y líderes de la investigación agrícola en países pequeños va necesitar el establecimiento de nuevas relaciones de trabajo y un nuevo tipo de formación.

Acronyms

AGRIS	International Information System for the Agricultural Sciences and Technology (FAO)
AIBA	Agricultural Information Bank for Asia
CABI	CAB International
CARDI	Caribbean Agricultural Research and Development Institute
CARIS	Current Agricultural Research Information System (FAO)
CGIAR	Consultative Group on International Agricultural Research
CIAT	Centro Internacional de Agrícola Tropical
CSC	Commonwealth Science Council
CTA	Technical Centre for Agricultural and Rural Cooperation
EEC	European Economic Community
FAO	Food and Agriculture Organization of the United Nations
IAI	International Africa Institute
IARC	international agricultural research center
IDRC	International Development Research Centre
IDS	Institute of Development Studies, University of Sussex
INSAH	Institut du Sahel
IRAZ	Institut de Recherche Agronomique et Zootechnique de la CEPGL
IRETA	Institute for Research, Extension and Training in Agriculture
IRRI	International Rice Research Institute
ISNAR	International Service for National Agricultural Research
MSIRI	Mauritius Sugar Industry Research Institute
NARS	national agricultural research system(s)
SAREC	Swedish Agency for Research Cooperation with Developing Countries
UNECLAC	United Nations Commission for Latin America and the Caribbean
UNESCO	United Nations Educational, Scientific and Cultural Organization
US	United States
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
WARDA	West Africa Rice Development Association

Information and Agricultural Research

The main function of research is to seek information and knowledge. If the information does not exist or is not available in the researcher's institution, it can be generated by experiment. If experimentation is ruled out (by resource limitations, perhaps), researchers will scan knowledge sources outside the institution, hoping to identify information, ideas, and technologies that can be borrowed and adapted for local use.

Since even a large research system cannot generate all the technologies it requires, "an effective national agricultural research system must have the capacity to borrow both knowledge and materials from the entire world" (Ruttan 1987: 84). For larger countries, this capacity to borrow from outside is desirable and complements the in-country capacity to generate technology. In small countries, where resources for technology-generation are scarce, it is essential to be able to borrow.

Getting knowledge and information to researchers is therefore a critical management function — to ensure that past investments in research and information are adequately assessed, evaluated, and utilized *before* experiments begin. This limits duplication of previous efforts and ensures that current activities use, and benefit from, existing knowledge.

Management of information within an institute can be examined at two levels. It can be examined at the level of the information unit where the main objective is to ensure that the service runs smoothly, that it delivers information, and that technical operations such as ordering and indexing, or dissemination, are done efficiently. At this level, the emphasis is on management by the documentalist or information specialist.

At a wider level, managers outside the information unit determine the size, scope, and shape of the unit, allocating the resources necessary for it to carry out its tasks. Thus, research managers decide what kind of information service they require and can afford, and they set policies and priorities for service and clientele. Their main aim is to manage those external factors that influence an information unit's ability to disseminate information, delegating actual operation and management of the unit to its manager. This level of management often receives little attention, and information specialists operate in an uninformed vacuum without the support and guidance that is necessary for effective use of information. This broader management level is the main focus of this paper.

Basic Concepts

Three major aspects of information flow and management determine the ways in which information is accessed and managed in agricultural research. These are the *demand* for information, the potential *sources* of information, and the *mechanisms* used by the research system to identify and acquire information. Information management is a process of matching demands for information with available or accessible suppliers of information, in order to deliver it to scientists. This breakdown is based on the following logic:

- Research programs or activities generate *demands* or needs for information. The needed information depends on the characteristics of researchers and research programs, and the way in which the research is conducted. Researchers often need help identifying their needs for information and converting them into demands for service.
- There is some information about all research problems, but it is spread over a range of *knowledge sources* or systems whose characteristics influence its availability and the way it can be obtained.
- *Mechanisms* are created to assess and interpret demand, identify and evaluate suitable knowledge sources, and obtain and disseminate the information that is needed. The characteristics of each mechanism determine its ability to do specific tasks: some are more responsive to certain kinds of demand; others are more appropriate for specific knowledge sources.

Agricultural Research in Small Countries

The ability of a country to conduct useful research is largely determined by two factors — scale and scope. Scale refers to the human, physical, and financial resources available to the system. Scope is the breadth of an institute's objectives and the associated activities carried out to attain them. All national agricultural research organizations face a dilemma in that the research programs that farmers and policymakers would like to see implemented exceed what is possible, given the resource constraints. Small-country research systems are further characterized by their small scale and inadequate or overextended scope (Eyzaguirre 1991), and resource limitations restrict the system's scope so that research objectives and priorities are often not achieved.

For these reasons, small-country systems must rely heavily on external sources for much of their technology and information needs. In West Africa, for example, the World Bank notes that small countries need to draw "as heavily as feasible on international and regional programs for back-up basic, strategic and applied re-

search information" (World Bank 1987: 4). They do not, however, provide research managers with guidance about what level of information borrowing is feasible, nor how the small system can determine this.

These needs are also recognized at the national level. Discussing the Gambia, its director of Agricultural Research says that the "limited capacity of small NARS strongly implies a primary reliance on information transfer rather than research *per se* to generate an appreciable supply of innovations for even a modest subject and commodity coverage" (Sompo-Ceesay and Gilbert 1989: 2). Small countries must therefore put a high priority on linkages with external information and technology sources, and the process of making and using linkages needs to be well managed to achieve the desired economies of scale and scope.

Research scope can be enhanced through judicious participation in networks and the selective use of external sources of knowledge. These participative activities allow the small system to define its programs and activities so that they complement external research programs and thus derive "spillover" benefits for the system. The scope of the small system can be substantially enlarged and enhanced (certainly beyond local resource limitations), and the range of technologies available for transfer and local adaptation consequently becomes much larger than the sum of the local system's actual research activities.

Economies are also achieved by working together with other external institutes and "delegating" some research elsewhere. The fruits of research conducted elsewhere can be screened, adapted, and used by the small country, provided that effective linkages with the technology source are maintained. This allows a small system to concentrate its scarce resources in a few high-priority areas where good results can be expected and in those areas where relevant information and technologies are not readily available from outside the country.

Small countries, therefore, instead of developing conventional, broadly based research systems, "should give top priority to organizing an effective capacity for exploiting research conducted elsewhere" and developing a "well-targeted, carefully specialized 'spill-in' capability" (Pardey, Roseboom, and Anderson 1991: 298). According to Gilmour (1990), this requires that they have

- the *ability to identify technology needs*, essential because "demands for technology are almost infinite," as is its supply;
- the *ability to scan technology*, using combinations of intelligence or alerting mechanisms to discover what is available and then to obtain it;
- the *ability to conduct adaptive research* to suit local conditions;
- the *ability to convince or persuade* other institutions to do the more fundamental research on problems that are beyond local capabilities but which can later be adapted locally.

Demand for Information in Small Countries

Demands for information and knowledge originate in the research programs and activities that are derived from national agricultural priorities. The primary function of an information mechanism is to anticipate and respond to demands by identifying and delivering information from the most appropriate sources. Its effectiveness as a mediator between researcher or other sources of demand and potential knowledge sources depends on its understanding of a their situation and needs, its ability to accurately convert needs into demands, and thereafter, its ability to design a search strategy to locate what is required. Accurate interpretation of demand is a prerequisite for all other information activities and should receive the highest priority from research and information managers.

