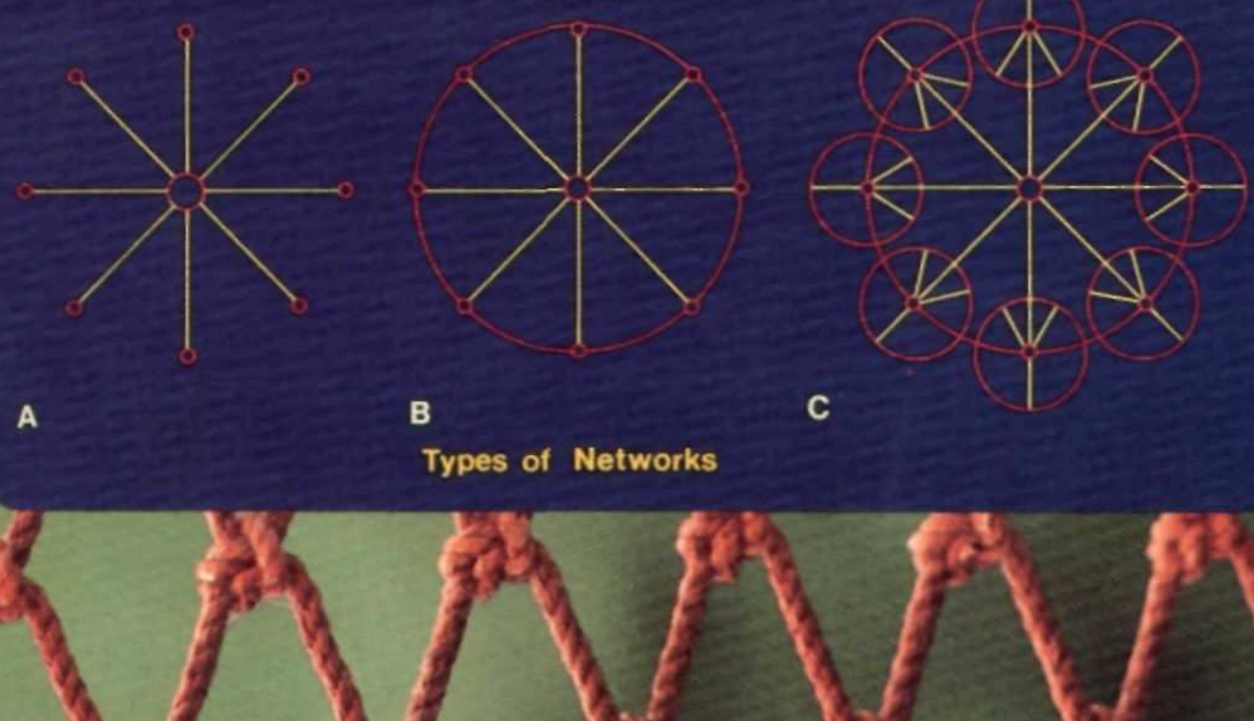
Agricultural Research Networks as Development Tools



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Types of Networks

International Development Research Center

International Crops Research Institute for the Semi-Arid Tropics

Abstract

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An Agricultural Research Network (ARNET) is a cluster of scientists or institutions linked together by a common interest in working dependently or interdependently on an identified shared problem or problems. ARNETs are popular with agricultural research scientists, administrators, and donors as tools to strengthen the research capability of national agricultural research systems (NARSs) and to identify, address, and solve farmers' problems. An effective network will overcome isolation, facilitate sharing of research information and ideas, help reduce unnecessary duplication, provide the critical mass of effort needed to give quick answers to pressing problems, and hasten scientific breakthroughs. Inappropriate reliance on networks by NARSs can over extend their scientists and upset national priorities. ARNETs have five important components: membership, research, coordination, communication, and assets that interact with each other. Networks are dynamic and responsive to changing needs in agricultural systems. There are many types of ARNETs depending on the problems that need to be addressed, the membership and its requirements, the extent of coordination available or needed, the research strategy developed, and the assets available. The author shares in this book the results of his search to understand the workings, benefits, costs, and pitfalls of networks and he provides information from his own experience and that of others to help those wishing to organize and operate ARNETs.

Résumé

Référence : Faris, D.G. 1991. Réseaux de recherche agricole en tant qu'outils de développement : avis d'un coordinateur de réseau. Ottawa, Canada : Centre de recherche pour le développement international, et Patancheru, A.P. 502 324, India : International Crops Research Institute for the Semi-Arid Tropics.

Un Réseau de recherche agricole (ARNET) constitue un groupement de chercheurs ou d'institutions relié par un intérêt commun de travailler en dépendance ou en interdépendance sur des problèmes identifiés et partagés. Les ARNETs sont exploités par des chercheurs, des administrateurs et des bailleurs de fonds en matière de recherche agricole, en tant qu'outil pour le renforcement des moyens de recherche des systèmes nationaux de recherche agricole (NARS). Ils servent aussi à identifier et à résoudre les problèmes des exploitants agricoles. Un réseau efficace permet aux membres d'échapper à l'isolement, de partager des idées et des informations de recherche, de réduire la duplication inutile du travail, et fournit la masse critique d'efforts nécessaires à l'identification immédiate des réponses aux problèmes urgents, permettant ainsi d'accélérer des progrès spectaculaires. La dépendance inopportune à l'égard des réseaux par les NARSs peut surcharger leurs chercheurs et déséquilibrer les priorités nationales. Tout ARNET comporte cinq composantes principales : l'abonnement, la recherche, la coordination, la communication, et des avoirs en interaction. Les réseaux sont dynamiques et répondent aux besoins changeants au sein des systèmes agricoles. Il existe plusieurs types d'ARNETs selon les problèmes à traiter, les membres et leurs besoins, l'étendue de la coordination disponible ou nécessaire, la stratégie de recherche élaborée et les avoirs disponibles. Dans ce livre, l'auteur met à notre disposition les résultats de ses travaux visant à comprendre le fonctionnement, les bénéfices, les coûts et les pièges des réseaux. Il fournit des informations tirées de sa propre expérience ainsi que celle des autres afin d'aider tous ceux qui désirent organiser et opérer des ARNETs.

Agricultural Research Networks As Development Tools

Views of a Network Coordinator

D.G. Faris
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The International Development Research Centre is a public corporation created by the Parliament of Canada in 1970 to support research designed to adapt science and technology to the needs of developing countries. The Centre's activity is concentrated in six sectors: agriculture, food, and nutrition sciences; health sciences; information sciences; social sciences; earth and engineering sciences; and communications. IDRC is financed solely by the Parliament of Canada; its policies, however, are set by an international Board of Governors. The Centre's headquarters are in Ottawa, Canada. Regional offices are located in Africa, Asia, Latin America, and the Middle East.

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Contents

To my father

who had a deep and abiding love

for the world's least fortunate farmers

Foreword

Advances in scientific knowledge depend, in large measure, upon researchers having access to current information. Since modern scientific inquiry began, scientists have sought ways to make their communications more effective and have developed various mechanisms to achieve this, for example, by publishing scientific journals, creating learned societies, and participating in scientific conferences.

As knowledge becomes more specialized and the problems tackled by scientists more complex, so the need for greater communication and collaboration increases. The term "networking" has increasingly been used to describe the various arrangements and mechanisms developed to meet scientists' needs both for a timely and accurate exchange of information and ideas and for forging closer links for collaborative research.

In recent years, networking has come to be regarded as indispensable to the efficient conduct of scientific research, whether national or international and regardless of the level of economic development of the country or countries involved. In no field are research networks more important, or offer a greater potential for increasing research effectiveness, than in applied agricultural research. This is particularly true in less developed countries where research networks can contribute greatly both to breaking isolation among scientists and, through sharing of information and research tasks, to a more efficient use of scarce resources.

The International Development Research Centre (IDRC), since its establishment by the government of Canada in 1970, has devoted a significant percentage of its budget to the creation and support of research networks. About 75% of the budget of the Agriculture, Food and Nutrition Sciences Division of IDRC is granted either to institutions in developing countries for research linked to networks or for direct funding of mechanisms to coordinate networks.

We are pleased to be associated in publishing this book on agricultural research networks. The publication is based both on the personal experience of Don Faris as a practicing network coordinator, and on the knowledge and insights gained during his recent sabbatical leave from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) during which he was able to observe many different research networks around the world. Although he does not attempt to critically review all the networks visited, the author does draw useful general conclusions and makes recommendations with respect to the effective operation of research networks in general, and collaborative agricultural research networks in particular.

We believe that this publication constitutes a useful addition to the growing literature on research networks and we are confident that it will prove to be of considerable value to a wide range of people involved in such networks—from participants, coordinators, and research leaders to those in organizations that fund research.

Geoffrey Hawtin
Director, Agriculture, Food
and Nutrition Sciences Division

Preface

Recently, interest in the use of networks has mushroomed, and many people want to know how networks are organized and operated and what they can do. I have an intimate interest in networks because, since 1986, I have been coordinator of the Asian Grain Legumes Network (AGLN) supported through the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). In 1987-88, during a year's study leave, I had a chance to stand back from my duties and look at networks in a broader perspective.

This book arises from my study and is written because of a demand for more information about networking. Other books and many articles have been written about networks. However, as far as I am aware, this is the first book written from the viewpoint of a network coordinator. I hope it provides new insights into the subject. The principles of agricultural research networks have been applied for several decades, but the use of the term "networks" and attempts to characterize them more precisely became common only in the 1980s.

As a plant breeder, I have been involved in collaborative agricultural research since the mid-1950s when I was at the Regional Research Station at Samaru in northern Nigeria. There, each year, the research scientists held a coordination conference with agricultural officers who were conducting research at stations throughout the region. Results of their experiments were shared and a research plan for the next year was agreed upon. This meeting permitted feedback from the agricultural officers about farmers' problems. I also had contact at Samaru with staff of the Empire Cotton Growing Corporation that supported collaborative cotton research throughout the British Commonwealth.

In the 1960s and 1970s, I was involved in the cereal and oilseed advisory committee, later called an expert committee, in Canada, organized by the National Research Council. This was one of several committees that brought together scientists from federal and provincial agricultural research organizations, universities, and private industry in Canada to share their research results, develop plans for uniform nurseries and collaborative trials, and provide advice to the government in such matters as release of new varieties, and research and educational requirements. While in Canada, I also participated as a cooperator in the international wheat nurseries of the Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT).

In 1980, I became involved at ICRISAT in coordinating international nurseries for pigeonpea. The outreach activities involved few formal meetings with national scientists and, hence, did not always provide the most appropriate material for each national program.

The ICRISAT board, with encouragement from certain donors, proposed in the early 1980s an initiative to upgrade contacts with national programs. This initiative resulted in meetings in December 1983 and again in 1985. On the recommendation of representatives from throughout Asia at these meetings, the Asian Grain Legume Program was established in January 1986, and I was appointed coordinator. Before the end of the year, this had officially become the Asian Grain Legumes Network (AGLN) in line with the Consultative Group on International Agricultural Research (CGIAR) and ICRISAT's growing interests in networks. As coordinator, I was responsible for constructing a network that would meet the needs of legume scientists in Asia based on the expertise, material, and technology available at ICRISAT.

In mid-1987, I began a study leave to examine the operations of networks and look for ways to strengthen AGLN. The International Development Research Centre (IDRC), because of a long-standing interest in networks, offered to help support this study, which included visits to London, Ottawa, Washington, Mexico, Costa Rica, Peru, Colombia, Niger, Burkina Faso, Zimbabwe, Malawi, Kenya, the Philippines, Thailand, and Hawaii. During this travel, most of the networks and regional programs I looked at were supported by IDRC or ICRISAT.

I also spent about 4 months at the International Rice Research Institute (IRRI). I assisted IDRC in holding a network coordinators' review at Nairobi, Kenya, and attended two meetings on coordinating activities among networks.

For this study of networks, I had planned to develop a questionnaire, but the array of factors involved was too large and varied to be easily categorized so the idea was not used. Rather, I have drawn on the literature and on items emphasized during discussions with those I visited, including network collaborators in national programs. The number of interviews with national collaborators was fewer than I wanted for many reasons. Given another chance, I would give greater stress to this type of activity to ensure a more balanced input from national scientists.

I want to thank ICRISAT and Drs L.D. Swindale and Y.L. Nene for giving me the opportunity, and IDRC (especially Drs Geoff Hawtin, Gordon Banta, and Andrew Ker) for providing support. I also want to thank IRRI (particularly Dr V.R. Carangal and IRRI staff) for providing facilities at Los Banos and giving me access to information on the international programs at IRRI. I also owe gratitude to Drs D.L. Plucknett, N.J.H. Smith, and S. Ozgediz, and to Dr C. Valverde, for sharing with me their manuscripts on networks before these had been published. I am also indebted to the staff of the many institutions I visited during the year. They all openly discussed their activities.

I am deeply grateful to the late Amy Chouinard for her expert revision and restructuring of my text.

D. G. Faris
Coordinator, Asian Grain Legumes Network

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Introduction

Recently, networking has attracted attention as a way to use facilities and staff more effectively. It is used to avoid duplication of effort and to engage, at relatively low cost, a critical mass of personnel in research to solve specific problems. It is not new: coordination, collaborative research, and sharing of information and material among scientists were used before World War II in agricultural research organizations in many developed countries (Remenyi 1987; Plucknett et al. 1990a). Today, networking is seen as a tool also to strengthen agricultural research in developing countries. International donors and many others, seeing the value of networking as a tool for agricultural research, have become interested in determining the elements needed for success and the hazards to be avoided.

To assist in identifying the characteristics of a good network, this book takes a look at how some networks are organized and how they operate. It is addressed to research scientists in national programs who could join a network as a way of increasing contacts with their peers in other countries and in international institutes. The book explains what other benefits they might expect and how these could strengthen their personal scientific capabilities and upgrade their research.

The book is also addressed to national program administrators who must consider the pitfalls to their national programs of becoming involved in networks: the effect networks can have on national research priorities, the time national scientists will be expected to spend away from their regular programs when involved in network activities, the resources they will need to commit for network activities, and the possible partial loss of control over their research program. These must be weighed against the benefits the networks will bring in the form of new ideas and technology, contacts with other programs, and the strengthening of the national agricultural research system (NARS).

It is addressed to staff at institutions with international responsibilities for research, particularly the international agricultural research centres (IARCs) who see networks as a means of expanding their information bases and of sharing their material and information with their peers in national programs. The contents should provide them with suggestions for forming links with national program scientists that will help strengthen the NARSs as well as providing a way of making their own research programs stronger and more appropriate.

The book offers donors and sponsor groups a look at the pitfalls as well as the expected benefits from networks and suggests how to support networks so that they receive the greatest return on their investment. It addresses the interests of all these groups because a successful network serves them all.

This book has been written from the point of view of a network coordinator, and many of the examples are taken from my experiences in this role. Looking at networks from a coordinator's viewpoint has merit because a coordinator's responsibility is to understand the needs of participants and to propose and implement courses of action that serve the needs and unify the group. The examples that follow reflect my experience and contacts and may not be the best available.

Costs and Benefits

Networks are not a panacea (SPAAR 1987b). There are costs, and there can be problems associated with them (Plucknett and Smith 1984). From the perspectives of different participants in a network, a benefit to one party may be a cost to another. Although networking may save on research costs, it demands a commitment of resources, including staff, by all participating organizations. Commitments to network activities may distort a country's research priorities and put a strain on national scientists to the detriment of their research programs, especially when they become involved in more than one network (Plucknett and Smith 1984).

I have found that looking at a network's objectives can help to put its costs and benefits into perspective. A group of experienced network coordinators meeting in Nairobi, Kenya, in 1988 (Faris and Ker 1988) proposed that networks aim to:

- Strengthen the applied research capability of NARSs to identify, address, and solve farmers' problems;
- Generate appropriate technology by using existing research personnel, facilities, and other resources more effectively;
- Ensure stability of agricultural production through a responsive research capability; and
- Provide the support, both technical and financial, needed to facilitate the coordination of activities on a regional basis.

This group of coordinators placed strengthening NARSs as the first objective, and any network activity that does not do this may be considered a cost rather than a benefit. Networks benefit NARSs both by strengthening the research program directly associated with the network and by improving members' ability to do research in other programs. In networks, NARS programs become part of the critical mass needed to provide break-throughs. A good example is the Trypanotolerance Network, which has quickly identified animals that can flourish despite being infected with trypanosomiasis (ILCA 1986). This was possible because the Network was able to share existing solutions to the problem originally known by only a few members.

NARSs can be strengthened just by being involved in the activities of a network. For example, learning from the network research-planning procedures or being involved in an interdisciplinary team on a research project. They can also benefit from being involved in the site characterization associated with networks such as the International Benchmark Sites Network for Agrotechnology Transfer (IBSNAT), which encourages adaptation and transfer of research results from a site where research results are being generated to similar sites elsewhere (IBSNAT 1986).

The research programs of participating NARSs can be particularly strengthened in networks where each member takes responsibility for conducting a component of the strategic research program and receives support to carry out the research. This is clearly demonstrated in Programa Andino Cooperativo de Investigacion en Papa (PRACIPA): researchers from Bolivia agreed to develop simple methods for farmers to produce seed potato; those from Colombia worked on control of the Andean weevil; Ecuador on rapid multiplication of virus-free seed potatoes; Peru on integrated pest management; and Venezuela on integrated control of *Scrobipalpopais solanivora.*

In general, networks do not build facilities specifically for their activities nor do they employ many permanent staff; thus, they can change research directions easily as new, more important problems are identified by participants as has been amply demonstrated by the flexibility of the Asian Rice Farming Systems Network (ARFSN) to adjust existing projects and add new ones. They may even close down. An example of a network that disbanded when it had met its objective is the Consumer Preference Network Studies on Cowpeas in West Africa, organized to collect information needed to improve cowpea processing and promote cowpea use in West Africa. Institutions from three countries came together in 1973 to plan their activities, met in 1974 to discuss their progress and make necessary adjustments, and in 1975 to collate their results and prepare a final report (Steckle 1975). All three countries got more from the program than any one doing it alone. The broad base also meant that the results could be generalized to other countries in the region.