The literature on library and information science refers to the need for the *right* information, to reach the *right* scientists, in the *right* format, and at the *right* time. In a general way, this is an accurate representation of the relationship between researcher and information service. It is insufficient, however, to determine the activities and focus of an information unit, since "rightness" varies between institutions and scientists, depending on their particular situations. Up to now, determining the "rightness" of information activities has been left to information specialists and others with vested interests in an information mechanism, who usually make subjective and perhaps overoptimistic judgments on the relevance and effectiveness of their activities.

In this paper, we suggest that demand for information can be attributed to certain characteristics and elements of the research itself, the people conducting the research, and the environment in which the research is being conducted. While these elements or characteristics are difficult to measure and assess quantitatively, their influence in creating and shaping the nature and type of demand *can* be isolated and discussed. Simple indicators, such as the crop content of a research program, indicate which crops will need to be supported with information Researcher mobility, however, is a more complicated factor and results in multiple information needs and diverse demands for different kinds of information.

Demand for information is rarely the result of one characteristic or factor; more usually, it is derived from a mixture of influences and circumstances linked to one another. Thus, the characteristics of research are intimately tied to its purpose, the farming system where it will be applied, the crop being researched, and the amount and quality of resources available for experimentation. This makes it difficult to generalize about specific situations and cases and to isolate the effects of each specific factor. In the interests of clarity, however, the next section discusses each factor as if it were separate from the others.

Programs and Scope of Research

The actual programs and activities in progress or planned by researchers are usually the basis for determining the demand or need for information services. Resources are used to acquire information that is of direct relevance to research. Information that does not contribute to any research in progress is not needed and should not be obtained for the system. The logic of this is clear, and all information services aim to mirror their institute's research priorities and programs through their information activities.

In small countries however, the size and number of problems needing research can be greater than the research system can handle — knowledge and technologies must be borrowed from outside to cover problem areas that are beyond the local system's capacity. Information in small countries may therefore have a broader or different scope than the actual research program.

This approach uses information as a complement or even a supplement to conventional research. It requires a deliberate strategy to acquire information in areas that are not the subject of research but that are important to the country. Information resources must be used to broaden the system's capacity to understand these different technologies and provide advice about them, even if they are not on the research agenda. It is critical to determine how to identify and maintain a balance between information support for commodities that receive no research and those that do.

Changing Programs and Diversification

The economies of small countries are more susceptible to external pressures and to change than are those of larger countries. They do not have internal markets and structures that act as buffers between agricultural producers and the outside world, and small changes in export crop prices, for example, have a major impact on them. In agriculture, the recognition by small countries of their vulnerability to these kinds of pressures has led to greater emphasis on diversification to reduce the risks associated with concentration on a few commodities. One characteristic of diversification programs is the almost constant search for alternative and potential replacement commodities. Producers move into new crops, trying to stay ahead of competitors or responding to market changes. Research priorities follow or try to anticipate their interests, and the emphasis on new crops is often short-term with frequent changes in work programs from year to year.

This has a major effect on small-country information services which must accommodate a wide range of new commodities and maintain flexibility in the short term. Given the rapid changes in program content, longer-term programs to strengthen information resources in some commodity areas may be neither useful nor feasible. Instead, small countries may want to strengthen their capacity to identify current information quickly and to respond to change rather than building larger retrospective collections of information. Indeed, another important role of an information mechanism in these conditions is to scan knowledge sources, acting as an intelligence service and seeking new opportunities for research and production.

Changes in commodity focus (from sugarcane to coffee, for example) or shifts between sectors or subsectors (such as from diseases to fruit marketing) require that the information entering the system be reoriented in order to serve these needs. Changes in the research program require more than the cancellation of some information services and the addition of others. Patterns of information generation and flow vary between commodities; the research system must identify the specific information patterns for each new commodity before exploring mechanisms for gaining access to the needed knowledge.

Orientation of Production Systems

The degree to which an agricultural production system is commercialized has a major effect on the type of research that is conducted. Crops with greater commercial potential receive more attention from the private sector and tend to be grown on a larger scale in order to maximize returns to investment. Thus, Caroni, Ltd., a commercial company in Trinidad and Tobago, focuses its research on crops that can be grown commercially with a high degree of mechanization, reflecting the needs of Caroni's own production systems.

Research on the same crops for the small-farm sector is handled by public-sector research institutes working with small farmers for whom the Caroni results are less useful. Thus, private and public institutions work on the same crops, but if they have different clients and are looking at different products, what looks like duplication is actually specialization according to client needs. These refinements in demand are difficult for formal information services to take into account.

Some countries conduct research on high-value, small-scale commodities such as cut flowers or fresh vegetables where there is local demand (such as tourism) or export markets in which they can compete. Research programs that can maintain and improve the national market share of these commodities require information units that can access specific, market-related information (prices, freight rates, etc.), as well as the results of research in other countries. Although they may draw on outside services and institutions — and may be very costly — specialized information services that provide current and locally targeted information must be developed locally.

The kinds of demand for information on a commodity therefore vary depending on the orientation or purpose of the research that it supports. Information for research on cotton as a large-scale commercial crop, for example, will be very different from information that is required to support its role on small farms as an income-generating supplement to food crops.

Kinds of Research

Research can be classified in a number of ways. Pray and Echeverria (1991) differentiate between mechanical, chemical, biological, and management (agronomic) research and use the characteristics of these kinds of research to assess the degree of private- or public-sector involvement in them. The Consultative Group on International Agricultural Research (CGIAR) categorizes research

according to its main purpose:

- **basic research** to generate new understanding;
- **strategic research** to solve specific research problems;
- **applied research** to create new technologies;
- **adaptive research** to modify technology for local conditions;
- **testing/screening** for farmer use.

These categories have been used to differentiate between the kinds of organizations doing research and to assign certain kinds of research to different types of institutions. Generally, the international agricultural research centers focus on applied and strategic research, but they are beginning to move "upstream" towards more basic research. National research systems in developing countries are further "downstream," focusing on applied, adaptive, and testing research. In the future, some national systems are expected to move upstream and take over some of the research that is conducted by international centers.

Private-sector organizations also work on downstream problems, although new research techniques and biotechnologies are drawing them towards the basic end of the spectrum. Nongovernment organizations and extension agencies are firmly linked to downstream technology testing and transfer linkages with farmers.

Small countries, as a whole, are constrained by their limited resources to operate at adaptive and testing levels, and their research programs must make systematic use of existing ideas and technologies. These technologies can be borrowed from neighboring countries, from developed-country research systems, or through regional and international networks. Once they have borrowed a technology, the emphasis is on adaptation to local conditions. Basic research is conducted in rare and special circumstances where technologies or information is not available outside, or where local priorities such as maintaining a competitive edge over rivals make it essential for development in-country. In Mauritius more upstream research than would normally be found in a small country is conducted on sugarcane because of the international role and comparative advantage of the research programs in question. This is also true of cocoa research in and Trinidad and Tobago, for the same reasons.

The main information implications arising from the kind of research conducted involves the degree to which it is location-specific. Generally, downstream research is focused on farmer problems or on improved technologies for specific circumstances or localities. Upstream research relies more on laboratory research, is more theory-based, and creates the knowledge that underpins and supports downstream efforts.

The information required to support upstream research is expensive; there must be large investments in basic science journals such as chemistry, physics, botany, and biology. Effective upstream research needs to be on the cutting edge of new ideas and requires more specialized information, and in greater depth. Networks and personal contacts may be the most appropriate mechanisms for small countries to use in obtaining this information.

Information units in small NARS have tiny budgets relative to the international costs of information. The decision by a small system to conduct basic research will severely affect the kind of information service that can be provided. A basic research program requires access to large amounts of information that is only available though expensive scientific journals which the library's budget would be

stretched to pay for. Alone, without access to substantial financial support, the institute's library could only provide thin and superficial access to the necessary literature. Effective support for even a small basic research program would probably consume the entire effort of a small research library. The only option is to develop strong links with other institutes conducting the same types of basic research and willing to make their resources available. This suggests a greater role in small countries for research networks, personal contacts, and publication-exchange agreements as mechanisms to obtain this type of information and support upstream research.

Demands for information on *local* soil conditions, cropping systems, rainfall, and livestock numbers, for example, dominate all kinds of on-farm and adaptive research programs. In many countries these data are difficult to find. It is frequently produced as "grey literature" — documents that are distributed in small numbers outside formal publishing channels, and which are thus difficult to identify and obtain. Furthermore, the sources of this information are often institutions or agencies specializing in areas such as anthropology, sociology, and geography with whom agricultural researchers have few contacts.

Adaptive programs also need information about techniques or methods that have been successfully used to test technologies, survey farmers, or generate greater farmer participation in the implementation of new technologies. This information is usually not location-specific and can be adapted to local conditions.

Because downstream researchers adapt and test ideas from programs further upstream, there must be excellent mechanisms to inform adaptive programs about what is happening and what is available to them. Without this, researchers who are looking for ideas will miss potential technologies. There is less demand for details on new technologies or techniques and their development and more emphasis on potential applications.

In summary, downstream research pays more attention to widely available, broadly based methodological tools and issues — then it relies on local information. A broad awareness of what research is being conducted and what technologies are available is more useful than in-depth information about specific issues or problems. In small countries, libraries and information centers provide wide access to the information that is needed to identify technologies, as well as to some local knowledge. However, specific technologies obtained for testing or adaptation usually include a package of knowledge, training, or technical assistance that limits the need for more information support.

Socioeconomics and Farming-Systems Research

In general, socioeconomic research is the most site-specific of all agricultural research, focusing on defined farming systems or locations and on testing alternatives under "real-life" conditions. This suggests that the results of such research from regional or international centers is of limited value and cannot be borrowed so easily as agronomic or breeding research (Gilbert 1991). This is in contrast to laboratory-based research programs which use controlled environments and rely more on external information about specific techniques and devices, and have less need for information about local farm practices.

The site-specificity of on-farm, farming-systems, and other farmer-participatory research programs means that most information is generated from farmers' fields and environments. The "knowledge and information required for this type of research (including methods and approaches) is generally not found in textbooks, but needs to be identified in the field in discussions with farmers" (Stoop and Bingen 1991: 246). However, results and experiences are often written up or presented at workshops, so there is a substantial literature available, particularly about methods and strategies for managing and implementing these approaches. Donor involvement in many farming-systems projects means that information is usually cheap to obtain. It can, however, be difficult to identify useful material, and the costs of searching for and obtaining very location-specific information may outweigh any benefits.

One problem with farming systems research is the limited use of traditional channels (journals, reports, etc.) to diffuse ideas and knowledge; greater reliance is placed on nonconventional or grey literature, networks, personal contacts, conferences, and workshops. Participation in many of these activities is usually by individuals, and managers must ensure that the information acquired is shared and disseminated within the national system. This is particularly important because these channels of communication usually operate around, or bypass, the information unit and its more formal library or information networks.

Research Personnel and Their Functions

Managers of research in small countries tend to stretch their human resources to cover a broad range of crops and commodities that are important to the country. In practice this means that groups of commodities such as root crops, grain legumes, or ruminants will be the responsibility of one researcher or perhaps a very small team. This contrasts with the situation in larger countries where, for example, a root crop program will have several staff members, each one responsible for a specific crop or problem area.

Unlike small countries, they have enough depth of expertise to work effectively on root crops as a group. Researchers in small countries are therefore more likely to be generalists who concentrate on one crop, but they are also expected to stay abreast of ideas and technologies in several others as well. Their demands for information are also likely to be general, emphasizing broad coverage of their crops. Thus, large amounts of in-depth information may not be necessary for each crop, but it must be accessible if a crop becomes a major focus of research.

Given this distribution of staff, the promotion and movement of researchers in small countries is likely to involve changes in research focus and responsibility, and little continuity. Promotion for a citrus researcher may require that he or she move to research on other fruits or perhaps tree crops. Depending on replacements and other staff movements, research activity on each crop will follow staff availability — movement of a researcher out of a crop may consign that crop to a low priority with no research effort. Demand for information will be significantly different than in a large country where there is greater continuity for each crop or commodity.

Staff in small countries who move to a new crop will need basic information on its production, botany, and agronomy. This more elementary information is in addition to the specialized information that

researchers are thought to require. Access to general and wide-ranging sources may be more useful than a concentration of information on fewer commodities.

A distinguishing feature of research in small countries is that research staff are expected to perform nonresearch activities in addition to their research work — they are frequently responsible for some training, teaching, administration, advisory services, and extension. This is a major aspect of the demand for information often overlooked by visitors from large systems. These visitors expect to see functional divisions between research, extension, education, and training with linkages to one another, and they design information support aimed towards these different groups. This works in a large country where nonresearch functions can be concentrated in separate departments or sections of an institute and where they do not involve research staff. Information services can then be tailored to fit well-defined user groups. This is not the case in small countries where most staff have multiple tasks and most demands for information are multifaceted.

In small countries, allocating such varied additional responsibilities to research staff may be an efficient allocation of scarce staff resources, but it creates difficulties for the information units attempting to serve them. The additional roles create demands for information that are not directly related to the research program. Information services that are aligned with the research activities in small countries thus provide only part of the information that they need, and they may not support other functions, which sometimes take up more time than the research itself. In addition, it is usually easier and more efficient to acquire and target information for a well-defined range of demands. As soon as the roles and tasks to be supported become very broad or ill-defined, the demands become more complex, requiring widely differing types of information from different sources.

These problems arise mainly from the role and functions that national policymakers assign to the research system. If these change, and the different functions are distributed among different entities, then the information service can also be more specialized. It is unlikely, however, that research will be separated from other functions in order to make the information services more efficient. The challenge for small-country managers is to develop specialized information services for research within more general structures.

The Time Dimension of Research

The time needed by research to produce useful results is often overlooked as a determinant of information demand. Some types of research (or commodities being researched) require greater investments in time than others. Research on natural resource problems such as soil erosion and drought or on perennial tree crops like cocoa or coconut may require several decades before results begin to be really useful.

The expense and resource implications of long-term programs usually mean that small countries are less likely to become involved in them. Ten-year programs tie up resources that could be used for other activities, and they reduce the system's flexibility and ability to respond rapidly to changing demands for technology. However, the location-specific requirements of natural resource management means that all countries need some research capacity in this area. An information service must be able to seek out and obtain relevant local and external information on

methodologies and approaches.

Because the research in small countries is usually geared toward short-term, frequently changing programs, a shift to long-term research will mean that the organization and focus of information support will have to change. Sustained information collection for long-term research topics requires significant medium- to long-term resource commitments. There may be a greater need for a more extensive range of information materials, and perhaps more sophisticated information resources from upstream sources, compared to the more intensive, problem-oriented information that is appropriate to topics of short-term interest. Continued support for information will be needed, even though intensive contacts between the researcher and the information unit may be cyclical, reflecting different phases of the project. Long-term commitments require a greater emphasis on storage and retrieval of information generated or collected over time.

Institutional Structures

Small systems are as prone to organizational complexity and diffusion as larger ones. Agricultural research is often only a part of some wider agricultural ministry or incorporated within an industrial and scientific research institute (this position is sometimes lowly, making the information unit even more insignificant), and researchers have to rely on an information unit that serves other clientele, such as extension, students, or administrators. This may help to bring nonresearch information to researchers' attention, but it is more likely to subordinate research needs to those of other user groups who are larger and more vocal. In other cases, there may not be a clearly defined institute responsible for agricultural research, and any information services to support researchers will be diffused through a range of places, each tending to give low priority to information that is specific to agricultural research.