Most networks, however, have been very stable, and over time the NARS's responsibilities in each network has steadily increased. An obvious example of this is the Programa Regional Cooperativo de Papa (PRECODEPA) network (Valverde and Brown 1985). This has given the NARSs a chance to increase the overall ability of their staff.

Clearly, networking strengthens a NARS's scientists, reducing their isolation within even their own country. Not only do network scientists have a chance to meet their peers in their own disciplines but they make contact with scientists of other disciplines. Network activities, such as workshops, give them a chance to share ideas and results, interact with international experts, and broaden their outlook (Dupont 1983).

Being associated with a network can provide a forum for national scientists to publish their research results, enabling them to contribute to related newsletters, proceedings, etc. Their association can provide access to sophisticated research equipment and extensive library and literature-search facilities. It also may prompt provision of courses at IARCs to improve the participants* skills for contributing to the network's research (IRRI 1980; Bunting 1985; Breth 1986). For example, Red de Investigation en Sistemas de Production Animal en Latinoamerica (RISPAL) brings together scientists to analyze their data under the guidance of statisticians.

For their part, IARCs view networks as an ideal means for solidifying their partnerships with national scientists (Baum 1986). IARCs often use networks to channel technology to NARSs for use by farmers (Denning 1985). Good examples are the international nursery trials of wheat and rice that formed the basis for the Green Revolution (Borlaug 1983; Dairymple 1985). Networks also directly benefit the IARCs' research programs by providing a way to test material under a wide range of conditions and by encouraging feedback from NARSs, national scientists, and even farmers. The partnership between IARCs and

NARSs demonstrates the value of multidisciplinary research and may foster similar approaches at the national level (Flinn and Denning 1982).

Donors see networks as an aid in allocating their funds (USAID 1972)—to identify high-priority problems, direct assistance to specific, well-organized targets, and reduce duplication of effort (ISNAR 1987b; SPAAR 1987a). Networking is used by some donors (the International Development Research Centre (IDRC) is an example) to bring together staff from projects with similar themes to benefit from each other's experience (Nestel et al. 1980).

Ultimately, farming families and urban dwellers of the developing world should benefit. They are the raison d'etre for the efforts to develop and distribute appropriate technology that can overcome constraints to high and sustained food production (ISNAR 1987b; von der Osten 1987). A strong agricultural economy allows the residents of such countries to contribute effectively to their society.

The costs of achieving these benefits (Plucknett et al. 1990a) are not only the expenditure of funds, time, and effort but also the problems and losses that at times result from involvement in networks.

The activities rarely require that NARSs build new facilities or hire new staff but rather that they commit existing staff and facilities—in most cases, more than just the time and effort to do research. Time must be freed up for travel, attendance at network meetings, workshops, monitoring tours, and training and preparation of reports for the network. Some networks expect managers, as well as scientists, to be involved in the network planning, and certain networks expect NARSs to provide network coordinators and support staff on a rotational basis (Valverde and Brown 1985).

In some networks, NARSs are expected to bear the costs of hosting network workshops and training programs. Even with external financial assistance, the time devoted by staff for these programs can be a considerable cost. When agreeing to become involved in a network, officials for each NARS usually are asked to arrange easy movement of personnel, equipment, and research materials into and out of their country, and at times they give expatriate scientists special privileges such as tax and import privileges. In addition, they may seek tax-free entrance of equipment and material associated with the network; usually the cost to their government is offset by the equipment, which eventually belongs to the NARS.

When NARSs participate in networks, they relinquish some control over their research agenda and may even have to dedicate key researchers to work that does not address their priorities. In fact, a network with strong financial backing may entice researchers to abandon research with weak support and may, thus, distort the NARS's priorities. The danger increases with any increase in the number of networks with which a NARS is involved. NARSs should, therefore, carefully consider and choose the networks in which they become involved and not be enticed by donors to accept inappropriate networks. A good guideline is whether the NARSs will eventually be able to integrate, and fully support, the network activities into their own programs.

Also, large NARSs can dominate a network and can quickly absorb all the network's resources. Network planners must ensure weak NARSs benefit most from a network even though they get a smaller proportion of the total network's resources than do large and strong NARSs. Sharing resources fairly in a network is a challenge. For example, in the Asian Grain Legumes Network (AGLN), India and China could easily dominate countries such as Nepal and Sri Lanka.

The commitment of time and resources to network activities reduces the time for the scientists' own research and increases with the numbers of networks in which the scientists participate. Although they may gain recognition in, for example, the publication of results or the appointment to a network committee, their contribution as part of the whole group may go unrecognized. This often happens to scientists involved in international trial nurseries who are growing varieties to identify superior traits at many locations. Individuals become one of a large number of collaborators and may feel that they are poorly paid staff of an IARC. This anonymity can be overcome somewhat if collaborators receive recognition when contributing material to the trials.

IARCs normally provide a network coordinator and support staff and much scientific backstopping. They also provide the network's administration, operation, and communications, including workshops, training, participants' travel, and publications although the costs of these activities are often covered by special funds from donor agencies.

IARCs must be prepared to hand over to NARSs the responsibility for research that currently falls within their mandate, as the NARSs demonstrate their ability to do the research (CGIAR 1987). IARCs must adjust their research plans to continue to support and strengthen the research programs of the NARSs. In collaborative network activities, IARCs need to give full credit to NARSs for their input into the network. For example, IARCs must encourage NARSs to use country designations for improved lines. IARCs may hesitate to share this recognition for fear of losing funds from donors, but most donors are now looking for signs that IARCs are making a difference to NARSs. NARSs can help by publicly recognizing assistance and material given to them by the IARCs.

Donors provide funds to groups other than IARCs to coordinate network activities, such as the Executive Committee of PRACIPA or the regional program for beans in Africa (Kirkby 1988b). In some cases, they direct funds to regional institutes, such as the Inter-American Institute for Cooperation on Agriculture (IICA), which has been funded by IDRC to coordinate RISPAL network (IICA 1986a,b). Donors may dedicate their own staff to coordinate networks (Nestel et al. 1980) but often they provide support through an IARC (Seshu 1988).

Normally, research activities are funded by NARSs, either from their operational budgets or from special bilateral projects. In some cases, NARSs do not have adequate funds, and the progress of research in the network is hindered. To overcome this problem, donors often set aside small sums for network coordinators to use to ensure continuity in the research.

Although networks are promoted because they can effectively and inexpensively bring together an interdisciplinary critical mass of research effort, they may pay a price in terms of research efficiency arising from less accountability of scientists to the network than to their own administration and because network scientists are more scattered. In many developing countries, the shortage of well-trained staff causes instability in networks, as individuals fill vacancies or move to higher, unrelated positions.

There needs to be an evaluation of the cost-benefit ratios of using well-funded multidisciplinary institutes compared with networks for providing answers to problems. I believe the effectiveness depends on the importance of the problem to be solved and the clarity of the research objective. In addition, networks are probably more effective in tackling problems that are straightforward and limited and where the objective is time bound. They are also probably more cost effective in disseminating research results over a wide area than if done at isolated institutes.

The return on investment in networks needs to be compared with that for similar investments in IARCs or in NARSs although I believe that the three complement each other and that all should be supported. In the long term, each NARS must be able to provide the agricultural research needed for its country. This is why IARCs, donors, and networks alike aim to strengthen NARSs. IARCs fill the research gap until NARSs are fully capable of conducting their own research. The IARCs continually move upstream to do research that the NARSs are not yet capable of doing. The networks support both NARSs and IARCs and tie their research together.

In some cases, networks have fulfilled the role an IARC would play. For example, in West Africa, networking among francophone countries has received support from France in preference to the setting up of an international research centre in the region. Conference des responsables africains et francais de la recherche agronomique (CORAF) was organized in 1986 after a series of meetings on research and technical cooperation (Schilling 1988). Under its steering committee, CORAF encompasses research networks covering maize, rice, groundnut, cassava, and drought resistance. The participants seek to:

- Facilitate the development of their NARSs so that they acquire a regional or international dimension;
- Provide the conditions for cooperation among regional and international organizations; and
- Identify priorities for research in each network and for which support can be sought from international sponsors.

By July 1988, 15 francophone countries plus France had participated in CORAF, and plans were in place to bring in others. In fact, staff in the groundnut network invited International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)—more specifically one of its scientists working on groundnut—to attend a network meeting in Dakar in March 1989 as an observer.

The groundnut network is organized around a general assembly with one representative from each country. The assembly is supported by a permanent secretariat responsible for coordination, exchange of information, organizing meetings, network representation to organizations such as other international centres and donor groups, and publishing a semiannual newsletter. This coordination is carried out by Institut senegalais de recherches agricoles (ISRA) in collaboration with Institut de recherches pour les huiles et oleagineux (IRHO).

Similarly, the aquaculture networks (Pillay 1987), the network covering banana and plantain (INIBAP 1987), the oilseeds network for East Africa and South Asia (Omran 1988), and the bamboo/rattan network (IDRC 1986) have acted as proxies for international centres. In other cases, such as the cassava research network, IARCs eventually took over the operation of the network (Nestel and Cock 1976).

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Collaborative Agricultural Research Networks (CARNETs)

Definition

A general definition of agricultural networks is difficult because of the diversity of purposes, forms, and operations. Banta (1982) suggested that an agricultural research network is "... a voluntary association of research organizations with sufficient common objectives to be willing to adjust current research programmes and invest resources into network activities in the belief that they will meet their objectives more efficiently than conducting all research alone."

Based on Plucknett and Smith's 1984 article, Dzowela (1988) brought in the scientist with the definition "... a cluster of scientists or institutions linked together by a common interest in working dependently or inter-dependently on a shared problem or problems." Valverde (1988) broadened the concept even more: "In the broadest sense, Agricultural Research Networks (ARNETs) link individuals or institutions with a shared purpose into some form of collaborative effort ".... Viewed as a particular system, an ARNET is 'an assemblage of NARS, or parts of them, programs, projects, or individuals which take a collaborative cooperative format to accomplish a set of common goals'".

I wish to propose a simple definition that should take in all forms of agricultural networks, including information networks, collaborative research networks, and those that include on-farm trials and extension of technology to farmers.

> *An agricultural network is a group of individuals or institutions linked together because of commitment to collaborate in solving a common agricultural problem or set of problems and to use existing resources more effectively.*

This definition includes scientists, technicians, extension workers, and farmers as well as institutions—national, international, or regional—donors, government agencies, and agribusinesses.

Network Types

The ways networks are classified depend on the purpose of the classification. People studying dynamics and management may classify networks according to the level of involvement of the different "actors;" scientists may classify them on the basis of commodity, production system, or discipline; administrators may classify them on the basis of priorities and commitments; whereas donors may classify them on the basis of criteria for support. Classification to meet any of these purposes is not simple; networks vary widely and are dynamic. They can shift from one classification into another in short periods.

The classification that was considered a breakthrough in grouping networks (Plucknett et al. 1990a) and has been the most widely reported (World Bank 1987; Faris 1988;

Valverde 1988) was the one proposed by Ralph Cummings, Jr. and Calvin Martin to the Special Program for African Agricultural Research (SPAAR) (SPAAR 1987a,b). Their system is based on the level of research in the network and the degree of collaboration used to plan and conduct research. The continuum in this classification runs from networks simply moving literature from a central source to interested recipients to networks where all members plan together and execute their activities in a completely collaborative manner.

To clarify the differences, they broke the network continuum into three:

- Type I—Information Exchange facilitates simple exchange of ideas, methodologies, and research results;
- Type II—Scientific Consultation allows individuals or groups to focus on a common problem, conduct their research independently, and share their results at common meetings; and
- Type III—Collaborative Research provides joint planning and monitoring of a common research problem (SPAAR 1987a,b).

Plucknett et al. (1990a) have refined this classification further by separating the technology base of ARNETs into information exchange, material exchange, and research, and the planning base into independent and joint. Their classification more clearly indicates the level of shared participation in planning and by implication in operation of a network.

Examples of networks

Information and material exchange networks are relatively cheap and easy to establish. They range from a one-way exchange of information, such as the abstracting network of the Sorghum and Millets Information Center (SMIC) at ICRISAT that compiled lists of annotated references that were distributed to over 1000 members. It provided free basic information needed by developing country sorghum and millet researchers. The African Livestock Policy Analysis Network (ALPAN) at the International Livestock Centre for Africa (ILCA) provides a two-way "postal seminar" for exchanging ideas on livestock development policy among members through a newsletter (ILCA 1985).

Many of the IARC-based international nurseries started as essentially independently planned material exchange networks. As these networks evolved, they gradually added more input from the NARSs into their planning, some more so than others. One program that has maintained a fair amount of independent planning for the IARC involved is the maize improvement program at Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT) (Sprague and Paliwal 1984). Despite this independence in planning, the program has adjusted well to the needs of the NARSs through feedback of results, adjustments in nurseries to provide the best populations, and the design of new nurseries to fit more refined ecological requirements. This program has maintained close contact with NARS maize scientists trained at CIMMYT. NARS scientists independently select material for their own programs from the material supplied to them in the nurseries. This program also has contact with NARS scientists through the CIMMYT regional maize programs throughout the world.

The International Rice Testing Program (IRTP) (recently renamed International Network for Genetics Evaluation of Rice (INGER)) at International Rice Research Institute (IRRI) is a centre-based material-exchange network that started with virtually all material being supplied by IRRI breeders. It evolved, and now 70% of the lines are submitted by NARS scientists (IRRI 1980; Seshu 1988). Any promising material in the nurseries is used in the breeding programs both at IRRI and in the NARSs. The network involves about 800 rice scientists from more than 70 countries. Representatives of the member countries serve on an advisory committee to assist in program planning and implementation. These representatives also participate in planning the network's breeding strategies during the IRTP-sponsored monitoring tours.

Research networks with completely independent planning are rare, as are those with completely joint planning. Most research networks fall between the extremes.

An example of a research network with mainly independent research planning is the oilcrops network for East Africa and South Asia. This network was organized because international research support for this group of crops has been relatively small (Omran 1988). As a group, oilseed crops are important but, individually, most are minor crops and are neglected. The network strengthens research on these crops by facilitating exchanges of material and scientists. The network is now encouraging more collaboration in research by organizing subnetworks based on species groups. The first one operating is the Brassica subnetwork (Omran 1987).

In some cases, such as RISPAL, there are a group of independently planned and run projects that are joined together by a common research methodology. In RISPAL, projects are related to different animal-production systems and the participants use a common method to identify problems and analyze results.

In the West African Farming Systems Research Network (WAFSRN), scientists formed a professional society that now operates as a network. After its inception, the network was strengthened by input from the Semi-Arid Food Grain Research and Development Project (SAFGRAD) and by the addition of a full-time coordinator. The network aims to strengthen independently planned farming-systems programs (Faye 1988).

ARFSN has a strong methods component. The members use a common methodology and plan collaborative trials, especially for the development of component technology for use by the network (Carangal 1985; Carangal and Guo 1987). All these networks have active coordination and communication components (see next section).

Red Internacional de Evaluacion de Pastos Tropicales (RIEPT) is an example of a network where all activities are jointly planned (Toledo et al. 1984). This network has a series of regional trials using uniform methods. The first set are observation trials of pasture species sent out by Centro Internacional de Agricultura Tropical (CIAT); next are clipping trials, grazing trials, and feeding trials (animal responses) (CIAT 1987c). Recently, on-farm evaluations have been added and the network has become popular and productive, with more than 200 scientists attending planning meetings. One of the grasses identified by the network *(Andropogon gayanus)* is now grown on about 300 000 ha in tropical America. Because the network has become so large, covering 115 sites in 15 countries, it has recently been split into four ecological sections, each with a full-time coordinator (CIAT 1987d).

Another network that is jointly planned by members is PRACIPA, which has been modeled after PRECODEPA (Valverde and Brown 1985). To start PRACIPA, the directors of five Andean countries met with representatives of Centro Internacional de la Papa (CIP) in 1982 and identified 16 priority problems. From this list, the directors chose the five top priorities for research by the network. They then assigned one problem to each country, based on the importance of the problem in the country and on the country's comparative advantage for doing the research needed. They arranged for financial assistance to carry out the research. The PRACIPA coordinator is selected from one of the five countries and planning is done by a committee composed of the chief research administrator from each country interacting with a technical committee composed of scientists representing each country. The interaction ensures that each project is technically strong and is supported administratively as part of the national programs.

CARNET components

Much of the book focuses on five major components of networks and how they interact and relate to the evolution and development of a network. These components are research, coordination, communication, membership, and assets. They form the essence of a network and each is vital to its successful functioning.

Research is the component around which collaborative agricultural research networks (CARNETs) are organized. This component covers a broad spectrum, including information and literature; research per se, conducted independently or collaboratively by network members; the products of research, such as new technology or crop varieties; methods; socioeconomic analyses; and databases. How these activities are dealt with in CARNETs is a key to the merits and weaknesses of networks in strengthening research initiatives.