Commodity, regional, or disciplinary structures influence the way information is delivered and to whom. Small research systems with few commodity and disciplinary subdivisions will have simple organizational structures, which should make the task of the information unit easier. However, information specialists serving relatively complex organizations with clearly identified commodity teams or divisions often use these categories to target their information products. The amorphous and homogeneous nature of small systems makes it difficult to clearly identify and categorize users' information needs, making it more difficult to target information to specific individuals or small groups of researchers.

Summary

The main factors that shape demand in small countries are the agricultural production systems of the country, the function and scope of the research program, the kinds of research conducted and the approaches used, changes in program content such as diversification, and the distribution and management of research personnel (table 1).

Table 1. Factors That Influence Demand for Information

Characteristic	Influence
Scope of Research	The scope of research determines the kind of information needed by researchers. Because small countries cannot generate all the information that they need from research, they need to acquire it by using information mechanisms. Thus, the scope of information entering the system may be broader than the scope of the research itself.
Change and Diversification	The effects of changing policies are more pronounced for NARS in small countries, particularly in response to external economic factors. Changes in research focus also require that their information support be reoriented to serve new needs. This involves links with new sources of information and, possibly, new mechanisms.
Production Systems	The orientation of research depends on the farming systems where new technologies are to be used. Differences between farming systems create demands for different information, probably from sources serving similar production systems.
Kinds of Research	Small countries are involved in more adaptive and testing research, requiring a capacity to scan upstream knowledge looking for suitable technologies to acquire and adapt. Information mechanisms need to be broadly based and able to access a wide spectrum of information.
Socioeconomics and Farming Systems Research	Socioeconomic and farming systems programs need access to local information. Much of this must be generated and collected locally, since regional and other external agencies have little ability to do so. Often these types of information are generated by scientists and institutes outside agriculture, and different patterns of information flow can be expected.
Time Dimension	Research on perennial crops or natural resources requires long-term information commitments, as compared to research on annual crops or short-term research priorities. Frequent changes in small-country research programs may cause problems for long-term projects, and information support over a long period requires special treatment.
Research Personnel and Their Functions	In small countries, limited numbers of staff can make it easier for information services to identify and monitor staff needs. However, movement of staff between crops or commodities alters their needs for information, and frequent monitoring of staff activities is needed. Researchers in small countries are frequently involved in other tasks, and their demand for information may reflect these needs rather than their research activities.
Institutional Structures	The nature of small-country research systems, with few specialists and many generalists who work on several crops or commodities, makes it more difficult to target information services.

Sources of Information for Small Countries

An essential role for an information unit or mechanism in a NARS is to scan and survey potential sources of knowledge in order to locate useful information. The ability of the NARS to do this depends not only on its own resource base and priorities but also on the characteristics of the institutions that generate the knowledge. Their priorities and orientations will determine the degree to which their information is disseminated and the ease with which the NARS can use their expertise.

The main participants in research and technology transfer can be grouped according to their governance, source of funding, mandate, and role. The result is a breakdown of actors in research that differentiates between public- and private-sector institutions; those that have national, regional, or international mandates; those with education, training, or technology-transfer roles in addition to research; and those for whom scientific research is not a major orientation, such as farmers (Biggs 1990; Valverde 1990).

A "central-source-of-innovation" model of agricultural research suggests that technologies and information flow in a fairly predictable pattern from international research centers through national research and extension to farmers. Alternatively, in a "multiple-source-of-innovation" model, innovations and technologies evolve in a wide range of situations, involving different actors that are not limited to research institutions or researchers (Biggs 1990). The emphasis of this second model is diversity, multiplicity, and decentralization with knowledge flowing in many directions. This model seems to be a more accurate representation of contemporary agricultural research, and because information flows will be more unpredictable, it will require different skills and a broader vision from information intermediaries.

Small countries that cannot maintain in-depth contact with all potential sources of information need new strategies to gain access to a wide range of information as well as to larger amounts of predigested and synthesized knowledge on specific topics.

The characteristics of research institutions play a large part in Eyzaguirre's (1991) classification of technologies. His approach groups research domains according to the way in which research is conducted and how information and knowledge can be expected to flow. Patterns of information flow for cassava, for example, are closer to rice than to another root crop like taro. This is because of the way in which research is conducted on these crops. Rice and cassava can be considered together because they are the focus of applied international research efforts at CGIAR centers. Centers like CIAT and IRRI share similar funding sources and the same commitment to research and technologies for developing countries, so the patterns of knowledge dissemination are also similar; they share a "public-good" orientation, meaning that research results are widely disseminated to NARS using accessible mechanisms such as reports, journals, and networks.

Taro, however, is less important commercially than cassava. It is not the major focus of any international research program, and what research there is tends to be scattered among a number of countries and institutes, many paying it only slight attention. Information on taro is thinly

scattered across countries, and researchers looking for it must emphasize broad contacts, rather than a few concentrated links as might be sufficient for cassava.

International Agricultural Research Centers

The centers affiliated with the CGIAR and other organizations with international mandates support small NARS by providing information to them at little cost. Publications, networks, and training are the main methods that they use. Using traditional library and information linkages, it is relatively easy to identify and obtain the information that they produce. Because of the international mandates of these centers, however, small NARS must be very selective in what they request and acquire from them — it is easy for a small operation to be overwhelmed by the large amount of information that these centers generate, much of which may be of only marginal use to a small national system.

The networks coordinated from international centers tend to be active and to operate well with the good support available in the center. Again, while they can be extremely useful for small countries, it is important that networks do not become a mechanism for IARCs to test and verify their technologies in a variety of locations, with little input by NARS in priority-setting and resource allocation. IARCs produce large amounts of potentially useful information on global staples and offer training and other opportunities for strengthening research systems. Each small country should maintain strong relations with those IARCs that are useful for its own research, ensuring that it is able to choose and select what it wants from each center.

A number of other international agencies and organizations are less concerned directly with agricultural research. These include United Nations agencies such as the FAO and the World Bank; agencies such as CAB International and the CTA, with mandates to facilitate access to information; and donor agencies such as USAID, IDRC, or SAREC, that provide funds and technical assistance. These agencies are often good sources of information, although it is more oriented towards policies and priorities, and they can play a critical role in supporting and strengthening all aspects of agricultural research in small countries.

Regional Institutes

Research institutes with regional mandates to strengthen political or agroecological zones are increasingly seen as essential parts of the global research system. Most are located in small countries, reflecting a major expectation that they will be particularly active in small countries. Often located in universities (IRETA in Western Samoa, IRAZ in Burundi, CARDI in Trinidad and Tobago), they seek also to integrate regional resources for higher education with research.

For information management, they have an extra role that the IARCs do not have. They represent groups of smaller countries and are often expected to act on their behalf, screening and disseminating information to their members. Being one step removed from small-country scien-

tists and having to maintain balanced services to many different countries, they are likely to lack an in-depth knowledge of a small country's particular information needs; instead, they provide generalized services for the whole region.

The focus on smaller countries and representation of small countries on their governing bodies suggest that regional, more than international, centers can be *used* by a small country to supplement its own research and information efforts. This may need to be an explicit policy in small countries with limited capacity to acquire and manage information.