Virtually all the most effective CARNETs rely on a coordination unit to organize and harmonize the network activities. This unit usually consists of a coordinator and one or more steering groups that have a variety of names and functions. These steering groups represent the members' needs and wishes; they guide and direct the activities of the coordinator. The coordination unit plays a vital role, and it represents a major expense associated with networks, the effectiveness of which depends on its relations with participants in a network. Ways of making the relations work can be gleaned from examples of successful networks (see Chapter 3 and Appendix 1).

Links and communication tie a network together. The communications component enables the interchange of information and material through correspondence, telecommunications, visits, meetings, workshops, training, and publications. All are relatively expensive so usually require special funding.

The membership component is the body of a CARNET; the members produce and draw on the information and databases of a network. Members can be scientists or administrators from national and international programs, from developed countries, and from donor groups. In some networks, whole projects, institutions, or NARS are considered the members. All members should feel that the network and its activities are designed for them personally.

The assets of a network include the members and the facilities and resources available to its members plus the external finances to support its activities. This component derives value from the other components and is an integral part of them. The sources and use of assets strongly affect the way networks are organized and operate and in turn networks can serve as a means for channeling funds for research support.

Network structures

The structures of networks—how their components and entities are linked and how *they* interact—explain much about their functioning and dynamics, which, in turn, suggest the elements that encourage success.

Organizational charts are widely used to quickly show an organization's structure and the relationships among its various parts. Networks have been depicted graphically in several ways and can be represented so that their strengths and weaknesses are elucidated. The depictions or models can also help clarify differences among networks.

One simple diagram that was used to depict the African bean network (Fig. 1) linked a series of circles. It gave some indication of the relationships of the entities and groups in

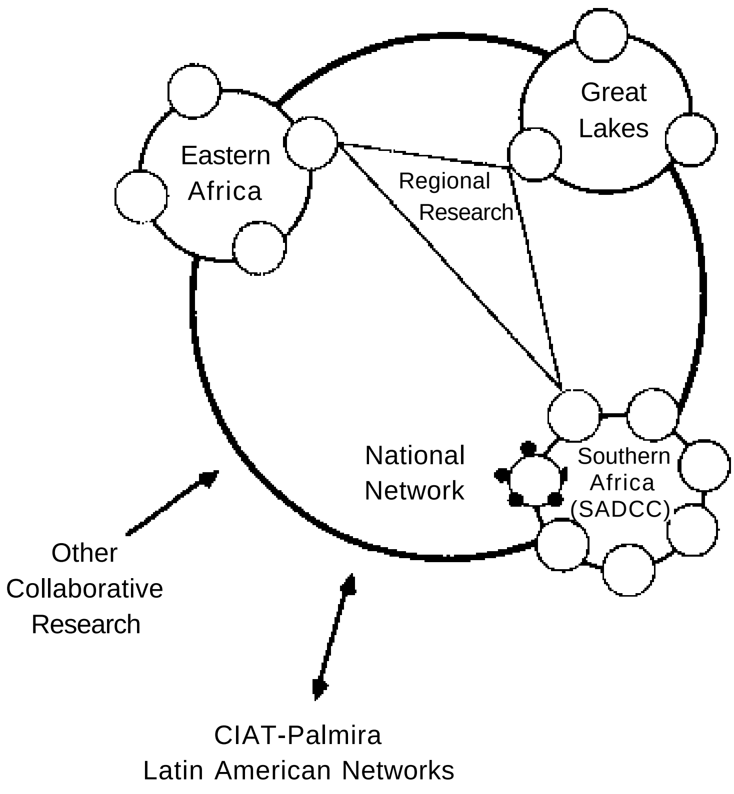

Fig. 1. The interconnections (rims) of the African bean network, with the first order being the pan-African rim, the second order being regional rims, and the third order being NARS rims. Some indication is also given of connections outside the network (Kirkby 1988b).

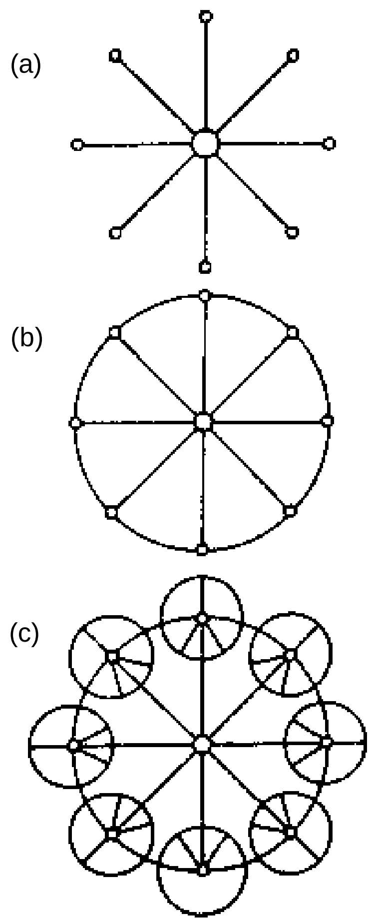

Fig. 2. A wheel-like depiction of networks, showing the coordinating hub in the centre, the spokes linking the nodes (a), the rim joining the nodes (b), and the nodes forming research units or subnetworks (c) (CGIAR 1983).

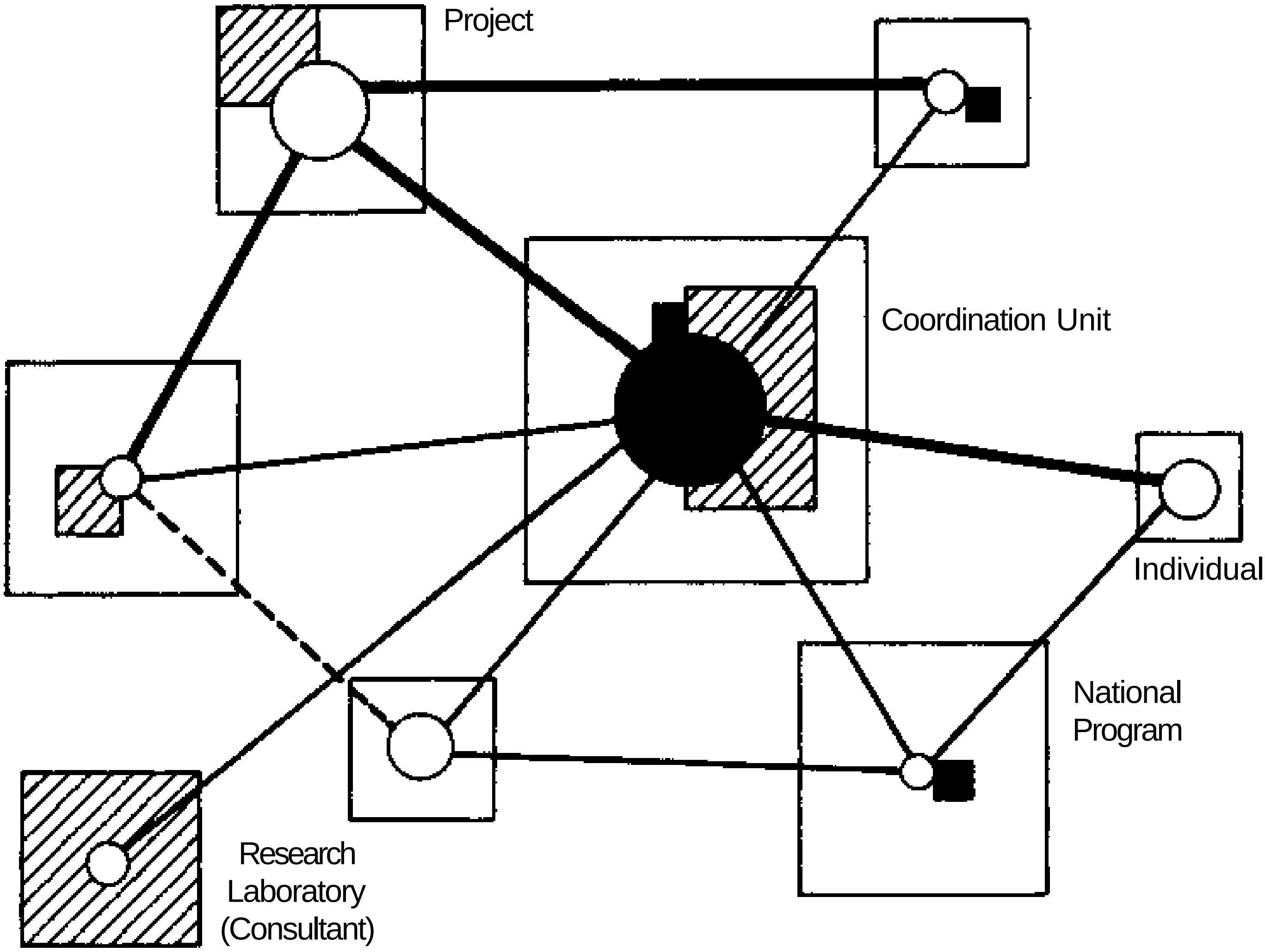

Fig. 3. A scheme for graphically representing collaborative networks, with the size of the elements indicating their relative extent: ▨ collaborative research carried out with joint planning; ▢ independently planned research associated with the network; ■ research undertaken for the network; ○ coordination component, embedded in the research component, the contact interface in each entity; ● coordination unit; ━ links through communications. Entities can be NARSs, regional and international institutes, laboratories and consultants in developed countries, projects, or individuals.

the network but little information about the functioning of the different network components.

An attempt was made to indicate the coordination and communication functions in a simple wheel-like model, which was presented to the directors general of the Consultative Group on International Agricultural Research (CGIAR) in 1983 (CGIAR 1983; Baum 1986; Plucknett et al. 1990a) and is still the most widely used depiction of networking. The "hub" represents the coordination unit, which is connected to the network "nodes" through "spokes" (Fig. 2a). The spokes represent the communication component, the nodes the membership component. A node may be an individual, a research project, an institute, or a NARS. In a simple information-sharing network, the movement can be one way from the hub to the node but in, for example, a material-exchange network, the movement is two way. If the network also includes communication directly between nodes, through such devices as workshops, monitoring tours, and correspondence, then the network is seen as having a "rim" (Fig. 2b). The rim is also part of the communication component. All networks that plan jointly have a rim. In most collaborative agricultural research networks, the nodes are also hubs with spokes to cooperative research units (Fig. 2c); these setups can be found in countries like India (Randhawa 1979; Desai 1982) and Chile (Bonilla and Cubillos 1987) or with subnetworks such as the Brassica subnetwork of the oilseed network for East Africa and South Asia or the Groundnut virus subnetwork or working group of the AGLN (Faris and Gowda 1989).

I believe there is much to be gained by graphically representing greater detail about how the main network components are associated with each other (Fig. 3), depicting the members' and coordination unit's contribution to the functions or activities of the networks—research, communication, and coordination. The relative amount of network research being carried out in each entity or module in connection with the network can be represented by the size of the box around the entity. The coordination component is embedded in the research and in the communication links attached to coordination. This does not mean that all communication must pass through an individual or unit identified for coordination in each network entity. Rather, coordination can be achieved even when two research scientists merely discuss ideas or results directly with each other.

Diagrams can differentiate networks reasonably well. In, for example, the simple information network between SMIC at ICRISAT and its cooperators (Fig. 4), SMIC collects

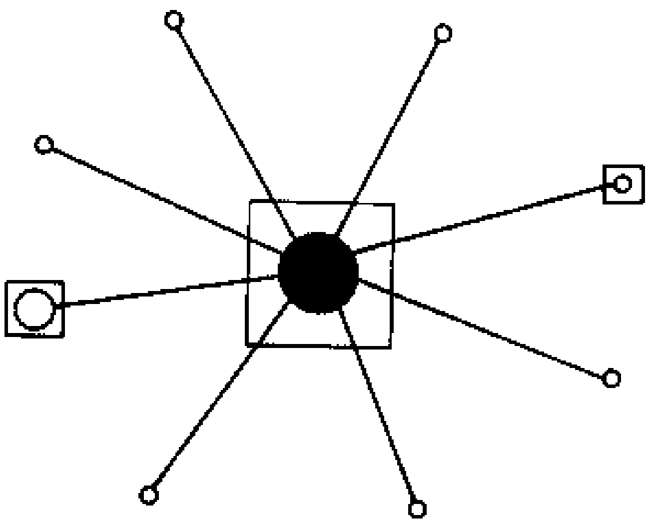

Fig. 4. An information network such as SMIC. (Legend of symbols shown in Fig. 3.)

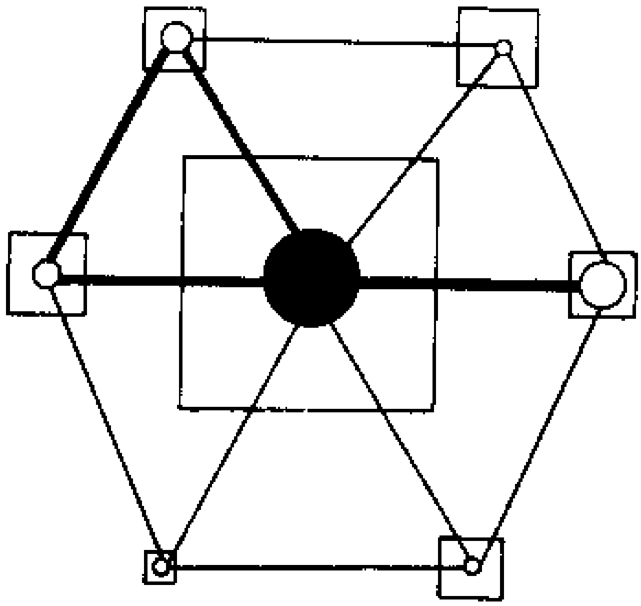

Fig. 5. A simple international yield nursery, represented on a smaller scale than Fig. 4. (Legend of symbols shown in Fig. 3.)

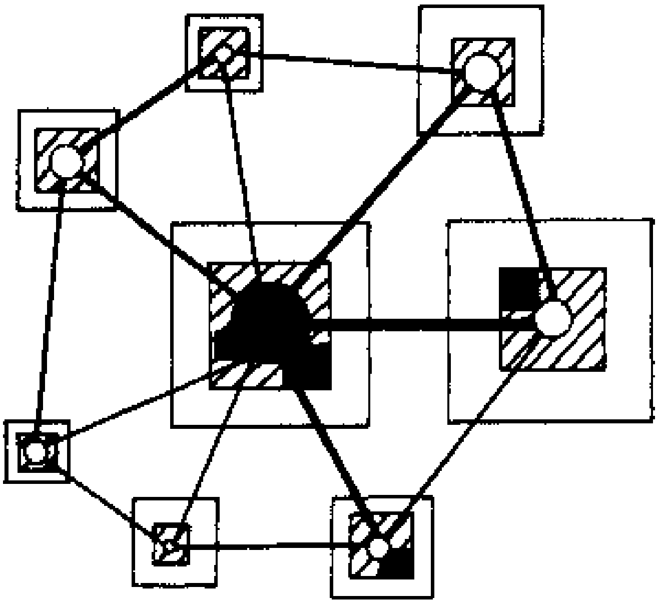

Fig. 6. The international rice testing program of IRRI involves 70 countries, some of which (e.g., China and India) have much more extensive breeding programs than IRRI, although the diagram simplifies the connections. (Legend of symbols shown in Fig. 3.)

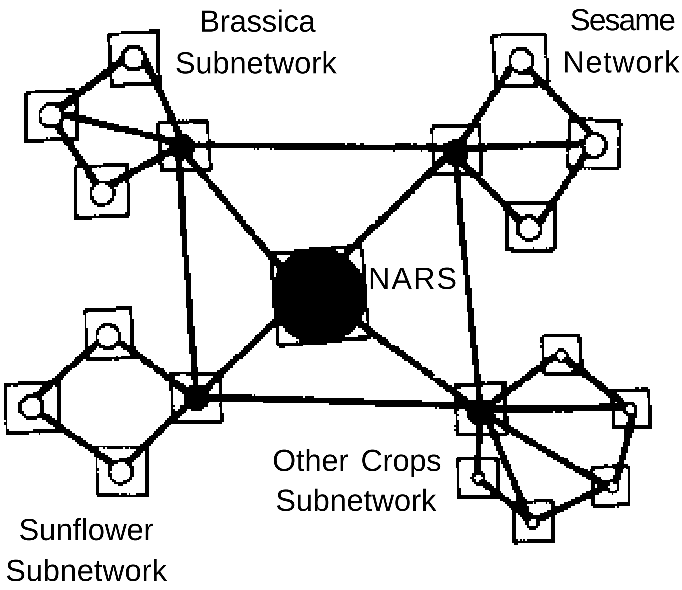

Fig. 7. The oilcrops network for East Africa and South Asia has little if any research associated with the coordination unit, whose main functions are to bring together representatives of the subnetworks and to facilitate movement of information and materials. (Legend of symbols shown in Fig. 3.)

information and forwards it to individuals or libraries. Most of this network's activity is associated with the coordination unit, with relatively little research being associated directly with the cooperative entities. However, some cooperators do send abstracts or short articles.

Two-way communication in early networks associated with international yield nurseries from various IARCs (Fig. 5) can be depicted easily with the model: the central unit provides a large amount of material and information to members and receives feedback after it is tested in the members' own research programs.

These international nursery networks have developed over the years and have strengthened contacts between members and centres. The result, for example, in IRTP (Fig. 6), is joint planning and implementation of the program by the centre and member countries (Seshu 1988). Strong links are forged in this network through monitoring tours and courses. Also, some special research is being carried on in China and in Korea. The joint planning in the network is not substantial because of the site-specific responses of most of the breeding material. This means that worldwide breeding programs will continue to depend on regional or country programs that are somewhat separated from the network, although they share considerable common material. The greatest benefit will come from the sharing of material shown to yield well despite the presence of specific biotic constraints. Thus, there will continue to be screening in countries with "hot spots" or areas where the constraints are daunting (Guiragossian 1988).

The general model I have described can be used to depict even a network where there is little or no research directly associated with the coordination unit, as is the case in the oilcrops network for East Africa and South Asia (Omran 1988) (Fig. 7). Almost all research in this case is carried on in participating NARSs. To facilitate the exchange, subnetworks based on crop groupings have been or are being established (Omran 1987).

Other presentations of network structures have been used (Guiragossian 1988), but none truly represents the dynamic and constantly changing character of networks (Bonilla and Cubillos 1987; Martinez-Nogueira 1987; Plucknett et al. 1990a). Like a living organism, a network is conceived, born, grows and develops, learning from mistakes and from experiences of similar organisms. The network members can be thought of as the body of the organism, providing the bulk and muscle power, carrying out network activities. The research component-the source of new technology, materials, training and methods-is like the metabolism, yielding life, energy, and products that the blood circulates. The heart and blood vessels, along with the nerves (the coordination component), together form the communication component. The assets component-consisting of national and international facilities and human as well as financial resources—is like food that provides the energy that keeps the whole organism active. The analogy ends there but serves the purpose of illustrating the interdependency of network components. It also illustrates why networks should develop all components together.

The diagrams above broadly show the networks' functions and delineate differences between networks. They have been drawn by hand—a time-consuming exercise—but in future could be modeled, with computer assistance, from network databases.

Databases

Preparing profiles of these and other networks would be simplified if one could draw on databases that encompass information on the five essential components—research, coordination, communication, membership, and assets (see next section). At present, databases on agricultural networks are few, one notable effort being the database initiated by Plucknett et al. (1990b) collecting information on the name, contact person, focus, history, size, area served, organization, funding, strategy, planning procedures, activities, and impact indicators.

I believe that there is good reason for a database organized on each essential component of networks as it would, in some way, be sure to meet the needs of all users of the database. A database on the research component might be organized hierarchically by theme, focus, approach, and disciplines involved. There could also be a listing of the network experiments and where they were run, plus an indication of sources of research backstopping for the networks.

A database on the coordination component might include the coordinator's name and address and information about coordination committees (titles, organization, and frequency of meetings). The database on communication could include meetings (workshops, conferences, and monitoring tours), training (within network and advanced degree), publications (results, proceedings, and newsletters), and travel. The membership component might include area covered (countries), requirements for membership, and number of members. There might also be a section for the assets component separating out the staff and facilities available in NARS and international institutes and the funding, showing amounts, sources, and channels.

Developing an exhaustive list of the information needed in each database would require input from many levels of personnel, from a wide range of networks, and from an expert in management of computerized databases. I believe that the effort would be repaid because the databases would provide a powerful tool for effectively learning about networks, particularly if funded for a long term and located at an institute such as the International Service for National Agricultural Research (ISNAR).

This book attempts to identify successful traits but suffers from the lack of comprehensive and comparable data on different networks. Of particular value would be the ability to compare the organizational structure rapidly to identify the factors important in successful networks and to advise on needed adjustments in networks experiencing difficulties. Building a database and using it in models would eliminate the guesswork and would enable studies that are no longer anecdotal in nature.

3

Traits of Successful Networks

Why one network succeeds and another fails is not always clear. The interpersonal dynamics in a network are complicated, and one person's definition of success may differ markedly from another's. However, I believe that a successful network is one that:

- Strengthens NARSs by enhancing their research capability;
- Efficiently resolves problems impeding agricultural progress; and
- Provides effective links and coordination to bring groups or individuals together in partnership to broaden each one's research base and enhance agricultural research progress through collaboration.

General reviews of networks almost invariably include a consideration of the characteristics of successful ones (Table 1). Authors vary in their opinions about which traits are

Table 1. Traits of five network components considered important for a successful CARNET (based on the number of times the trait was identified in 23 publications)[a].

Network component	Trait	Times identified
Research	A well defined common theme or strategy	14
	An important, widely shared objective or problem	10
	An existing or potential source of improved technology (research)	8
	A realistic research agenda	3
Coordination	Strong and effective coordination	13
	A steering committee or advisory group	6
Communication	Education and training	8
	Regular meetings (workshops)	4
	Information-exchange system	4
	Free exchange of results, methods, materials, ideas, and participants	2
Members	Commitment of funds, resources, and staff by NARSs	9
	Strong self-interest served	7
	Capacity to contribute	6
	Participants involved in network management	3
Assets	Flexible outside funding	11

[a] USAID 1972; Banta 1982; Dupont 1983; Evans 1984; Plucknett and Smith 1984, 1986a, 1987; Valverde and Brown 1985; Baum 1986; Kategile 1986; SPAAR 1986a, 1987b; Bonilla and Cubillos 1987; Greenland et al. 1987; ISNAR 1987b; Ker 1987; Martinez-Nogueira 1987; Pillay 1987; von der Osten 1987; World Bank 1987; Valverde 1988; Plucknett et al. 1990a.

important; however, certain traits are mentioned frequently (Winkelmann 1987; Valverde 1988). 1 have examined the traits identified by 23 authors and have classified them by network component (research, coordination, communication, members, and assets) (Table 1); the results indicate that some authors do not take note of all five of the components I regard as being important for the success of a network.

Research

Many authors mentioned traits of research as being major contributors to success. First, a network must be based on an important research purpose or goal—usually to provide answers or solutions to problems that are blocking progress toward improved and stable production, marketing, and use of food. The more important the problem is to the participants, the more they should be willing to commit to the network. If all the participants collaborate in the objective setting and planning, they have the opportunity to serve their self-interests and should have greater commitment than if they are invited to join a network planned by others.

The network must have a focused strategy that clarifies what the participants are expected to contribute and to gain. The more nearly the network meets the expectations of participants, the better are its chances of success. The research plan derives from a clear statement of the problem and the objectives the network addresses. Each objective should consist of a single measurable action, so that, together, the objectives form the basis for the plan of action and for eventual evaluation.

Deciding how many countries should be included in the network profoundly affects the outcome of research as well as the ease in coordination, the costs and efficacy of communications, and the drain on assets. Setting up networks or subnetworks in a region where problems, ecological conditions, cultures, and languages are similar makes good sense as does planning early for the long term: how the results will be shared with the end user—the producers, processors, sellers, and consumers.

The network must supply participants with improved technology or methods to answer their problems. The initiators must conduct a careful inventory of available research results for use by the network and the staff, facilities, and resources that can be devoted to the network by each participating organization to do research to develop missing or inadequate technology.

Finally, both the research and the timetable must be realistic; the planners must design an agenda that is within reach, given the capabilities and assets of the network. The agenda should specify the methods and materials to be used, allocate the research tasks, assign the responsibility for analysis, interpretation, and reporting of results, and detail the procedures for review, planning, and adjusting to meet new research needs.

Coordination

Like research, coordination has been regarded by many authors as important to the success **of a network** (Table 1). Several considered the personality and ability of the coordinator to be a key to success, whereas others felt that the coordinator's influence has been overrated (Winkelmann 1987). Most authors regarded the job of coordinator as being full time for most networks, although many coordinators are, in fact, part time.

Several authors viewed the efficacy of coordinators as being linked with their access to scientific expertise. They suggested that coordinators be scientists who are well trained in the topic of the network. Some authors contended that coordinators are more effective if they include in their duties an active research program related to the network.

Network coordinators have successfully operated from within national programs and from within international research centres. The advantage of the former is its clearer focus on NARSs and of the latter, the administrative and logistical backup, access to a multidisciplinary pool of highly trained scientists, and continuity.

In my opinion, the coordinator must have a good steering committee, although surprisingly few other authors highlighted the importance of having a group to guide the coordinator's activities (Table 1). Of those who mentioned it, all stressed that it should be composed of representatives from the NARSs to provide the kind of feedback that a coordinator needs. I agree and believe that the chances for success increase if the representatives include both managers and scientists. Incorporating individuals from the managerial hierarchy improves the potential for network activities to be integrated into the NARS program, while the scientists can judge whether the network program is technically sound.

Communication

The communication component encompasses many devices. The chief ones that have been identified in successful networks are training, meetings, and other means of exchange of information and material.

Training is an effective means of moving information and knowledge from one part of a network to another. The authors who identified this activity as being important for network success generally considered that the emphasis of training should be to prepare participants to conduct the research associated with the network. Short courses, 1-26 weeks, depending on the purpose, were recommended by most authors. Some networks—for example, RISPAL—provide frequent training to upgrade participants in the latest methods by assembling members to analyze their data under guidance.

Some authors regarded meetings as effective and recommended regular get-togethers—committee meetings, annual meetings, review and planning meetings, workshops, and monitoring tours. According to proponents, meetings give the network life and can be a reward for members (rather than the supervisors) who effectively participate in network research. Also, meetings can be used as a forum for training and for formal presentation of results. Published proceedings help to circulate results among members unable to attend the meetings.

Free and quick exchange of results, methods, materials, ideas, and participants is a basic trait of successful networks, but it did not receive high priority among the 23 authors I reviewed. Although probably taken for granted, easy exchange is not necessarily the norm; it can be assisted by formal arrangements such as memoranda of understanding or being under the umbrella of groups like the Organization of African Unity (OAU) and the Southern African Development Coordination Conference (SADCC) (House 1988).

Members

Members may be NARSs, universities, institutes, projects, or individuals, depending on the network organization. The authors who regarded members' traits as important focused on qualifications or actions. Most cited members' commitment as a key to success. I would say commitment not only by scientists but also by managers. When both groups are convinced that a network's objectives are of high priority, the network's activities are usually integrated into the NARS program and can draw on its staff, facilities, and resources.

A driving force for commitment is self-interest: an urgent need for the results of the research; a chance for upgrading skills; an opportunity to attract funds; or simply an opening to increase contacts with other NARSs and scientists. Self-interest entices participants to join but can distort priorities—for example, when members perceive participation as a chance for international recognition even though the NARS's priorities are not met by the network's objectives. Another danger is excessive competition that interferes with sharing among participants.

Members must have some capacity to contribute. Networks where all participants are well trained and have at their disposal a strong research organization are likely to be capable of rapid progress. However, scientists from NARSs that have little capacity are the ones that need help most and so can benefit most from participation in a network. I believe that the coordinator, with the help of the steering committee, can identify specific weaknesses of participants, and plans can be made for training to deal with shortcomings and for members that are strong in one phase of research to help weaker counterparts. IARCs are in a good position to back up network members needing assistance; in some networks—PRECODEPA is an example—members of one or other national program accept the leadership role on problems where they have expertise and facilities to conduct the necessary research (Valverde and Brown 1985). In most networks, the participating NARSs seldom can contribute equally, but all members could contribute better if their skills were enhanced.

Each member must contribute to the network's management not only because this input strengthens the ties between the NARSs and the coordination unit but also because it expands the participant's management skills and is in line with a major objective of networking—it strengthens the NARSs.

Other traits that have been identified as being important among members of successful networks include stable membership, working as equal partners, and development of an esprit de corps.

The main advantage of stable membership is that it allows the network to build on the experiences of its members. Change means lost time because new members must learn about the network's operation and research procedures. However, it also means more scientists in a NARS are exposed to and hence are upgraded by networking.

In most successful networks all members and the coordination unit work as equal partners, although the perception of equality is sometimes difficult to achieve because the participants are seldom equal in their ability to contribute to the network. When one or more of the member NARSs or the coordination unit is much stronger than the remaining participants, its representatives must make a special effort not to dominate the network. Coordination units associated with IARCs must make a special effort not to dominate a network. Dominated members soon lose interest in the network.

An esprit de corps helps networks succeed and will evolve naturally if all or most of the other traits for success are met.

Assets

To succeed, a network must be able to use the assets, staff, facilities, and support offered by network members; it also normally requires outside funding for the coordination and communication components, as these rarely fit into the budgets of NARSs. In other words, salaries and operating expenses of the coordination unit, travel for the steering committee, and funds to support exchanges such as training, meetings, and workshops are externally funded. In an IARC-sponsored network, some or all of this funding may be provided by the centre, often through special grants.

The responsibility for financing the research component is borne by the members, whether they obtain the funds from internal or external sources. The network normally is not called upon to raise funds to support their members' research. However, the coordinator should have access to financing for network research in case the funds committed by participants are insufficient. The main rule for success, however, is that the total funds and resources available to the network should match the network's research agenda. As some authors have indicated, the funding mechanisms must be flexible enough to accommodate shifts in the plan.

4

The Research Component

The research component influences the network's purpose, structure, and operation. It includes not only the research being conducted independently or collaboratively by network members but also the products of research, whether they have been generated within the network or not. The scientific literature, the findings by network members, the materials such as crop varieties and equipment, technologies, methods, socioeconomic data, agroecological data are all integral parts. Although training is part of the communication component, the curriculum is part of the research component. The entities doing the research can be NARSs—not only the government agencies but also universities and private in-country institutions—bilateral projects, regional and international institutes, laboratories outside the region, consultants, and the coordinating unit.

Research is the fundamental element of a CARNET; it is the component around which the CARNET is built.

Building a CARNET

Networks begin as a germ of an idea in someone's mind, fertilized by discussions with other interested people. Their gestation is characterized by surveys and meetings to delineate the limits of the problem, to explore the potential for a network approach to dealing with the problem, and to gauge the interest of NARSs and donors in being involved in a network (ICRISAT 1984, 1987; Bonilla and Cubillos 1987). The meetings are very often in the form of workshops (Alvarez 1988): in fact, networks are usually born at one of the meetings (Dzowela 1988; Faye 1988; Said 1988).

Once the participants have agreed to collaborate, they work together to implement the research activities within the network, following certain organizational and management stages (Martinez-Nogueira 1987):

- Identifying problems and needs,
- Setting priorities,
- Defining objectives,
- Drafting work plans,
- Scheduling activities and projects,
- Conducting activities and projects,
- Monitoring and evaluation, and
- Transferring results.

Following these stages or in parallel with them, the network expands its activities to include, for example, workshops and training, increasingly integrating all these activities (Martinez-Nogueira 1987).

Torres (1987a,b) described the start of the Agroforestry Research Networks for Africa (AFRENA) and delineated the phases as planning, formulation, implementation, and monitoring and evaluation. The planning was done by a task force composed of policy, research, and extension staff from NARSs and staff from International Council for Research in Agroforestry (ICRAF). Because the concept was new, the planning included a promotional phase to encourage interest in the idea; a methodological phase to provide a means to collect information that would be used to identify problems, to determine priorities, and to develop a plan; a descriptive phase; an assessment phase to determine the nature and severity of constraints and the role of research in overcoming these constraints; a priority-setting phase; and a networking phase involving a task force of extension and research workers. This task force formulated a work plan implemented by the pertinent research institutes, and it participated in the monitoring and evaluation phase.

The research institutes that eventually formed the nodes of the networks were organized during the planning phase, which included input from research managers and scientists of participating NARSs, specialized agencies such as ICRAF, and donors. The networks emerged as packages ready-made for collaborative research by all parties. Each package was unique because it was a product of the interactions between the people involved, their particular resources, and the problem or problems to be tackled. Nevertheless, the steps followed a general path, beginning with the identification of problems.

Identifying problems

Similarly, WAFSRN was set up by members of a scientific society in West Africa who felt they needed ways to find answers for their farming-systems problems (Faye 1988); another example is Comisi6n Latinoamericano de Investigadores en Sorgo (CLAIS) that was set up by sorghum researchers at a meeting of the Programa Cooperativo Centroamericano para el Mejoramiento de Cultivos Alimenticios (PCCMCA) (CLAIS n.d.). The heads of state in Southern Africa who formed SADCC identified the need to upgrade research on sorghum and millets in their countries. To do this they asked ICRISAT to implement a regional program for these crops (House 1988).

The group identifying a problem may include an IARC. Each IARC has a mandate to conduct research on specific problems (Baum 1986), and the mandates among IARCs overlap as little as possible, although all IARCs have been given a mandate to strengthen NARSs. The centres have conducted extensive research to find answers to problems within their mandate, that is also of interest to many NARSs. Thus, NARSs are often interested in joining networks involving research related to an IARC mandate (ICRISAT 1984; Valverde and Brown 1985; Faris 1986). Representatives from NARSs in a region meet with staff from an IARC to determine the need for a network based on the IARC's mandate and within this context to identify the priority problems. The meetings are sometimes preceded by surveys and contacts with the NARSs to determine interest and to prepare an agenda for the organizational meeting.

Donors also conduct surveys to determine problems that would be amenable to research by a network (Omran 1988) or bring together individuals from a group of projects on similar problems (Nestel et al. 1980).

Most networks revolve around a commodity or system. Examples are ARFSN, the Eastern Africa Regional Sorghum and Millet Network (EARSAM), the oilcrops network for East Africa and South Asia, and WAFSRN. In my opinion, the collaborators in organizing a network should attempt to list as many of the problems as possible associated with the main theme of the network and then to set priorities for dealing with them. Although the initial list may include many unimportant or impractical entries, some key ideas surface if the discussion is not restricted by considerations such as cost, crop, or scientific discipline.

The discussions should draw on studies or surveys made for the region, and participants should consult reliable regional data sets—including information on population, production, research budgets, and trade. They should consider the potential for developing a new technology within the region with and without a network.

Establishing priorities

To determine which problems the network will tackle, research managers and scientists from each country should be involved in vetting the list, everyone participating as an equal partner and perhaps chairing one of the sessions. Participation should be balanced so that no group greatly outnumbers the others.