National Agricultural Research Systems

A national agricultural research system is comprised of the institutes and organizations within a country that have responsibilities for agricultural research. The precise contents of a NARS typically include traditional agricultural research institutes, universities, nongovernment organizations, private-sector companies, foundations, and parastatal agencies. Every country has a NARS, so we need to differentiate between those in more-developed countries and those in developing countries. In the former, research usually has a longer tradition, is better funded, has better facilities and more personnel, and has made substantial investments in information resources and their dissemination. The problems that they face are different from those of developing countries, and their research is less directly relevant to small developing countries.

Institutes and universities in more-developed countries, particularly those that are publicly funded, can be valuable sources of information for small countries. Access to published materials is relatively easy through the databases of the FAO, USDA, and CAB International, but it can be costly. Formal institutional linkages are often supported by a donor agency but must be focused on small-country requirements. More common are the informal personal linkages developed by scientists who have studied abroad.

Many research and electronic networks link scientists in developed countries, but it will be some time before small countries can be connected — and they will probably never join some of the European research networks that are aimed at fostering research within the EEC group. There are large quantities of information in documents, libraries, and databases in these developed-country research systems, but these are probably the information sources that need the most critical evaluation and selection by small countries — because of the doubtful relevance of much of it to small-country situations as well as the propensity of individual countries to promote "their" information and products in a competitive manner.

Important potential sources of information for developing countries are NARS in other developing countries. In principle, this information should be most useful for a small country, coming as it does from situations where agricultural and social systems may be similar. The concept of "south-south" knowledge is not new; however, there are many barriers to its wide use. Although the emphasis by donor agencies on making the knowledge and information of their own countries available in preference to that of a third country is changing slowly, most donor support still promotes "north-south" knowledge flows. (This idea is not limited to donor agencies — many NARS scientists also regard technologies from developed countries as more desirable.) Another problem for south-south information flows is the limited ability of many

developing NARS to produce and disseminate information for their own use, never mind for outsiders. There is also limited coverage of what they do produce by the international, regional, and national databases and publications.

For all these information sources, a small country must emphasize selectivity and the relevance of the information to local needs. Small countries, with their weak capacity to assess knowledge, will be in a poor position unless they know what they require and can select from the mass of information offered or available to them. They could look to other developing countries for information and technologies, especially those with similar agricultural systems. They can also pool their resources through regional and other collaborative mechanisms and increase their capacity to share information. This may need a reorientation of information services away from traditional links with developed countries towards nontraditional sources in neighboring countries. A change in donor attitudes that gives more recognition to a small country's need for this information would also be required.

Private-Sector Organizations

Research by private-sector companies has always played an important role in certain areas of agricultural research. Today, there is an increasing trend towards privatization of public-sector research in more-developed countries, and similar thinking is shaping donor and national policies in less-developed countries. From an information point of view, these are important changes in the institutional structure of agricultural research, and they will have a major impact on information flows and access.

Pray and Echeverria (1991) provide an overview of the main policy issues associated with the growing role of the private sector. They categorize research activities by types of technology to indicate where private-sector companies are most active.

Mechanical and chemical technologies are the areas of greatest private-sector activity, followed by biological and managerial technologies. These concentrations of effort are linked to the concept of *appropriability*, which is the degree to which benefits from a technology can be retained (appropriated) by the researcher or company involved. Innovations and technologies related to chemicals, fertilizers, pesticides, and farm machinery are most appropriable, especially with the protection afforded to inventors by patents and other forms of intellectual copyright. Increasingly, developments in biotechnology are making biological innovations more appropriable, and private-sector companies are moving into an area that was once dominated by public-sector research institutions. Managerial or agronomic technologies, which tend to be longer term and rely more on packages of practices rather than specific inputs, remain the domain of public-sector researchers.

Differences in availability of information between commodities often reflect commercial interests and involvement. National food crops receive less attention from the private sector than export crops, and there is likely to be less information available about them. However, this smaller knowledge system may in fact be more accessible than that of export crops, reflecting greater public-sector involvement in traditional food crops research (Eyzaguirre 1991). Overall, however, the effects of private-sector involvement in research on information and knowledge flows have not been fully explored. There is some evidence to suggest that information from the private sector has different

patterns of flow than does public-sector knowledge. It is also more difficult and more costly to identify and obtain.

Crow and Bozeman (1991) developed a taxonomy of research and development laboratories in the US that shows the distribution of different kinds of research among them. Applied research was cited as a "major mission" for 98% of the private-sector and about 60% of the public-sector respondents to their survey. Basic research was a major mission for about 10% of the private-sector companies. This highlights the different priorities of private and public research, as well as the private-sector emphasis on applications that can generate revenue.

Crow and Bozeman also identify different categories of knowledge outputs from laboratories. They show that agricultural experiment stations with large public-sector investments tend to produce knowledge in the public domain, such as articles, reports, and conference papers. In a private-sector laboratory, such as Pfizer, more than 60% of knowledge outputs are of a proprietary character.

Pistorius (1991) shows how license agreements between the Government of China and private companies to distribute hybrid rice varieties restrict the flow of information about them to other governments and to IRRI. Waller and van der Graaff (1989) discuss the knowledge system for perennial, mainly export, crops and note the emphasis on applied and short-term research such as pest control. They suggest that commercial, but not necessarily private-sector, involvement is responsible for this. Kruiter's (1990) study of information flows for banana in Costa Rica demonstrates how local public-sector institutes cannot compete with large transnational corporations to generate and disseminate technologies that farmers may need. The main reason is the dominant role of the transnational company, in research, marketing, and distribution.

An area of increasing importance to small countries and the private sector is high-value fruit, ornamental, and exotic crops. Information, both production- and market-related, is mainly in the hands of companies and individuals who, for commercial and competitive reasons, are unlikely to provide it to NARS at low cost. For the same reasons, the most useful information on these crops is difficult to find at all — it is not widely disseminated except to commercial partners, is rarely published in traditional sources, and is difficult to access through conventional bibliographic databases. In Trinidad and Tobago, for example, personal contacts with commercial growers in Thailand have been the most effective mechanism of acquiring information about orchid production technologies that was not easily available through other sources.

Universities

Most small countries do not have their own universities, and they rely on regional or foreign universities for educating and training their research staff. Other than the direct linkages between research institutes that hire university graduates, the research linkages between NARS and universities tend to be poor. This partly reflects different roles and priorities — education and training are usually seen to be the main role of a university, and any research is secondary. However, much research does take place in universities and other academic institutions, mainly to satisfy the requirements of earning a higher degree. This academic emphasis often directs university research activities towards more applied and basic prob-

lems, with less emphasis on farmers' problems (FAO 1991). The desire of students to complete their academic requirements, together with restrictions on funding and land, means that research on food science and technology and on socioeconomics, rather than field-based work on crops or livestock, is more widespread than in national institutes. The value of this research, done in universities, should not be underestimated. Their work on botanic resources, farm management, genetic resources, and market structure, for example, is useful to the national research institutes that work in other areas but which need background information or specialized expertise.

Libraries and information services in universities tend to be better organized and funded than those in other research institutes; perhaps this is a result of greater staff interest in publishing and disseminating their work in order to gain recognition or promotion. It is also a recognition of the role that information plays in teaching and learning. The public nature of university funding usually means that information is available without many restrictions — and a great deal of useful information is available, often as much a by-product of teaching as a product of research. In addition to their information resources, universities are a reservoir of well-trained scientists who have technical and advisory skills to contribute to research programs. Students, if properly organized and harnessed, can be useful to work with projects where there would otherwise be insufficient personnel to carry them out. Wherever possible, universities or colleges, with their function as repositories of knowledge, should be used as information resources by research institutes in small countries.

Biotechnology and Small Countries

Biotechnology research is receiving more attention than ever before, and paradoxically, while it becomes increasingly important and its methods more widely used, biotechnology information may be more difficult than ever before to acquire. The increased role of the private sector is largely responsible for this. Applied research on biotechnology is moving away from the public to the private sector, especially to the private sector in developed countries. This has implications for accessing information; better access was possible when the information was in the public domain (Javier 1990). New institutional arrangements, such as the trend in joint public/private research, have had a similar effect, moving public information away from conventional, accessible channels towards more restricted commercial circulation.

It has been suggested that most small countries do not have the capacity to make "productive investments in agricultural biotechnology" (Herdt 1991) on the grounds of cost, lack of demand, and shortage of trained staff. It is important, however, to note that within biotechnology, there is a gradient of technologies (Jones 1990) running from relatively low-cost, simple or "traditional" methods such as tissue culture, through to "modern" genetic engineering programs that require high levels of investment and scientific knowledge. Traditional biotechnologies are already part of small-country research programs; it is the modern techniques that may not be practical for small countries.

Without any major involvement in biotechnology research, most small countries will only need limited access to technical biotechnology information. Instead, they will require links to sources of knowledge that provide them with the predigested or synthesized information

Table 2. Sources of Information — Characteristics and Issues

Information Source	Characteristics	Information Issues
International Centers	• publicly funded • oriented towards developing-country problems • often coordinate networks • research moving upstream	• relatively easy access • specialized subject focus • large output of knowledge • use variety of mechanisms to disseminate information
Regional Centers	• publicly funded • most are oriented towards small countries • often coordinate research rather than doing it themselves • research tends to be adaptive and applied	• relatively easy access for countries in their region • often a focus for information development and coordination for the region • more relevant outputs
More-Developed National Systems	• publicly funded • moving to commercialization • research tends to be applied and strategic	• relatively easy to identify information • costly to obtain information • information must be adapted to small-country situation
Less-Developed National Systems	• publicly funded • donor supported • research tends to be location-specific	• difficult to identify and retrieve information • limited knowledge outputs • outputs are often very relevant
Universities	• publicly funded • research tends to be upstream • more socioeconomic research • research is only one role of staff	• good sources of in-depth, wide-ranging information to support longer-term research • method of access to upstream research • good source of interdisciplinary information • major source of socioeconomic data and knowledge
Private-Sector Organizations	• research tends to be applied • research oriented to commercial applications	• dissemination of information restricted • information usually limited to situation or product • information costly to obtain • information difficult to identify

needed to evaluate potential technologies for their own use, as well as sufficiently trained and informed staff with enough grasp of major biotechnology issues to provide knowledgeable advice to policy-makers.

Developing a capacity to remain up-to-date in biotechnology, as well as screening and evaluating new technologies, is a major undertaking. Biotechnology information is expensive, and the wide-ranging and interdisciplinary nature of the research means that it is scattered across hundreds of databases and sources. In the US, major agricultural libraries recog-

nize their inability to discharge this function properly, and they are joining together to create a Biotechnology Information Center to cater to their special needs and problems (Eaton 1991). If these well-funded libraries have to work together to monitor biotechnology information, then small countries with even fewer resources will have to make new alliances and partnerships with other countries or interested agencies in order to do the same.

Summary

The availability of information varies between types of institutions: public-sector involvement tends to promote dissemination; private-sector involvement tends to restrict information flows. Regional centers, because of the role of small countries in their management and governance, would seem to offer opportunities for a small country to share resources and acquire information efficiently. Similar differences between crops or groups of commodities can also be attributed to the characteristics of the institutions working on them.

Mechanisms for Acquiring and Managing Information in Small Countries

A major influence on an information unit is the size of the system that it has to serve. Large systems with many staff members often have an information unit that provides each of them with a little of what they need. Smaller institutes, in contrast, have few staff members — the information specialist is able to know researchers personally and to be able to provide them with personalized services. Small size may facilitate linkages between research programs and their supporting information unit.

Given the variety of globally available information, it is essential for an agricultural research institute to have effective mechanisms for managing both internal and external information. Mechanisms for linking small countries with external sources of knowledge include networks (formal and informal), meetings and conferences, information and documentation programs, training, staff exchanges, and technical assistance. There is, however, very little information available to assist managers in identifying potential sources of external knowledge and, once these are identified, in explaining how to derive maximum benefits from them.

Personal contacts, research networks, information networks, and scientific information services comprising library and documentation services and their role in small countries are the main focus of this study and are considered in more detail in the following section.

Scientific Information Services

Libraries and documentation centers exist in every agricultural research center or institute. They range in size from a single locked bookcase to large, well-organized collections of reports and journals backed up by computerized databases. Their impact and usefulness is often limited because they tend to be poorly staffed and underfunded and to lack close association with their research clientele. Their own ineffectiveness also affects the development of other mechanisms, such as research networks that emphasize information sharing.

The libraries of small countries have certain characteristics that are not shared by libraries in larger countries, and these strongly influence the range and effectiveness of services that they can provide; they have multiple roles, functions, and clientele. They attempt to serve diverse groups, including policymakers, researchers, students, extension workers, and even farmers. This would seem to offer some technical economies and opportunities for sharing resources, but from the research viewpoint, it may lead to diversion of efforts away from research needs. The benefits from bringing disparate users together in one place and the opportunities for cross-fertilization of ideas and better communication may, however, be significant, if rather ad hoc.

Agricultural research libraries act as an information service for research, and in small countries, they often also act as the national depository or archives for agriculture in general. These functions are quite different, and attempting to do both may stretch a small information service in conflicting directions. Collecting and storing all reports about a country requires an approach to information that is very different from that of a service whose aim is to be highly selective, looking only for relevant and useful information.

Large countries can afford information services for each group of clients, and they usually have enough staff to support specialized centers with a national archival role. If these multiple roles and client groups are to be served through a single unit in a small country, however, it is important to recognize the pressures that a small facility attempting too many tasks with inadequate resources may face.

Scientific information and documentation services are good at storage and retrieval of documentary information and at maintaining the institution's memory for the future. They are less able to provide the extremely current information that is required in some areas, and they may not have the breadth of personal, as opposed to institutional, contacts, that is needed to obtain much of the information that is not available though traditional and formal channels.

Information Networks and Collaboration

The growth in information, along with resource limitations, has pushed libraries and documentation services towards cooperative ventures. These mostly involve standardizing databases and software to facilitate data-sharing, collaboration in training, interlibrary exchange agreements, joint schemes to index the documentation of a region or commodity, and joint development of tools and standards for sharing and accessing information (Foss 1990; Sison 1990).

In agriculture, international programs initiated by FAO, such as AGRIS and CARIS, enable each country to have access to global information in return for its own national contribution. Organizations such as AIBA, CARDI, IRETA, and INSAH collaborate and coordinate information activities at regional or subregional levels. Problems occur when national resources are not adequate for full participation or the services and outputs of the networks have not been targeted to serve national requirements.

These general cooperative ventures are supplemented by a number of donor-funded specialized information centers that concentrate on one or two commodities. Each center attempts to collect, or at least identify, all information about a commodity and then disseminate it to interested researchers and libraries. In theory, they provide in-depth access to specific information that is not available through normal, "general" agricultural libraries in a country. Coconuts in Sri Lanka, beans in Colombia, root crops in the Philippines, sorghum and millet in India, and agroforestry in Kenya are examples.

Although these centers are not information networks as such, they are resource centers for other institutes working on a commodity, and they allow national centers to concentrate their energies on the information needed to support other priority areas. Apart from those located in IARCs, the main problem for specialized centers is how to maintain their activities after donor funding stops.