Procedures for priority-setting are being developed for NARSs by ISNAR (Norton 1987). I believe the procedures should be flexible because priorities are influenced by many factors, including the NARSs' research programs, IARC mandates, and donors' interests. The participants from NARSs should present their lists of priorities with the understanding that they will be given the greatest weight. However, no approach is perfect: language differences can form a barrier to clear understanding among participants; the promise of additional funding through network participation can induce NARSs to shift their own priorities unwisely to become members of an inappropriate network.

Next comes the task of balancing priorities of one NARS against those of another. Besides considering the severity of the problem or constraint and its distribution, the collaborators can profitably speculate on the cost of conducting the research, the economic return from solving the problem, the cost of the technology when it is implemented, the potential beneficiaries, and the likelihood of acceptance—a simplified benefit-cost analysis. Other determinants are the research already in progress (inside and outside the network), the expertise available within the network to direct the research, the willingness of members to commit resources to the research, and the probability of receiving donor assistance to support research on the problem.

Clarifying objectives

Once the priority problems have been identified, the research planners next define the objectives, which are ultimately connected to how the results of the network research can be used. Thus, there is merit to considering the problem as part of an overall system.

ARFSN does this as a group, by developing a systems model of problems, causes, and potential solutions.

Sharply focused objectives can serve as a clear outline for work plans. Well thought-out and clearly written objectives have a second, very important use: they form a basis for evaluating the success of a network. To be most effective, objectives should be simply stated—a single action that can be measured.

Under each main objective will come subobjectives, each a description of how the objective is to be attained. Again, each subobjective should consist of a single action that can be measured and the name of the person or group responsible for the action, a time frame, and specific quantities to be generated.

Drafting work plans

The research plan articulates the efforts by the scientists—coordinates the critical mass—to increase the chances of a breakthrough. Crucial to the plan is not only the number of scientists but also the range of disciplines and the level of research, that is, basic (to generate new understanding), strategic (to solve specific research problems), applied (to create new technology), or adaptive (to adapt technology to specific environments) (CGIAR 1981). The degree of integration of the research depends on whether the approach is disciplinary (e.g., plant physiology, genetics, pathology, or tissue culture), multidisciplinary (scientists in different specialties pursue research interests they perceive to contribute to a common research goal), interdisciplinary (scientists of different disciplines cooperatively define problems, design and conduct experiments, and evaluate and interpret results), or transdisciplinary (the highest level of research integration, where scientists transcend their individual skills and disciplines and work with other disciplines to create a new common cognitive map of a problem) (Flinn and Denning 1982).

Like setting priorities, drawing up the research plan is a task in which all partners can contribute (von der Osten 1987). Involving multiple disciplines improves the depth of the research and its relevance (Flinn and Denning 1982), particularly if participants consider how the research fits the production systems in their countries and what can be done to ensure that the technology generated will be acceptable to farmers or other end users.

Although the advantages of interdisciplinary research are very real, it demands a level of integration and coordination that is difficult to attain (Flinn and Denning 1982). In CARNETs, most research will be multidisciplinary, which provides the network with a powerful research organization. Experience in using the multidisciplinary approach may eventually lead to the sophistication needed to carry out interdisciplinary research in the network and in rare cases transdisciplinary research.

The move toward increasingly integrated research in networks has popularized the systems approach. Methods have been designed, tested, and accepted by many NARSs (Fresco and Poats 1986). An example is the farming-system methodology developed by ARFSN (Zandstra et al. 1981)—an approach that uses on-farm research to identify problems, to obtain background for the network's research plan, and to provide feedback for adjustments in direction. The approach begins with site selection and characterization (environment, resources, and existing cropping practices), as the means to identify weaknesses in the farming system. The research plan is designed to produce and test new technology and systems to overcome the weaknesses. Before being moved to farmers in a full-scale production program, new technology is tested on farms at key sites, as are promising new systems or modifications to existing systems (Zandstra et al. 1981).

Networks using a systems approach and those focusing on crop improvement or other component technology have much to gain by establishing links with each other. For example, AGLN could identify superior groundnut varieties for use in the cropping systems program of ARFSN; in turn, AGLN would receive valuable feedback and on-farm demonstration for its varieties. These possibilities were explored recently in a joint ARFSN-AGLN workshop held in Nepal (Faris and Gowda 1991). The value of such links is clear from the experience in Latin America with RIEPT (Toledo et al. 1984)—a network that exists to develop acid-tolerant pasture species—which interacts with RISPAL—a network testing animal-production systems.

Clearly, network organizers have a duty to become aware of activities of other networks and pursue links where they can reduce unnecessary duplication of effort. Like undertaking a literature search, finding out what other networks are doing is a prerequisite to a research plan.

Also prerequisite is an understanding of the interests and capabilities of the NARSs in the network. NARSs must be both technically and administratively capable of integrating the network research into their overall research program, dedicating staff, facilities, and resources to carry out the activities (Gastal 1987). This is the reason that administrative as well as scientific staff from each NARS should be involved in the planning.

I recommend that, where possible, the network coordinator and perhaps others in the network hold in-country meetings in each NARS of a network to finalize their plans for research. Such meetings offer an opportunity to widen the representation by local scientists and administrators and to simplify decisions about sites and responsibilities for experiments. This approach has been used effectively by AGLN to develop country work plans within the context of the whole network (Faris and Gowda 1989).

Combining the strengths and weaknesses of the various NARSs into an integrated plan can improve the chances of success. An analytic model to classify the general dynamics of networks has been developed and is based on the differences in NARSs' capabilities (Martinez-Nogueira 1987):

- Networks of NARSs with generally weak capabilities and needing limited scientific exchange and requiring an external supporting body, such as an IARC, to provide their central core;
- Networks of NARSs with heterogeneous capabilities, able to participate in joint research, with some NARSs giving more input than others into the activities of the network's central core; and
- Networks of reasonably well-developed NARSs that can tackle specific activities and can contribute clearly differentiated portions to a research plan.

This classification is a reminder that the NARSs' capabilities strongly affect the level and type of research plan that can be developed. Implicitly, it also acknowledges the issues of a political and institutional nature that can affect the level of NARS participation in the network (Martinez-Nogueira 1987). Finally, it notes that the level of NARSs' capabilities influences the amount of input into the network needed from an external supporting body, such as an IARC. As a network matures, the level of direction needed from an IARC or other external support will diminish. The evolution takes several forms, exemplified by existing networks:

- Research done by a central research group or hub and sent to participants, illustrated by the functioning of early international nurseries. These nurseries depended on uniform trials of material developed at the hub and grown over a wide range of conditions by participants in NARSs (nodes) and the return to the hub of yield results. As these nurseries have evolved, an increasing amount of material in the nurseries has come from the nodes, but nurseries continue to be distributed from the hub. The products of these nurseries go directly to the nodes for testing and used there or sent back to programs at the hub for further development.
- Research at the hub plus some strategic research at the nodes, as is the case in EARSAM and the African bean networks (Kirkby 1987). Material is distributed from a regional program, which acts as a hub, with strategic research done in nodes or at the hub to identify such factors as disease resistance or agronomic practices that favour growth of the new material. Many of the international nurseries have parallel nurseries for identifying resistance to constraints to yield, such as disease, with material fed into the main breeding program at the hub or at the stronger nodes.
- Research at the hub and in the nodes, with strategic research throughout, e.g., the barley yellow dwarf (BYD) virus network. Resistant material comes from many sources in the network and extensive research is done throughout the network to screen for resistance, study epidemiology, develop viral probes, as well as deal with other topics associated with the problem.
- Research originates at the hub but later moves to the nodes, e.g., RIEPT. Material originating mostly from a research program at the hub is screened through a series of regional trials in NARSs culminating in on-farm trials and release to farmers.
- Research methods developed at the hub or key test sites, such as in ARFSN or by many network members working together such as in RISPAL. The methodology is modified by network members as they use it. In these two networks, the NARS scientists share the results of their research among all members. The research topics are mainly site-specific.
- Research at the hub sent to each NARS and collaborative research in the nodes, e.g., AGLN. The research exchanges between the central hub and the NARSs for chickpea, pigeonpea, and groundnut are set out in country-by-country work plans. Among these country work plans are cooperative network activities such as the peanut stripe virus subnetwork involving all the NARSs concerned with this problem.
- Collaborative research by all NARSs, e.g., PRECODEPA and PRACIPA. The research is assigned to nodes by individuals representing the nodes and is done collaboratively so that the results are shared. There is occasional backstopping by an external group. These and other networks are reviewed in more detail in Appendix 1. The implication

from these examples is that, although each network can draw on the experience of other networks, it must still consider its own problems, priorities, participants, and resources, and come up with a plan for sharing research responsibilities that best serves its needs. Also, the organizers should attempt to design the simplest plan that can be expected to resolve the problem identified.

Implementation and monitoring

Participants can carry out their assigned tasks if the research plan clearly describes the method to be used, identifies the resources, and specifies each participant's agreed-upon responsibility. In practice, however, unforeseen problems arise, and backup systems should be in place to deal with them. Often the coordinator has a large share of the responsibility to carry through these backup plans. The problems may be simple but vital, such as unavailability of a certain insecticide or fertilizer, which is part of a treatment, or an unexpected shortage of labour.

I suggest putting in place a few administrative details, often neglected, that can facilitate the research:

- During site characterization, analyze the soil and collect weather and market data. IBSNAT has developed a minimum data set and models that can use site characterization data to help in the transfer of technology from one site to another (Beinroth et al. 1980). The information can also clarify genotype X environment interactions that affect the performance of specific cultivars at different sites.
- Break bottlenecks. Often the unavailability of some small item of equipment, such as a tape measure or thresher; supplies, such as seed dressing or spray; or labour for planting or harvest can greatly reduce the value of an experiment or even prevent its completion. Such bottlenecks can be broken with small financial input from the network.
- Arrange early for rapid but safe clearance through quarantine of materials (particularly seed) that must be moved across national borders . Do not assume that the delivery of material sent by post will be quick and reliable. Some networks find courier service or hand delivery an essential expense.
- Standardize sheets or books for data collection and include clear instructions that have been pretested by cooperators. Not only do they facilitate uniform data collection, but they also make data entry much easier (Murray et al. 1983; CIMMYT 1985).
- Collect as much of the needed data as possible from each experiment, encouraging economists or other scientists to collect data from the same experiment rather than expending resources on a similar parallel experiment.
- Build in at least one visit by an expert to each site during the experiment, the arrangements for which can be made by the coordination unit. The expert should be chosen for his or her ability to judge the progress of the experiment, technically support participants, and compare the performance of experiments at different sites. In large networks, it may be necessary to appoint network members to be responsible for visiting a given group of sites within the network.

- Anticipate the training needed by participants so that they can meaningfully contribute to the research. Often, short courses can ensure uniformity in methods and data collection.

Other details relate to data analysis and interpretation. The responsibility for, and the type of, data analysis should be clearly spelled out in the work plan. The work plan should delineate the needed training or backup so the analyses of network experiments will be done correctly without undue delay. This may include identifying the need for equipment such as microcomputers so the task can be done efficiently.

A major weakness reported for many networks with multilocational trials is slow return of data and incomplete data sets. If this is identified as a problem, the coordination unit during its regular visits might be able to identify causes for the delays and suggest possible solutions.

If data are being analyzed or reanalyzed at a central location, the analysis for each trial should be a top administrative priority, with immediate turnaround of the results. Interim reports distributed to all participants will prompt action by individuals who have not yet sent in their data and will help identify data sets lost in the mail. Immediate distribution of results is a way of keeping members' interest in the network.

An important outcome of the network's activities is to ensure that all NARSs have the capability to carry out network experiments and analyze and interpret the results on their own.

5

The Coordination Component

The coordination component harmonizes the activities of a network. It has been called the central core (Martinez-Nogueira 1987) or hub (Baum 1986) of the network. Its functions are to:

- Initiate and convene;
- Structure and lead tasks;
- Provide technical support;
- Manage program resources;
- Be the hub of a communications network;
- Coordinate actions;
- Supervise actions; and
- Evaluate actions (Martinez-Nogueira 1987).

In essence, the coordination component is the management group that oversees the setting and reviewing of priorities for the network and the conception, planning, implementation, facilitation, and evaluation of network activities. The two major parts of this management group are a steering or advisory group and a coordination unit or secretariat. How the duties of managing and coordinating the network are split between these two parts varies with each network. Normally, planning and evaluation are the major responsibilities of the steering group, and implementation of the plan is carried out by the coordination unit. This implies that the coordination unit is accountable to the steering group.

Steering group

The steering group guides the network and the coordinator's activities. Its activities have been considered indispensable for an effective network (Table 1; ISNAR 1987a; Winkelmann 1987; Faris and Ker 1988). The steering group is accountable to the membership in some way—whether elected by the members, appointed, or composed of all the members such as a symposium (Faye 1988) or workshop (Guiragossian 1988).

In some networks, direction is provided by more than one group, each with interlocking responsibilities. SAFGRAD, for example, has a sponsoring group that has representation from OAU's Scientific, Technical, and Research Commission (STRC), donors, and national directors who evaluate network performance and oversee the finances of the network's research components. There is also a council of research directors that provides policy guidance and has responsibility for the Oversight Committee. The Oversight Committee consists of seven researchers from all over sub-Saharan Africa whose role includes helping to establish new networks and reviewing their technical progress. Each SAF-

GRAD network has an advisory committee elected from among its members that is responsible for establishing, implementing, and monitoring the network's objectives.

In RISPAL, a board defines policy, selects the coordinator, and approves and supervises work plans and budgets. PRECODEPA and PRACIPA have directors' committees that define and approve action plans, ratify budgets, evaluate progress of programs, and establish technical reviews of network projects. They work with a technical committee of national potato coordinators whose responsibilities include helping to prepare action plans, implementing and supervising trials, evaluating results, preparing budgets, and reporting to the directors' committee.

In existing networks, the level of involvement of a steering committee ranges from controlling to rubber-stamping the coordinator's activities. The steering committee for WAFSRN includes only four NARS representatives (Faye 1988), whereas EARSAM's committee includes representatives of each member country (Guiragossian 1988). In some cases, committee members are appointed by designation, such as in the African bean networks, where the coordinators for each country's program of bean research are the committee (Kirkby 1988b). In some networks, the research director in each country appoints a representative to the committee—this type of setup was suggested for the West Africa millets network, which comprises about 13 NARSs, but the committee is now to be appointed by the membership.

ARFSN has a working group of about 20, including national farming-systems leaders and coordinators, the network coordinator, and one to three other scientists from groups with similar interests. At meetings, the group reviews and takes decisions on collaborative research, updates methods on production systems, and identifies problems and research issues to be considered (Carangal and Guo 1987).

Steering committees sometimes include observers or representatives on behalf of donors, IARCs, or other special groups. The head of the nutrition unit in ILCA, the regional program officer for IDRC's crop and animal production systems, and the coordinator of the Pastures Network for Eastern and Southern Africa (PANESA) are all ex-officio members of the steering committee for the African Research Network for Agricultural By-Products (ARNAB) (Said 1988).

Virtually all steering committees include the network coordinator as a full or ex-officio member, ensuring some continuity within the committee. The coordinator acts as an executive secretary who carries out the plans and follows the policies set out by the steering committee. The chair of the steering committee is usually chosen by the committee from among its members.

WAFSRN has ensured continuity in the steering committee by having, as an ex-officio member, the chairperson of the past committee (Faye 1988). Other networks have the terms of their members overlap to ensure that a steering committee is not composed of all new members who have not yet learned about the operations.

Many steering committees are composed of NARS scientists who, as a group, guide the networks' management on the needs of the NARSs and help develop technically sound programs for the networks. The relevance of scientists' decisions is reinforced by their knowledge about the network's research and the direct effect of their decision on their own research. However, some authors recommend that committees be formed by leaders of the respective country's research program (Webster et al. 1987) so that the research plan receives the backing needed and is in line with national priorities. Also, the direct contact with network planning puts the leaders in touch with what participation in a network means and is more effective in eliciting commitment than if they receive only secondhand reports from their scientists.

In the African bean network, a committee of program leaders or coordinators is responsible for coordinating the research of the network theme in their country (Kirkby 1988b). The aim has been to incorporate individuals leading a national program directly associated with the network problem, being senior enough in their NARS to influence national priorities and budgets, and perhaps even causing a national research network linked to a regional or international network to be organized.

As mentioned earlier, I believe that a good way to ensure that the national priorities are addressed by the network and that the program is technically sound is to invite participation by both an administrator and a scientist from each NARS (ICRISAT 1987).

For example, PRECODEPA has a regional permanent committee, which has two scientists as representatives from each country participating in the network. One of the scientists is usually a director and the other is the leader of the national potato program. This committee meets once a year to evaluate past work, make policy decisions, and approve the budget (Valverde and Brown 1985). PRACIPA goes one step further and has a directors' committee that is formed by the research heads of each institute in the network and a technical committee composed of coordinators or heads of the potato program at each institute. These two committees meet at the same time and place once each year. Some of their sessions are joint and others separate. The technical committee reviews the progress of the past year's plan for each project and prepares a proposed plan for the next year. The plans are presented to the directors' committee, which makes adjustments.

Involvement on steering committees can take considerable time from other duties, and NARS staff, particularly busy executives, must weigh the importance of the network's problem, the proposed size of the network activities, and the time available; they must balance these with their own country's and institute's priorities.

Senior NARS staff can be afforded an opportunity to participate in network coordination and hence indirectly influence steering committee decisions if the network organizers encourage the formation and operation of a national network associated with the international network. An administrator associated with the national network would be a logical participant (even if only for short periods) in deliberations of the steering committee.