Because there are few libraries or trained information staff in most small countries, information networks or collaborative ventures involving outside agencies and other countries all tend to work with the same focal point in the country. Thus, in Dominica, a single documentation center (a single individual, in practice) is simultaneously the national focal point for information networks on agriculture (AGRIS and CARIS), economic and social development information (UNECLAC), energy information (CSC/IDRC), and proposed networks for environmental information and, possibly, for drugs. These networks often have different technical requirements as well as substantial resource and time commitments that may detract from local activities. The number of networks and the degree of activity in each need to be carefully managed to ensure that national efforts are not overshadowed by activities designed to strengthen some external entity. If network activities can be shown to enhance local services, which is the case with many of them, then participation can be justified.

Almost all research institutions want to have their own information unit or library. In line with the approach described above, research institutes in small countries should investigate collaborative efforts with other organizations to ensure that relevant information is accessible. Collaboration and resource-sharing with other divisions or departments of a ministry can be fruitful; linkages with educational institutions, particularly faculties of agriculture, also have significant benefits.

Alone, an institute's resources are insufficient to provide its researchers with access to the information that they need. Joint ventures should allow the research system to maintain small, service- and program-oriented units that work closely with staff to obtain and deliver the needed information. The alternative is to develop a traditional documentation center that will probably never move beyond document storage and classification. Delegating these routine activities to another institution with more resources may be a better option.

The activities of information networks mainly involve collaboration in technical areas to create economies of scale. They are also mechanisms for improving and enlarging the capacity of scientific information centers to deliver their main

products — their primary contribution is to provide access to more of the types of information that already exists in documentation centers, but to do it more efficiently.

Research Networks

Research networks are a growing element in all research systems, as mechanisms both for information exchange and for joint or collaborative research activities (Plucknett, Smith and Ozgediz 1990). They "reduce costs, minimize duplication and boost efficiency" (Plucknett and Smith 1984: 990) and are recommended to managers for their capacity to generate new knowledge while making better use of current information. These sharing and economizing roles are considered to be "most valuable in countries with limited funds and scientific manpower" (Burley 1987: 68). The problem for research managers in small countries is that proliferating networks create more demands from participants, and appropriate strategies for managing and evaluating their contribution to a small research system do not exist.

There are few appropriate staff available in a small country to work with each network, and a frequent problem is for one or two scientists to each be involved in a number of different networks. Since networks require positive action from their participants, there is a danger that network activities could dominate a researcher's program to such an extent that local priorities are ignored or receive insufficient attention.

Research networks are selective in their membership. A major problem is faced by researchers or research systems who, for various reasons, do not participate in these networks. Inaction, an inability to participate, or plain ignorance of a network's existence means that the research system will be cut off from world knowledge. Researchers working in research areas for which there are no active networks may also be cut off unless there are alternative mechanisms that provide them with the information they need. Specialized support from the information services of the researcher's institute will be required to provide information that would otherwise come through a network.

The greatest strengths of research networks, as mechanisms for delivering information, is their ability to provide current and highly credible information. Network coordinators are often familiar with the researcher's program, and because of their scientific training, they understand the problems being studied. This helps them target information to individual researchers, and the information in turn is seen as very useful and credible because of the coordinator's expertise.

Usually based at an international or regional center, coordinators are in a good position to monitor current developments and disseminate important information to the network. Although much of this information is available from other sources, it is often perceived to be more useful and dependable if it comes from the network.

Other positive features of research networks are the range of communication methods available. Knowledge is spread through newsletters and publications, but regular visits by the coordinator and training courses, conferences, and study tours arranged by the network are probably more effective. These opportunities are not regularly available to a research system that relies on libraries and information networks; meetings with other scientists are often unplanned and infrequent and cannot be relied upon to deliver the knowledge that is required.

Personal Contacts (Gatekeepers)

In addition to the more formal research networks discussed above, scientists are well known for their informal networks, the so-called "invisible college." Much scientific and other information moves through an institute via a number of information "gatekeepers." These individuals are especially well linked to internal and external information sources, and they are used by their colleagues to find information.

Ensuring that the gatekeepers' efforts to "keep in touch" are facilitated and supported is critical if they are to function effectively and to the system's benefit. Gatekeepers need to be physically and administratively situated so that they are accessible to many other researchers, and they require opportunities to interact with colleagues outside the research system. Reliance on them is fraught with difficulties; in particular, they have individual interests and preferences which influence the kinds of information that they obtain and disseminate. Close management and control of the gatekeepers' activities is difficult, but selection of these people as network participants will benefit the institute as a whole.

Information Technology

Developments in computers and telecommunications are increasing the ability of small countries to manage local information and to link into international, regional, and other foreign information systems. Many people thought that information technologies would be the solution to many problems, but it has made things worse in some areas by providing "access to more, instead of offering selective mechanisms for limiting supply" (Owen 1989). The array of systems around the world is huge and grows day by day, so much so that small systems are threatened with an overload of information that they cannot cope with. For small countries, the most important characteristic to search for are systems that provide specific and perhaps digested information that will not overload local capacity. The possibilities that information technologies offer for efficiently moving and sharing information in and between small countries cannot, however, be overemphasized.

Discussion and Summary

The roles of different mechanisms are not always clearly defined, and it is very difficult to compare them directly. They provide access to different types and sources of information, and particular mechanisms must be designed or selected to suit the country's immediate needs. Each offers certain opportunities, and each also has drawbacks that determine how and where it will be most useful. Table 3 illustrates some of their positive and negative characteristics.

Where there are overlaps in information, as may occur between some research networks and scientific information centers, the small system must carefully assess which is more effective. The currency and

Table 3. Information Mechanisms — Characteristics and Uses

Mechanism	Positive Features and Uses	Problem Areas
Scientific Information and Documentation Services	• access to traditional documentary sources • broad subject coverage • institutional memory/repository function • access to public sector, universities, IARCs, and regional centers	• often out of date • not so good for nonbibliographic sources • poor links with private sector • emphasizes quantity more than quality and synthesis • more process-oriented than use-oriented • slow response to program changes
Information Networks	• access to traditional documentary sources • access beyond local resources • access to public sector, IARCs, and regional centers • fosters collaboration and extrovert attitudes	• requirements to participate may overload small systems • problems with stability and sustainability of donor funding • multiplicity of networks
Research Networks	• high credibility • current and up to date • popular and fashionable with donors • specialized subject coverage • more than just information, they link scientists to each other • access to public sector, universities, IARCs, and regional centers	• requirements to participate may overload small systems • multiplicity of networks • problems with redisseminating and using information in the system • may not match national priorities
Personal Contacts	• very high credibility • specialized subject coverage • all types of sources • convenient • multiple functions and purposes	• personal bias • problems with redisseminating and using information in the system • difficult to manage

credibility of information from personal or network sources has to be balanced against the often poor redissemination and institutionalization of the information within the system. Specific local mechanisms would be required to do this.

The degree to which small countries can afford to maintain active participation in research networks as well as investing in more formal libraries or information units is questionable. If a network provides the advice, information, and technical support that a research program needs, then what does the information unit provide? The decision is not *either* networks *or* libraries, but what investment should be made in each and for what purposes. The balance will vary according to local needs and the information flow characteristics of the commodity being researched.

Scientists will always rely on personal contacts for large amounts of their information needs. Managers can promote these contacts by providing and support-

ing opportunities for staff to attend meetings, study abroad, or go on study tours. Similarly, they can be open to outside expertise, encouraging movement and contacts between staff of different institutes who work on similar problems. The disadvantages are that as the contacts are personal, the information and knowledge acquired may never be shared with other staff in the system, nor will they become part of the institutional memory, available for future decisions and research.