Another indirect way to obtain input from the higher echelon into the network is for the network coordinator to visit NARS staff to draft a work plan for each country, meeting with staff at all levels and promoting the integration of network activities into the NARS program. Of course, holding in-country network-review and work-planning meetings is an expense borne by the network and should be budgeted accordingly. The best time for a visit is when the NARS is holding its own national research review and planning meeting, although some effort is required to ensure schedules do not conflict. At any rate, the review of research at the national meeting will include network research if the latter is truly an integral part of the national program.

Senior echelon can also be consulted easily when steering committee meetings are rotated among the different countries involved in a network. Such a rotation, however, has the disadvantage of not providing a chance for an interchange among senior staff of other NARSs unless one or two attended each meeting on a rotational basis or a special meeting was held solely for their input, for example, on a general topic.

In Africa, other, more political channels between the national programs and networks have been provided. In West and East Africa, SAFGRAD is a project to facilitate network development and operation. It works with networks on maize, sorghum, cowpea, and farming systems (OAU/STRC 1987). SAFGRAD has connections to the national programs through the STRC, an organ of the OAU. Likewise, the agricultural regional programs in southern Africa, such as the regional sorghum and millets improvement program, and the programs for groundnut, cowpea, and beans have been established, implemented, and, in certain administrative matters, governed by SADCC through the Southern Africa Centre for Cooperation in Agricultural Research (SACCAR).

In South America, the Programa Cooperativo de Investigacion Agricola del Cono Sur (PROCISUR) is a similar organization that provides a permanent system to support, through cooperative activities, the exchange of knowledge related to agricultural research (Gastal 1987). The program strategy of this organization is guided by an executive board, composed of the research directors of the six countries in the southern cone—Argentina, Bolivia, Brazil, Chile, Paraguay, and Uruguay. In this program are four commodity subprograms run by international coordinators. National coordinators for each subprogram are appointed by participating national programs. In addition, there are four technical assistance subprograms, each coordinated by a different institute in the region.

A coordinator working from an international or regional centre may benefit from the services of a network support or advisory committee composed of institute personnel to provide guidance on network policy and activities. Such a committee also provides a means to help coordinate the activities associated with the network being carried out by the different departments at the institute—international relations, training, publications, administration, finance, and relations with various scientific groups associated with the network's research. Such a group can be especially useful in planning and organizing distribution of trial nurseries, workshops, training sessions, visits by centre scientists as consultants to NARSs, visits by network scientists, and preparation of the networking budget. This group can also give the coordinator new ideas to present to the Steering Committee.

Coordination unit

The coordination unit consists of a network coordinator and staff, usually secretarial and sometimes professional and technical. PRACIPA and AGLN, for example, have a coordinator, assistant coordinator, and secretarial support (Valverde and Brown 1985; ICRISAT 1989a); WAFSRN operates a coordination unit that acts as a network secretariat to implement the plans developed by the steering committee (Faye 1988).

Most authors agree that a strong coordination unit is a requirement for a viable network (Table 1; Gastal 1987) so a more detailed look at its functions seems worthwhile.

The key member of the unit obviously is the coordinator, an essential actor within every network and usually a vital influence on success (Banta 1982; Ker 1987; Faris and Ker 1988). As the executive officer of the network, the coordinator carries out the decisions of the steering committee: linking the network nodes through correspondence and visits; providing scientific backstopping to members; serving as a clearinghouse for gathering, analyzing, compiling, and distributing research results and information for the network; organizing meetings and monitoring tours; initiating training; channeling funds; and editing some type of network newsletter.

When a network is first organized, the coordinator may also be called upon to help national programs establish effective operational procedures. Other duties include acting as a buffer between conflicting interests among national programs (Banta 1982) and floating ideas for consideration by the steering committee. As the person who has the most contacts with network members, the coordinator has the best overall picture of the network and its activities and spends the most time thinking about the network's future direction, plans, and activities.

The amount of guidance provided by steering committees varies from one network to another and influences the amount of planning and guidance expected from the coordinator. In AGLN, for example, the formal steering committee of NARS scientists was not fully functional for more than 3 years, so the coordinator was called upon to fulfil his role with guidance from each country's coordinator (Faris and Gowda 1989).

Some network coordinators are NARS scientists elected or appointed by, for example, the steering committee. If they continue to work within their national programs without additional support, important services, such as a secretary, or easy communications, may be difficult to obtain, and if they are expected to maintain their regular research projects, they will probably not have time to oversee the network effectively—a problem when WAFSRN was first organized (Faye 1988).

At present, most network coordinators are full time and are associated with an IARC or some other international or regional centre. The advantages in such an arrangement are the good facilities and strong technical, logistical, and administrative backup.

Also, staff associated with an international institute can usually move among countries within a region easily and run less risk than NARS scientists of being accused by other NARS scientists of favouring the host country. However, the coordinator needs to guard against showing too great a loyalty to the IARC at the expense of the NARSs. Likewise, the IARC administration should consciously strive to support the coordinator in building the NARS programs, even though it might mean less recognition for the IARC in the short term.

The qualifications and characteristics that a coordinator should have, according to Ker (1987), are an excellent scientific background, good organizational ability, and a capacity to form close relations with colleagues of all ages. Cultural biases, for example about age, can make it difficult for a coordinator to gain the respect of members, and these should be considered when a candidate for coordinator is chosen by a steering committee. If the coordinator is appointed by an IARC, the administration should clear the candidate with the steering committee. The person must be willing to travel frequently. Winkelmann

(1987) maintained (and I agree) that too much emphasis has been placed on the attributes of the coordinator.

Although academic ability and training help a network coordinator succeed, attitude appears to be the vital component for success. In my travels, I have met many network coordinators, representing a wide variety of backgrounds and personalities. Each had a distinct approach to the responsibilities of the job. The only characteristics that the successful ones appeared to have in common were enthusiasm and happiness about the work they were doing, a sense of service to the network members, an overall flexibility to deal with change, and an ability to cooperate, reflected in cordial relations. Only occasionally have I sensed a problem, and that appeared to be associated with coordinators who were trying to dominate the network.

At no time, not even when a network is just beginning, is a domineering coordinator appropriate, and as the network evolves, the coordinator has to be prepared to share, increasingly, the decision-making and to pass the reins to NARS participants. In PROCISUR, for example, Empresa Brasileira de Pesquisa Agropecuaria (EMBRAPA) in Brazil coordinates information and documentation in the network, and Instituto Nacional de Tecnologia Agropecuaria (INTA) in Argentina coordinates technology transfer and training (Gastal 1987).

One way of increasing the NARS input is to rely on the steering committee to provide part of the coordination (Winkelmann 1987) or to have NARSs sponsor workshops, courses, and conferences such as those held at the University of Peradeniya, Sri Lanka in 1986 (Gunasena and Herath 1986) and in Malang—a training course on groundnut virus identification—in Indonesia (Faris and Nene 1988).

Another way is to develop plans that clearly delineate what is expected from each member and that emphasize the self-interest of the members so that they willingly accept responsibility to keep the network operating. In turn, they strengthen their own ability to carry out activities independently.

How quickly the responsibilities are passed to NARSs depends on their ability and willingness to accept the responsibilities. Although the process may take time and patience, a network plan should include a strategy for implementing this development.

Eventually, every network that is worth maintaining should be coordinated by the NARS participants with scientific backstopping by international organizations or strong NARSs. It is in the national programs' long-term interest to have their scientists as network coordinators and to free them from their ordinary responsibilities so they can make the necessary commitment to the network. While visiting Central America, I was told by a scientist, due to become the coordinator of a network, that he had to delay accepting the position for a year while he readjusted his other commitments. Meanwhile, the network suffered, the interim coordinator not having had a chance to divest himself of other duties.

Coordinating the start-up

The coordination component must ensure that the network's focus and objectives are clear from the start, and, during establishment of a network, this role often falls to the group proposing the network—an IARC, a donor, or NARS. A few procedures that have proved useful in the past include:

- Holding a planning workshop that involves as many of the potential participants as possible (Faris and Ker 1988), calling on NARS participants at the workshop to present papers describing their research problems that fit the network theme and their institutional assets to research the problems. The papers should also identify difficulties that NARSs have in reaching their research goals and indicate what they hope they will get from the network.
- Forming small working groups to identify the list of problems and encourage them to reach consensus at a plenary session. Normally, workshop members elect a steering committee that includes a representative from each working group to develop detailed plans for presentation to and comment by the whole workshop (if time is sufficient).
- Ensuring a coordinator is appointed early and given sufficient support so that the plans for the network are carried through (Banta 1982). This is one of the first pieces of business for the workshop, organizing committee, or sponsors.
- Seeking agreement among the membership, steering committee, sponsoring body, and coordinator about the coordinator's duties and responsibilities so that the coordinating of research can begin effectively.

Coordinating the research and communications

Coordinating the research is the key to realizing the critical mass needed to solve problems. The importance of bringing together institutions with different and complementary approaches to research has been stressed for AFRENA by Torres (1987a,b). He has pointed out that universities in developed countries, because of their comparative advantages, can be called upon to contribute to basic research, probably in a twinning arrangement with developing-country institutions. IARCs are generally well equipped to carry out strategic research and some applied research, whereas NARSs are best able to carry out adaptive and applied research, support for which can be obtained in the form of bilateral aid.

The coordination unit can make or break cooperation and collaboration among the different institutions and members, although the unit's involvement, particularly that of the coordinator, can be constantly reduced as the members' capacity and interest in the research increases.

On the other hand, the activities in the communication component will probably continue to require major input from the coordination unit for a long time. The activities tend to involve all members rather than only those within a single NARS. Also, communication activities for a network go beyond what is normal within a NARS and mostly require external financial assistance.

6

The Communication Component

The communication component consists of the links that make a network and enable ideas, information, and material to move between members. The devices include correspondence by post or by electronic means, meetings, visits or discussions, training, and publications.

Devices

These are the tools used by the coordination unit to harmonize the network's activities, bring members together, and help meet members' needs. They are commonly the ingredients of networks that attract members to join, enabling NARS scientists to end their perceived isolation and offering IARCs and donors the contacts to carry out their mandates. The appeal derives from the promise of travel rarely affordable to NARS programs, stimulating ideas shared with peers in other countries, international recognition, and career advancement. Properly employed, these devices can effectively strengthen NARS by producing more capable scientists and by sharing information, material, and technology. The only danger is that these devices will weaken a NARS program by drawing scientists away from priority research problems or by encompassing so many activities that the scientists have little or no time left for research. Being involved in too many communication activities makes "celebrity" researchers, who spend most of their time going from one international meeting to another instead of reading and thinking about (as well as conducting) research projects (Dupont 1983).

The mail provides an inexpensive standard way to keep in contact and move information. Often it is the only way other than travel. Compared with other methods it is slow and impersonal. It is not always kept confidential.

Correspondents need to be aware of government regulations, particularly when writing to solicit attendance of NARS personnel at network activities. Thus, all members should be apprised of the protocols for each NARS and institute associated with the networks.

Electronic mail, too, can be impersonal and can attract unwanted readers. However, the similarity with traditional mail ends here. Communications by cable, telex, computer networks, and facsimile are all designed for rapid exchange of information, as are the telephone and radiotelephone. Their main disadvantages are that they are still relatively expensive and not dependable or even available in many developing countries—a condition that is rapidly changing. Global satellites can be expected to bring down costs and greatly improve the dependability of this type of communication.

Meetings and workshops

Regular meetings, face to face, are considered to be essential for success in a network (Plucknett et al. 1990a). They should be frequent enough so that members feel comfortable talking to each other but not so frequent that they have little new to say. When a network is being established, members need to meet more frequently than they do later when the network is fully functional.

The two major reasons for network meetings are to share results and information and to consider and update policies and work plans. The simplest form of meeting is one-on-one—for example, when the coordinator travels to each node, troubleshooting and advising on research activities (if necessary, arranging for later visits by a consultant). The visits also provide an opportunity to meet with NARS administrators to identify and, if possible, work out administrative problems, particularly any bottlenecks to smooth operation of the network.

The next simplest form of meeting is of committees such as the steering committee to review results, approve work plans, and make policy. Input for such decisions sometimes comes from larger meetings of network members (Mcintosh and Effendi 1979).

The sharing of research results and information, associated with the research component, is mainly covered by workshops and monitoring tours. Conferences, annual meetings, consultative group meetings, working group meetings, and reviews fill the same function as workshops.

Workshops bring together people to report on findings and develop a set of recommendation or an action plan. Workshops can plan a new network (ICRISAT 1987) or project (IRRI 1985), review results and plan research (Abalu et al. 1988), review a topic of mutual interest (Faris and Ker 1988), provide a state-of-the art report (CIMMYT 1984, ICRISAT 1990), allow participants to analyze their own data together to produce a bulletin (Virmani et al. 1991), and conclude a network (Steckle 1975).

Monitoring tours, sometimes called traveling seminars, provide a chance for network participants to see the research being conducted by their peers and to observe firsthand the extent of the problems being addressed. Learning by seeing is effective, and visits by peers have the added benefit of encouraging scientists to do the best job they can in anticipation of the visit. The host learns from the observations made by peers and scientists from other disciplines.

Traveling seminars have also been used to permit scientists to select material from each other's breeding programs for exchange and, for example, in northwest Thailand, to survey the range and severity of insect pests (on pigeonpea) and propose solutions (Faris and Nene 1988).

For logistical reasons, including movement within field trials, the ideal number of participants is 20 or fewer, although larger groups have been successfully managed. Many monitoring tours have paper-presentation sessions and discussions or brainstorming sessions. A report of the tour can also be useful (IRRI 1986). However, informal contacts can be the most important. Experienced organizers of monitoring tours facilitate such contacts by scheduling the travel to permit ample time for participants to relax together (V.R. Carangal, IRRI, personal communication).

In conjunction with a monitoring tour in Nepal, participants from AGLN (for chickpea and pigeonpea) joined with ARFSN participants in a workshop to share their observations, identify together constraints to legume production, and look for ways for the two networks to collaborate (Faris and Gowda 1991).

Major drawbacks of monitoring tours are their high cost and the difficulty of organizing them. An alternative is to hold a short (2-3 day) field visit in conjunction with a workshop.

Planning any of these types of meetings takes time. Giving members 1 year's notice is appropriate, and invitations should be sent at least 6 months before the meeting so that all the paperwork including visa clearance, travel arrangements, and presentations can be completed and distributed.

Organizing a workshop or a monitoring tour means drafting invitations; preparing programs; arranging field tours; overseeing travel arrangements (visas, tickets, and welcoming on arrival); providing for accommodation, meals, secretarial assistance, and equipment like photocopiers; paying participants' expenses; encouraging informal dialogue; editing the proceedings; and following up the recommendations. This is best done using a committee of experienced people each with a specific task.

The location of meetings influences discussions and demands thought. When networks are new, their tendency is to hold meetings at the sponsoring institute. This has merit if the coordinating unit is at the sponsoring institute and logistical backup is good. However, as soon as possible, meetings should be rotated among the various NARSs in the network. The difficulties for the coordination unit are more than repaid by the strengthening of NARSs' ability and confidence in hosting meetings and by their staffs direct exposure to activities of the network.

Training

Training brings network participants together so that they can share each other's experience while learning new procedures, analyses, and scientific or other skills. All types of training are appropriate, including degree or postgraduate training if the student is doing thesis research on a network problem and, in fact, support for this type of training can be especially appropriate if the research is done at one of the local institutions attached to the network. More structured training is normally held at the sponsoring institute or at a special facility with equipment or laboratories needed to satisfy the curriculum. A rule of thumb is that the training will benefit both the student and the network—for example, through the research undertaken or the candidates' direct involvement later as staff of a NARS in the network.

Much of the training associated with a network is in-service courses such as those conducted at many of the IARCs. These courses usually are no longer than 4-6 months, and they provide candidates with practice as well as theory related to the network's research. For example, 1CRISAT offers a course where participants plan, conduct, analyze, and report on two field experiments in addition to classes covering basic concepts and work with centre scientists. Trainees at any of the IARCs are taught the multidisciplinary approach to problem-solving and can see it in action at the centre. They also have the opportunity to interact with scientists from other countries, often ones that will be in the same network. Many close collaborative programs between scientists have started from contacts made at these courses.

Courses to develop a specialized skill for network research are usually either somewhat shorter than full in-service courses or they provide individualized training, such as working in a laboratory or with a group investigating a special problem. For example, a specialized course was given for identification of peanut (groundnut) stripe virus (ICRISAT 1989b).

The methodology networks—those that link groups conducting research that shares a methodology—employ specialized training as central in the development of the network. Thus, RISPAL has courses where network members bring their own data and are taught how to analyze it, using the network methodology. IBSNAT uses the same procedure extensively to help network members use IBSNAT growth models (IBSNAT 1986).

Training, in the form of a workshop, was organized by ICRISAT and AGLN in conjunction with the Food and Agriculture Organization of the United Nations (FAO), IRRI, and IBSNAT (Virmani et al. 1991). It brought together agronomists and agroclimatologists from eight countries to work with ICRISAT-AGLN members, geographers, and cartographers. The aim was to provide an exercise in learning by doing so that participants could prepare maps that illustrate data on climate, soils, biotic stresses, and crops. The maps with text were published at ICRISAT as an information bulletin. The event strengthened the NARSs involved by equipping their scientists with skills to produce more and better maps that can be used in planning within each country and for the region as a whole.

Training programs to ensure that technologies are passed to end users are strong components of systems networks (Denning 1985, 1988), and most networks have some type of training to pass technology to NARS staff or farmers. Examples are the workshops on management of legume pests sponsored in Thailand and Indonesia jointly by government, the Australian Centre for International Agricultural Research (ACIAR), and ICRISAT; and the Nepal in-country training on chickpea, pigeonpea, and lentil sponsored by government, ICRISAT, and the International Center for Agricultural Research in the Dry Areas (ICARDA) (ICRISAT Legumes Program 1988).

Material exchanges

The exchange of living plant and animal materials among network participants creates special problems. It is constrained by governments' concerns that valuable germplasm or trade advantages will be lost and by the very real fear of introducing new insects and diseases. In Malawi, for example, seed of a large-kerneled variety of groundnut has not been allowed out of the country and, commonly in developed countries, similar controls are enforced because of breeders' legal rights over varieties they have developed.

Networks have been able to encourage the sharing of useful characteristics through their international nurseries. Even though agricultural quarantining slows the movement of seed, sometimes for 1 year, the regulations protect national economies as well as the reputation of networks, which would be devastated if linked to the introduction of a disease or pest. However, new techniques for testing for the presence of viruses are now being used to certify seed lots and promise to speed the clearance of seed. The network coordinating unit must clearly understand the regulations and procedures to be followed for each country for the exchange of material. This includes an understanding of the customs regulations and the best routes for moving material. In some countries, for example, it may still be necessary to use the offices of an international agency to ensure that shipments arrive at their destinations.

Publications

Publications are a rich resource for strengthening the research and outreach of a network. The scientific literature, network newsletters or bulletins, annual reports, and proceedings are all precious to researchers. Many networks have developed systems for identifying and distributing the scientific literature needed by their members. Some rely on abstracting services such as are provided by the Commonwealth Agricultural Bureaux (CAB International 1986, 1987), on database searches and information services such as those of AGR1S, the International Information System for Agricultural Sciences and Technology (CIMMYT 1987a), or on simple photocopying of journal contents pages from which reprints can be ordered (Omran 1988).

Most networks produce their own newsletters (PRACIPA 1985; IDRC 1986) and supplement the news items with technical content (NACA 1984), the newsletter at times being the focus of a network (ILCA 1985; ODI 1986).

Proceedings of network meetings are a forum for members of networks to publish their research results and share the information with scientists around the world. The need to prepare a report before attending a workshop can be an incentive for scientists to complete their research and boosts the network's chances to succeed (Banta 1982). Workshop organizers have a duty to the network members to have proceedings published as quickly as possible. Some networks consider it also part of their responsibility to provide a means for their participants to publish their own research findings. These reports often appear as an annual report of results or progress (CIAT 1987b).

At present, CIAT is editing and publishing a tropical pastures bulletin of scientific articles submitted by participants in RIEPT and reviewed by peers (CIAT 1987e). This bulletin is providing a much-needed vehicle, one of the few Spanish-language journals on the topic. Likewise, WAFSRN is looking into the feasibility of publishing a farming-systems journal for West Africa (Faye 1988).

The coordination unit, and specifically the coordinator, usually oversees the editing and publishing of newsletters and proceedings. Too often, this duty is done late at night because no provisions have been made for special editorial assistance to speed release and distribution of network publications and to ensure high quality. Such assistance becomes particularly important where there is need for bilingual or multilingual publication.

7

The Membership Component

The membership component comprises all the people, organizations, institutes, and countries associated with the network, encompassing official and unofficial members. This component, thus, includes scientists, administrators, and extension specialists, nongovernmental organizations, donors, and bodies like subnetworks, NARSs, national institutes and universities, and international institutes. The membership component is the body of the network; it does the work and receives the benefits of the network.

This generic term is synonymous with constituency (body of supporters); participants (those that share in an enterprise); cooperators (those that work together toward a common end or purpose); and collaborators (those that work jointly).

Given this comprehensive definition, the membership's involvement in—and commitment to—network activities ranges from that of people or libraries that have simply requested scientific or network literature through that of cooperators who conduct experiments related to the network problem or participate in network activities such as workshops, to that of those who collaborate on experiments or who are members of the steering committee.

The level of involvement depends on how closely the network research or focus is related to the members' priorities, the resources available, and the work plan (both the research component and the other network activities). In general, the greater the level of involvement and commitment by the membership, the more successful the network can expect to be.

The farther removed a member is from the communications of the network, the weaker the commitment. In some cases, the network coordinator contacts members in a national program only through a country coordinator for the network. More often a network coordinator contacts all contributors directly, with individual members in a NARS keeping their network country coordinator informed through copies of correspondence.

The network country coordinators can act as a buffer to maintain national priorities and can help to get research completed, particularly if they have administrative authority over the scientists. A good network country coordinator can also help identify the appropriate staff to participate in network functions such as workshops. An example is the arrangement that AGLN has with its members in the Philippines through the director of the crops research department at the Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD) (Faris and Nene 1988).

The danger is that such an arrangement, by adding another administrative layer, can cut scientists off from direct contact with the network, leave them feeling divorced from the activities, and apathetic toward decisions. Much the same can be said for members whose connections to the network are through the leader of a project, with the position rather than the individual being the holder of membership.

Ultimately, however, individuals make up the body of the network, as they do the research and participate in the other network activities. The agreements between the network and the various NARSs, projects, and institutes associated with the network determine to some extent the form and level of attachment of the individual scientists with the network.

The methods used by different networks to identify membership deserve mention; they normally reflect the definition of membership laid down by, for example, the steering committee. The issues revolve around the interest in and value expected from membership and time and resources available to devote to the network activities. These factors influence both the prospective member and the network organizers.

For example, membership may be available to all who express interest in receiving literature from an information network, and, in return, the members may be requested to send relevant nonabstracted literature—an example is SATCRIS, the Semi-Arid Tropical Crops Information Services (ICRISAT 1988). In international yield-trial networks such as IRTP membership is available to all willing to grow a trial or set of trials with the expectation that data will be returned to the organizers for use by all network members. In PRECODEPA, members are national programs and their associated staffs who have agreed to be responsible for certain aspects of research for the benefit of the whole network. In such cases, special funding is often available to support this research (Valverde and Brown 1985). In IBSNAT, members are those who collect data to test models developed by the network and who share these results with the network. Such efforts are supported financially from outside the network (IBSNAT 1986). In RISPAL, members all belong to bilaterally funded projects in animal production; they have agreed to come together to develop and share a common research methodology, so membership is clearly defined. The International Board for Soil Research and Management (IBSRAM) has limited membership to those for whom it could identify funds to support participation (IBSRAM 1988).

Whatever decision is made as to who is eligible for membership in a network, I recommend designing an application form to get information about members. Serving as the basis for a membership list, this form must be easy to understand and complete. Database computer programs can sort by factors such as family name, occupation, country, training, discipline, research interest, or previous involvement in network activities; however, getting the forms completed accurately is difficult even from scientists closely associated with the network. The best system is face-to-face requests. Once information has been received by the coordination unit, it should be rapidly processed and the member contacted early so that he or she feels involved in the network.

The membership list will prove useful if it contains each participant's name, address and electronic contacts (phone, telex, and fax numbers), scientific discipline, training, research topic, interests, and reason for being associated with the network. With this information, the coordination unit can mail appropriate materials, identify new research cooperators and collaborators, match participants with appropriate network activities, and provide a useful inventory of scientists potentially capable of answering specific problems identified by the network.

The number of members in a network depends on the network problem, its work plans, and the type of members. Information networks and many international nursery networks have a large number of members or participants. For example, the IRTP at IRRI has about

800 participants in 70 countries (Seshu 1988) and, from CIMMYT, a total of 1 225 international bread wheat nurseries were sent to 88 countries in 1986 (CIMMYT 1987b). Networks where much of the research is closely collaborated are much smaller; RISPAL joins together 14 projects and PRECODEPA encompasses 44 full-time collaborators and 51 part-time (Valverde and Brown 1985). The involvement of participants in collaborative networks is generally at a much higher level than that in other types of networks. The size of a network can be measured by the number of participants, but some measure of the amount of input or involvement by each participant is also needed.

Donors can play an important part as members of networks, both in planning the organization and in providing the external resources to support coordination and communication activities. The funding benefits more than one NARS because of the links and activities of the networks. Also, the networks identify priority research problems that donors are anxious to help the NARSs overcome, and the results will have wider implications than those from projects not associated with a network. Donors want to help members, and members are appreciative. However, misunderstandings arise when the donors and other members do not clearly understand what is expected from them.

Advanced institutes, such as universities in industrialized countries that are CARNET members, usually fill a service role. They answer basic questions that NARSs do not have the facilities, staff, or time to address. Sometimes member institutes provide a place for NARS scientists to carry out collaborative research such as the characterization of peanut stripe virus by a Thai scientist in France. Also, they often fill a training role for other member scientists of the network.

The links that the network encourages between donors, institutes, and other members can be a major benefit to all, and the coordination unit has a duty to make sure the links are strong and working. It is in the members' self-interest to use them effectively. For example, when a coordination unit is collecting and analyzing data from network-wide trials, the members gain from getting their completed results to the coordinator as soon as possible. Similarly, when the combined analysis is returned, it is in the members' self-interest to study the output to see what lessons can be learned.

The network serves the self-interest of members by increasing their contacts; offering fora to exchange ideas with their peers in other countries; giving them experience working with others to identify problems, set priorities, plan and conduct research, and analyze and interpret results; opening the door to results of others' research; and enabling them to become more self-sufficient.

After becoming involved in a network, the members have an interest, therefore, in making sure that the group coordinating the network hears and understands the scientists' problems and adjusts its priorities accordingly. For this reason, members should be prepared to make the necessary effort to serve on network groups such as the steering committee.

Nevertheless, networks can mean problems along with benefits for members. Most problems arise when there is poor communication between one individual and the rest of the network. Unexpected problems include the nonclearance of seed shipments from the airport because notice of shipment had not arrived or the routing procedure was changed without notice. These examples underline the value of network links, especially those with the coordinator, who can often forestall or eliminate problems.

Some international nurseries, particularly in the past, had large numbers of entries, some more than 200, and network cooperators felt frustrated because a large proportion of the entries in some of these trials were poorly adapted to their conditions. In many instances, the organizers knew this but were anxious to get information from uniform trials at many sites so that they could get a good measure of the genotype X environment interaction and identify widely adapted material. Scientifically, the organizers had a supportable objective, but the cooperators did not have the resources to grow many lines known to be poorly adapted to their conditions—to be, as they saw it, poorly paid staff of international centres. Similarly, NARS scientists sometimes receive experiments that must be conducted with a fixed design that did not fit the system they are using. Fortunately, these conflicts are becoming fewer as NARS members take more leadership in planning network trials.

Some members become upset because their contribution to trials is lost in network publications, even when their input represents a relatively large part of their total research effort. Others become frustrated because they are not fluent in the language spoken at network planning meetings and have difficulties following the proceedings and contributing to discussions. The difficulties are exacerbated when networks require reports in a member's second or third language.

These problems may seem minor, but they can cause deep concern to the members involved. Most can be overcome as a network's operations mature and members who are doing the research have a greater direct input into the network planning.

Conclusions

The members have to do their share by using the network components to their advantage and to the advantage of the other members. In the final analysis, a network must be seen to belong to the members, if it is to reach its full potential.

Members must feel that the benefits and the value to them as scientists, to their careers, and to their countries' programs balance the costs required to be a member of a network. In other words, for a network to succeed, it must ensure that the benefits outweigh the costs for all or most members.

Although the cost to the NARS members—the commitment of time and resources—will generally start at the time they join, the benefits accrue in phases. For example, they may immediately benefit from attending a workshop or receiving improved varieties and literature already available in the network. On the other hand results from collaborative network research in helping to answer the members' problems or in providing international recognition for the members' input will normally take some years to be realized. Ideally, the network plan should aim at maintaining a continuous flow of benefits to its members.

8

The Assets Component

The assets component consists of two major parts—the part existing before the network started—such as the personnel, their capabilities, resources, and facilities—and the new extra finances, usually from external sources, to support the networking activities. Because the assets component is embedded within all the other components, it does not appear in schematic diagrams. Rather, it fuels and lubricates the network activities (Plucknett et al. 1990a).

Much of the impetus to form a network comes from the desire to use the assets that already exist more efficiently. The funding and effort that must be added to realize the network must be more than compensated for by the increase in efficiency. Sometimes, the funding and effort for networking comes from reallocation but usually it comes from outside sources. Thus, networks are seen as a way to trim costs and avoid duplication of research, while accelerating the development and transfer of technology using a relatively small extra investment (IDRC 1986). Networks increase the efficiency in use of existing assets by widening members' resource base through a sharing of assets, which may include access to expensive research facilities and services and the technology generated by others (Plucknett and Smith 1987). Networks also strengthen NARSs by expanding the human resources available to them through association with other groups.

To be successful, the network must design a work plan that fits the assets available. This means that an inventory of the assets must be made before the work plan is developed. What seems to happen is that a sponsor of a new network provides the funding for a coordination unit and some or all of the activities in the communication component. Then the sponsor calls together prospective members to determine what activities should be planned for the network based on the assets already donated and those the NARSs and other organizations are willing to contribute. This was the procedure, for example, in the formation of AGLN (Faris 1986). Or participants develop plans that can be partly supported by their resources; they then decide what external financing is required to make the network plan work. This was the procedure followed in the formation of PRECODEPA (Valverde and Brown 1985).

An assets inventory should include items such as facilities, financial resources, and staff available to each scientist or institute member for use by the network. The inventory should also determine the capability of each member to do research, including the disciplines covered and level of training, the type of equipment, and the technology and materials that can be shared with the network. Too often, the network activities are included in NARS activities with no realignment of assets in the existing NARS program nor additional assets to cover the new activities. The failure to identify or commit sufficient assets for network activities is judged by many authors to be a key reason for failure of networking activities (Table 1).

Although network members must take the initiative and commit their own resources, particularly to their network research activities, often they do not even have the resources to carry out their normal ongoing research program. Therefore, it becomes impossible for them to make the commitment needed to sustain network activities. When only small amounts are required to meet members' network commitments, especially when a shortfall is expected to be temporary, many networks provide financing directly. Large shortfalls may mean abandoning the network plans until special project funding can be identified.

While making the inventory, the coordinator should note factors that might affect members' ability to contribute to the network and put in motion efforts to rectify them. For example, short-term training may be needed to enable a member to contribute effectively to the research. Or consideration could be given to revising the work plan so that the individual can contribute at his or her present level of competence.

Although major recognition goes to network organizers, NARSs usually provide the major assets to a network, because they have research facilities, resources, and staff to carry out the major part of the network's research program. They also provide the problems around which a network is built and the guidance for the network's program through the steering committee. The network will, therefore, be strengthened as the NARSs' programs are strengthened. Where NARSs have few resources, they may require considerable external input. NARSs are increasingly able to contribute assets to network activities and are doing so by sponsoring workshops, carrying out training, providing coordinators, and conducting excellent research.

Often NARSs are associated with bilateral projects, with objectives that are the same as, or at least in line with, those of the network. In fact, some projects are given support to participate in networks, and many donors encourage formation of networks to enhance the effectiveness of the projects they are supporting.

International and regional centres, such as IARCs, and universities and institutes in developed countries are well staffed, equipped, and funded for conducting research. In addition, many have developed technology and material that can help meet a network's needs. Thus, they are valuable assets to networks in which they are members. In turn, the centres gain an opportunity to fulfill part of their mandate to strengthen NARSs.

Donors mainly support the networks with financial assets, but some, such as IDRC, have staff that backstop the network. Generally their funding is vital to success, particularly for the coordination and communication components (ISNAR 1981; Dupont 1983; Plucknett et al. 1990a). The monies, whether direct or indirect, pay the salaries in the coordination unit, underwrite the travel costs associated with the coordination function, and cover the costs for administering the network coordination program. Often, in networks associated with IARCs, the costs of the coordination activities are borne by the IARC, frequently as part of its overall core program. AGLN (ICRISAT 1987) is an example; in ARFSN, the coordination component at IRRI receives support from a donor, but the coordinator of ARFSN is now paid by IRRI. Where a coordinator is a staff member of a NARS, such as for PRACIPA or PRECODEPA, funds for travel usually come from a donor, and offices are provided by the NARS. Usually, the coordinator is provided by his or her own organization with administrative backup such as communications, fiscal and travel staff support, and an office.

The financing of the communication component is usually fractured. Thus, events such as travel for the steering committee might be funded as part of the coordination unit or they might be considered separate. Often, steering committee meetings are run in conjunction with other meetings such as workshops, thus saving time as well as money. Sometimes, funds for events such as workshops are considered in the overall network budget, but often each workshop is funded separately and the expenses of each member attending are met by different sources. The same can be true for other communication events such as training. In some instances, funds for training come from NARSs' bilateral programs. In fact, there are many sources, and the coordination unit usually has the responsibility of ensuring that the total package of resources for each communication event is sufficient.

Other authors have stressed that funds should flow evenly, be stable over the long term, and their use be flexible so that the coordinator or network advisory body can meet contingencies and ensure that problems are researched as they are identified in a network. Bottlenecks, such as a shortage of labour for harvesting or threshing, prevent completion of an experiment and should be broken.

In some networks, such as those for bean research in East Africa, the steering committee approves the use of the regional budgets for collaborative projects, workshops and visits, training, and equipment for national programs (Kirkby 1988b).

The SADCC/ICRISAT sorghum and millets improvement program has substantial funds to strengthen research in SADCC national programs while supporting networking activities of the regional research centre at Bulawayo (House 1988). In this instance, the networking part of the budget only supplies small amounts for breaking bottlenecks in the network research.

There are some NARSs—Indonesia is an example—that have built their collaboration in network research on a policy of requiring payment by the network for each experiment run. However, paying a fee to some members and not to others will create friction unless handled diplomatically and openly.