Selecting the correct blend of information mechanisms is not an easy decision for small countries. All kinds of information are needed, all types of information sources must be accessed, and information has a broader and more important role to play than in a larger country. In small countries there is a need for the services, products, and special skills that can be provided by libraries, documentation centers, networks, and personal contacts. Their scale, roles, and functions, however, must be different than those in larger countries — experimentation with different combinations and approaches is needed and even new models may be appropriate.

Key Issues for Small Countries

This paper contains a framework for assessing scientific information for agricultural research in small countries. The key element is accurate interpretation of the information needs of the research system and its staff. Selecting the most appropriate mechanism for obtaining the information is the last step in the process and follows an assessment of potential knowledge sources and their characteristics.

Identifying the Information Function

In many small countries, information management is not yet recognized as a key activity and function of research institutions, and its constituent parts have not been identified. In some cases, parts of the information function are identified and can be seen in the form of an information unit. However, other activities, such as attending meetings or participating in networks, are not considered to be informational — although their main function is to acquire knowledge and information and they are not managed in any systematic way. It is essential that the information function be recognized and identified before an approach to acquiring and managing information is developed. An incomplete view of the information function and its parts will result in an inadequate information system.

Responding to Demand

Accurate determination of demand is essential. This requires that detailed information about present and planned research programs be available. It also requires that scientists understand the importance of their role in determining what information enters the system and that information professionals make a commitment to focus their efforts on the information that is needed by the research system. A strong link between researchers and an information mechanism is an essential part of the process. Only when information intermediaries understand the nature of the research system's demand can that demand be articulated as an institutional or even systemwide information-demand profile and updated as required. This demand profile can be used to approach and evaluate potential information sources, discouraging or discarding those that do not satisfy the requirements of the small country.

Assessing and Using Information Sources

Small-country research systems must pay close attention to the different patterns of information availability and flow between commodities and the institutions that work on them. These patterns determine the amount, quality, and usefulness of available knowledge. Identifying, characterizing, and assessing different sources of knowledge requires the skills of the information specialist. Scanning knowledge sources and knowing which ones will have what is needed requires a broad awareness of agricultural information sources and institutes, as well as current information on their programs. While some of this can be obtained from documents and reports, other forms of in-depth contacts are needed to make the best use of key information sources.

Assessing the usefulness of external knowledge sources to in-country programs requires accurate information about local requirements and demand. This highlights the need for close cooperation between the people who scan and assess knowledge and those who will use it. Information management in small countries needs to be organized so that demand from researchers constantly updates the demand profile that is used to evaluate external knowledge sources.

As well as relevance, other criteria for assessing knowledge sources include the direct and indirect costs of acquiring the needed information, the speed with which it can be delivered, its user-friendliness (language and format), the resources required to adapt external knowledge to local needs, and last but not least, the credibility of the information source and its products.

Selecting Appropriate Information Mechanisms

Mechanisms for acquiring information serve different purposes and have strengths and weaknesses that predispose them to certain kinds of information

or information sources; their performance should be monitored to ensure that they remain effective. A mechanism cannot be evaluated without considering its purpose and the purpose assigned to it by the small country itself. An agricultural research institute library in the US will have a very different range of functions than a library serving a similar clientele in the Caribbean. Scanning, evaluating, and repackaging information are more important in a small country than processing, indexing, and archiving, although these latter activities cannot be ignored.

Other than its ability to satisfy its purpose, the criteria used to assess an information mechanism include the cost of creating and maintaining it, the longer-term commitments of staff and resources required by formal mechanisms, its comparative advantage in terms of knowledge sources that can be accessed, its convenience and suitability for delivering what is needed, its capacity to understand and interpret information demand as a basis for evaluating potential knowledge sources, and the degree to which knowledge can be disseminated, shared, and made available to the entire research system.

The Role of the Scientist

As research in small countries becomes less experiment-oriented and involves more and more knowledge assessment and synthesis, the role of researchers will change. Distinctions between researchers and information staff should be less clear-cut; knowledge handling would be recognized as the main task of both groups. Each would, of course, continue to bring different skills to a problem, but researchers would be expected to play a clearer and more active role in assessing and repackaging knowledge. Researchers in small countries will require some specialized training in information or knowledge handling to prepare them for this role — one that would be quite different from that of their colleagues in larger countries.

The Role of an Information Center

Clearly, research systems in small countries have neither the resources nor the requirements to build large collections of information in libraries. Their emphasis must be on building the necessary linkages and contacts that can deliver the information that is needed. Very often, this information will not be available in the country but must be obtained from outside. This does not mean that information centers should not be built up and maintained, but rather that they should be small and clearly focused and should pay more attention to acquiring the core information that must be available locally. Such information would include knowledge generated in the country, with a very selective coverage of regional and international information. Information personnel would be committed to close liaison with research staff, with involvement if possible in their projects, and would be trained to locate and obtain information, rather than processing and storing it.

The Role of the Information Specialist

The peculiar nature of agricultural research in small countries suggests that information personnel should have an expanded role in the research system. The dependence on access to information instead of research and experimentation requires that information scanning, synthesis, and dissemination become an integral part of any research program. No longer can information personnel focus on acquiring, processing, and storing information materials — they must move out to become active and integral parts of each research team.

This expanded role will need support and management commitments to ensure that the necessary changes in function occur smoothly. More important, the skill mix of information professionals in each country will need to be reassessed and reevaluated to meet new needs and opportunities.

The Role of the Research Manager

It is the task of a research manager to encourage and facilitate information flow. This requires appropriate mechanisms to link research staff with sources of knowledge and to link scientists with information specialists, ensuring, in particular, that information staff understand scientists' demands for information.

Establishing suitable information systems and mechanisms requires that managers be able to assess the information requirements of a research system or institute and convert them into an effective methodology to deliver the needed information. These assessments require knowledge about potential information sources and how to approach them, as well as the appropriate blend of mechanisms (networks, libraries, training, etc.) that can be used. Existing information services may need to be reorganized or integrated to create closer links with research programs, and they may need to be reoriented to provide services that can be sustained from local resources.

Cost and Financial Implications

Information is not free, and its effective acquisition and management requires consistent support from the research budget. The heightened importance and role of information in small countries means that the proportion of a research budget that is allocated to information activities will be higher than in a larger country. These investments are needed to train and retain skilled information professionals, to train or retrain scientists in new information skills, to acquire information, and to provide the necessary facilities and equipment, such as computers, that are so essential to the whole process. The whole notion of tapping into existing information systems in larger countries may even require that the small countries pay some of the costs of the research whose products they use.

Fragile Information Services

Trained and effective information personnel are a scarce and valuable resource in most small countries. The dependence of many institutes on one such individual, with almost no backup expertise in the research system, should be an area of concern for research managers. Building up the knowledge and understanding of the research system's needs and potential sources of knowledge takes time and commitment from staff that cannot easily be replaced. Ensuring that the necessary expertise is available is quite difficult, especially when small size cannot justify more information staff. Collaboration with other institutes in the country to make sure that information tasks are not dependent on one individual is an option worth investigating.

The Need for Synthesized Information

For a global commodity like rice or maize, a small country needs to have the huge amount of available literature reduced to usable chunks. Small countries do not have the resources to do this themselves, and information suppliers should rethink the nature of their services to small countries. Small countries may also have to consider whether collaboration with other institutes is a way of ensuring that information is screened and synthesized before it reaches them. In other commodities, where information is scarce or difficult to locate, access to mechanisms that emphasize broad, comprehensive coverage may be more important. Knowing when and how to look for prepackaged information and when to cast the net wide is a critical skill, and it depends on the information staff's awareness of different knowledge systems for different commodities.

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