Networking is a method of attracting donor funding. The attraction can be enhanced if the network is able to demonstrate some early success, so network organizers sometimes need to plan one or two initiatives aimed at quick returns. A successful network attracts funding to NARS programs and, the more success a network can demonstrate, the more of a magnet for funds it should provide for NARSs.

Often, after a network is organized and operational, one or more of the NARSs prove to be unable to meet their original commitment. If the shortfall is small, the network should strive to make up the difference. However, if a large input is required, the national program might consider a bilateral agreement supported by its association with the network. The NARS could approach some of the donor organizations with which it already has bilateral agreements and investigate the possibility of applying some of that assistance to meeting network commitments. Or it could reconsider its commitment to the network in light of its resources and other priorities, adjusting its program accordingly.

In future, donors will probably increasingly use networks as a means for channeling funds directly to research. They perceive that networks, if properly set up, have identified problems that are priorities for several countries and have the expertise to design research plans to answer the problems. They believe the network will provide an efficient organization to conduct the research and to distribute the results. They reason that using the network reduces their need to develop a series of bilateral agreements.

However, the trend toward using networks in this way creates a new administrative responsibility for the coordination unit. A major problem is that most coordinators are scientists and have only limited experience in administering budgets. This concern was emphasized at a recent coordinators' review in Nairobi where several coordinators found the task daunting even when the amounts to be distributed and accounted were relatively small (Faris and Ker 1988).

IARC-based coordination units probably have an advantage in handling network funding because they usually can draw on staff experienced in working with donors, and they tend to have fewer administrative blocks to release funds for research than do individuals in national programs. They also at times can draw on the centre's funds as a buffer to allow an even flow to network members. They are thus in a good position to meet contingencies (Plucknett et al. 1990a).

With experience, coordination units could perform as brokers, pooling funds from external sources and releasing funds to network members as required. While helping to ensure the smooth operation of the network as a whole, this approach would have to be accompanied by mechanisms to acknowledge the contributions by individual donors and to ensure reporting and controls that met the donors' requirements. Otherwise, the donors might feel that they had lost too much control of how their funds were being used and that they could not account specifically for the monies. The added efficiency and reduced cost for donors would have to offset the extra costs administratively for the network (Plucknett et al. 1990a).

In the same way that networks can coordinate the use of assets among national programs, donors have shown interest in coordinating among themselves their contributions for support of networks in a region. For example, the working group on networking under the Special Program for African Agricultural Research (SPAAR 1987a) was organized by a group of donors as a mechanism to coordinate donor assistance to NARSs in Africa, and it has identified 14 networks deserving of financial support. It is also studying mechanisms for financing these networks.

This approach grew out of donors' interest in reducing duplication in their efforts and unnecessary overlap in the use of assets. It also reflects their desire to link networks and thus to bring a wider perspective to research. Acknowledging the potential, the food legume coordination meeting held in Bangkok, Thailand, proposed to study the interest among NARSs in organizing a Southeast Asia food legume steering committee to bring together food legume networks and programs so that they can coordinate their research efforts and activities.

9

Evaluation

Evaluating a network provides data that can improve decision-making on network research, coordination, and communications; it can also provide justification for budgetary support for these components. The monitoring and review of progress that are built into good networks form the basis of an evaluation. These have been mentioned in the literature, but relatively few reports have detailed the methods to analyze and evaluate a network critically. A notable exception is the report by Valverde (1988) from ISNAR, drawing on knowledge about how the network functions and on empirical deduction about what effects it has. In this chapter, I have also touched on the "how-to" aspects, particularly the steps for evaluating coordination and communication components. I also review the evaluations of research programs and networks that have appeared in the literature.

Internal

Every network has some obligation to evaluate its own activities, to identify and deal with problems before they become serious. Among the many possible methods of evaluation, four are common and effective, involving actions on the part of coordinators, steering committees, network-wide workshops, and monitoring tours.

The coordinator in day-to-day contact with network members can monitor and evaluate the operations, by probing for small but important problems, such as the nondelivery of seed, as well as more serious problems such as changes in a government policy that affect the network's activities. The coordinator must keep records of events such as the movement of material and the registration of new members. Keeping track of the network records allows instant updates required for evaluations.

For example, the computer services at ICRISAT have provided a network management information system that stores and retrieves information about countries and NARSs, about members, about seed and data movement, and about meetings and travel, as well as other information related to AGLN. This management information system is on a microcomputer, but for small networks a pencil-and-paper (or card-based) system is usually more appropriate (Mook 1987).

The steering committee also fills a monitoring and evaluation role during its meetings; the role can be more formal than that of the coordinator. During review and planning meetings, their deliberations help identify needed changes and early action. A structured, formal evaluation is appropriate, particularly when a committee is new or has several new members, with the review of objectives, organization, and functions being a useful introduction to the network. I recommend having at least one item on the agenda of every meeting to permit the identification of progress and problems and the setting aside of time to make plans for any needed adjustments.

The steering committee could plan formal internal evaluations that draw on the expertise of its members as well as that of others. Finally, the steering committee should arrange an externally led evaluation at appropriate intervals, spelling out carefully the terms of reference and the level of each evaluation. The expense of this evaluation should be planned as part of the network's budget (Valverde 1988).

Another method of internal evaluation is to hold a workshop with good representation of the membership to review, for example, the mandate or priorities for research. To facilitate discussion, the members should prepare position papers.

Whatever the type of internal evaluation, the procedures should be agreed by all members; a survey seeking ideas and information is a prerequisite. Questionnaires have been suggested as one way to obtain input. The only reservation I have is that questionnaires are often used without preliminary testing. If there is even one question that is not understood or is difficult to answer, the returns can be disappointing. Preparing a good questionnaire is complicated by the need to cover many functions, often in a language that is not the respondent's mother tongue. If the coordinator or other network members, such as national coordinators, take the questionnaire to each institute, they can deal directly with difficulties in understanding and can make the results more consistent (Valverde 1988). A mechanism should be built in for maintaining anonymity as this can make the answers more reliable.

Monitoring tours are a form of evaluation and can be a good way to identify problems and sort out research priorities especially in the country or countries visited. They provide wide contact with and more input from the country visited. In fact, they tend to involve even more scientists from a country than do other meetings (say, for the steering committee) within that country because they entail visits to several locations and more closely meet the ideal—having every member feel they have been heard.

A good basis on which to evaluate a network is to examine how well it has met its objectives (Daniels 1987). This approach is effective as long as the objectives have been clearly written, with each one consisting of a single action and if possible designating who will do it and when it will be completed.

The objectives should be updated each time there is a review, and the appropriate work plans developed so that each objective can be met. Although the writing of pertinent and precise objectives takes effort, the payoff is high. In one sense, this procedure gives an ex-ante assessment of the network and provides excellent guidance for the network to carry out its activities.

However, many criteria can be used for evaluating the success of a network; deciding on the most appropriate depends on who wants the evaluation and why. A NARS manager may want to be shown how the network has provided needed technology and strengthened his or her program; a NARS scientist may want to know how well the network has met his or her self-interests; an IARC manager may want to know how a network has helped to distribute IARC materials to NARSs; a donor may want to know how the network has increased the cost-effectiveness of the research done; and the public may want to know how the network has helped to get new technology to the farmer.

In fact, identifying the impact of a network can be difficult. For example, the planting materials supplied to a NARS scientist are often integrated into the scientist's breeding program and lose their identity by the time they are released for use by farmers.

Even more difficult is measuring the impact on each scientist's capability to conduct research. Sometimes, the only measure a network obtains is a count of who attended each workshop and presented papers.

Many neglect to determine the time, resources, and facilities contributed to network activities by NARSs that might in the long run have been used in other, perhaps more important research.

Frequently, authors have commented that networks differ greatly, making generalizations difficult. However, some evaluations of NARSs provide useful ideas for evaluations of networks—for example, a workshop on the impact of research on national agricultural development (Webster et al. 1987) and a workshop on evaluation (Daniels 1987) that included case studies documenting the evaluation activities in NARSs. Noting that evaluation can improve research management, the participants at the latter workshop labeled evaluation as the weakest area of management in NARSs and discussed mainly what information NARS managers needed to carry out evaluation methods that have been published; they also called for balance so that the amount of effort, expense, and time taken from actual research does not make the evaluation counterproductive.

Another useful series were evaluations that elaborated the level of collaboration in agricultural research between the CGIAR centres and NARSs in, for example, Zimbabwe (Billing 1985), Nepal (Sharma and Anderson 1985), Bangladesh (Pray and Anderson 1985), Indonesia (Nestel 1985), and the Philippines (Gomez 1986). This series of papers is part of an overall study to evaluate the impact that IARCs' collaborative efforts have had on selected NARSs. They appear to have in general followed the procedure outlined by Valverde (1988) for evaluating networks so they provide useful models. As well, they provide information about each country's agriculture, its agricultural research system, and the extent and effect of collaboration with the CGIAR—useful background for network evaluations.

Project evaluations are also available as models for network evaluation. Castronovo (1987), for instance, evaluated five agricultural information miniprojects in Latin America and has detailed the methods and questionnaire used. The United States Agency for International Development (USAID), too, has published many evaluations of projects, and these include descriptions of the methodology (Wilkinson et al. 1984).

IDRC network projects were evaluated in the late 1970s by Nestel et al. (1980), whose terms of reference included determining the extent and form of networking in IDRC-supported programs; assessing the network's influence outside IDRC-supported projects; investigating how well links were maintained after project support was discontinued; comparing the different methods used to build networks, particularly their value in strengthening NARSs; and recommending ways to develop more effective networks. The method they used, as might be expected, was similar to that later proposed by Valverde (1988).

Despite in-depth studies, Nestel and colleagues could not generalize from their findings on typology, approach, or cost-effectiveness. In large measure, the reason was that the networks represented a wide range of approaches and different designs, styles, and management. I suspect that generalizations are possible only after a large number of networks that have operated for more than 5 years are evaluated with a uniform method such as that suggested by Valverde (1988). I also suspect that many other network evaluations have been made that have not been published. The evaluation of PRECODEPA (Valverde and Brown 1985), mentioned many times in this book, was a carefully conducted study.

Evaluators for any network should seek out any unpublished assessments to identify precisely the traits to be used and avoided in organizing, developing, and managing networks. The method proposed by Valverde (1988) has merit for conducting such analyses.

External

Valverde (1988) permitted me to review his method, which aims to:

- Identify and analyze the key constraints and elements that influence the execution of ARNET programs. This activity is based on clear terms of reference;
- Determine the capability of a network's system to make changes to meet alternatives in regional requirements;
- Provide a forum to share and debate the differing views on the network's research mandate, strategy, organization, and planning processes so as to identify the network's strengths and weaknesses; and
- Help NARSs' programs and scientists focus their concepts of their role in the NARS.

According to Valverde, these purposes provide a sound basis to recommend needed changes in planning, mission, and goals; to make short-range research plans and budgets; and to restructure management where necessary.

A conceptual model (Fig. 8) highlights the main components of the method, which:

- Does not set out fixed steps to follow for any of the components;
- Encompasses assessment of biological research activities, regional exchange activities, and network management (coordination);
- Depends on the nature and type of network; and
- Relies on informal as well as formal data gathering.

The evaluation is carried out in four phases:

- Revision of the past performance database from all linked groups;
- On-site observation for verification of the network's activities by contact with members (visits, interviews, and questionnaires);
- Discussion and interchange of ideas and experience, related to the results obtained in step two, involving review panel, governing body, and management, to clarify critical concerns, and network elements requiring adjustment; and

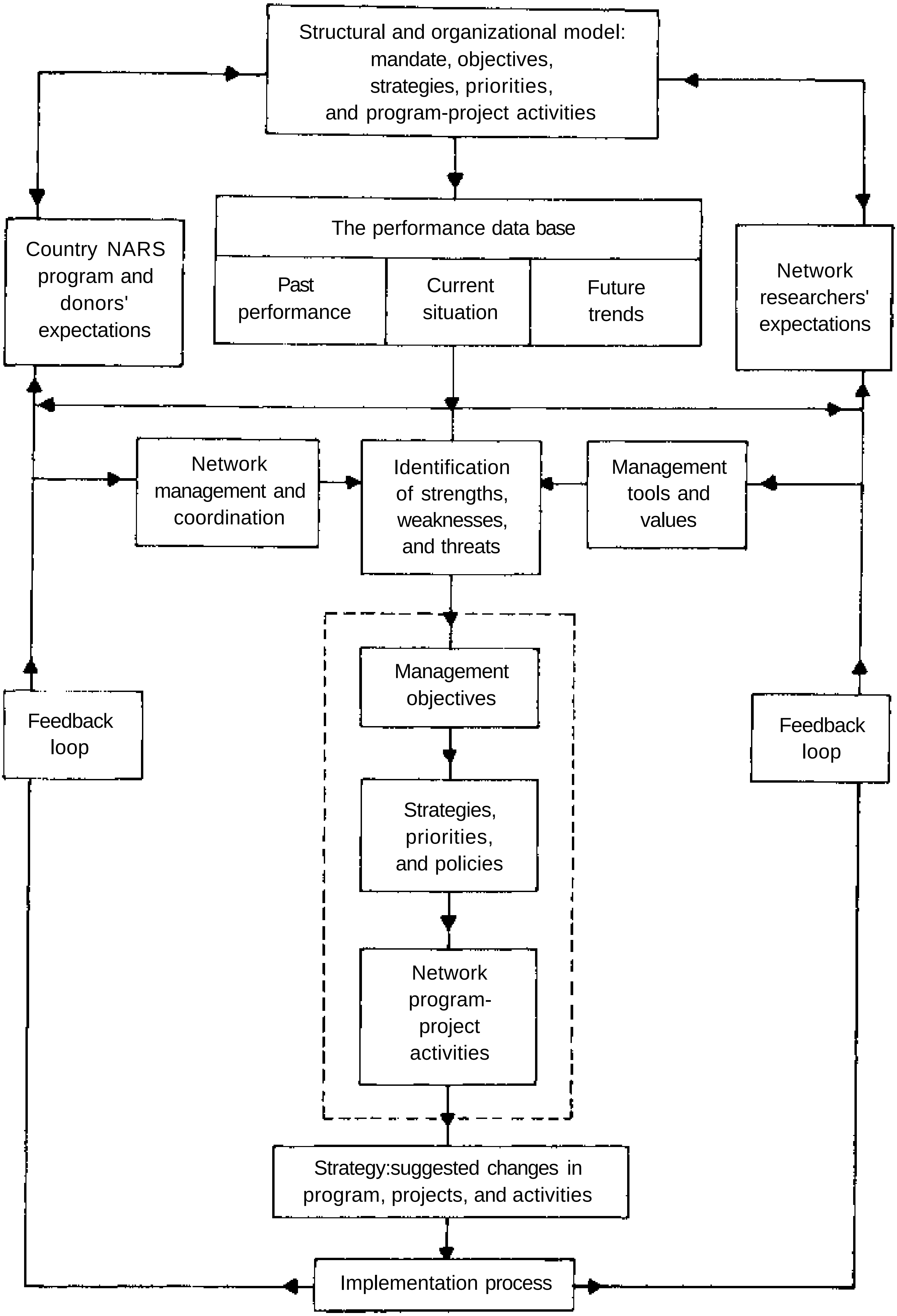

Fig. 8. Conceptual model for analysis and evaluation of networks (Valverde 1988).

- Final reporting, with conclusions and recommendations based on overall analysis and assessment of the network to be given to the appropriate body in the network organization.

Valverde provided a breakdown of major network components to help with the collection of data; this list follows closely the component breakdown I have used here with some differences in nomenclature. He suggested that such a listing is a starting point to be adjusted to each network setting.

He proposed, however, that each commodity or production factor, program, or project within a network be considered as a subnetwork coherently sustained by a central coordinating organization responsible for its management. He also proposed that data collection and analysis at the networking level centre on subnetworks as the focus of all activities or lines of action.

He divided networks into three components:

- Structure and organization, management and operation (equivalent to this book's coordination component);
- Program projects (equivalent to this book's research component); and
- Exchange activities (equivalent to this book's communication component).

The database from each linked group should include an overview of the agricultural sector and the NARSs, with some background on the region in which the network functions and the region's problems viewed as priorities. Data on past performance are required, including outputs of the network. These should be quantified to provide justification for specific trends. A minimum of information about the network itself is:

- A summary of regional program antecedents;
- A description of the program;
- An account of factors that have influenced network activities; and
- The results obtained in association with network objectives.

The coordination unit should list network records providing this information and make them available for use by the evaluators.

The data associated with the current situation of the network usually far outweigh those for the past. The data on scientific and technological progress vary by subnetwork, but the members doing the research are the experts and can supplement and clarify the data. The terms of reference decided upon at the beginning will determine the range and depth of information to be collected.

Valverde has presented ideas for obtaining information based on interviews, questionnaires, and indicators. The ideas follow the breakdown of network program activities. Sample questionnaires dealing with the communication component of networks have been offered by Valverde and these are not limited by commodity or production factor. They include questions on physical facilities, diffusion and exchange of results, in-service training, short courses, and technical seminars. They can be used to measure, qualitatively and quantitatively, main events and can assist one to judge the success or failure of the communication component.

Valverde also presented a simple questionnaire to identify the complex of factors in a region that can constrain the activities of a network. The questions probe for constraints to the network's development and efficiency as well as its collaborative activities; they also seek information with political implications.

Another sample questionnaire given in his document is aimed at measuring members' satisfaction with the network, including whether their self-interest is met. This idea is extended into an overall appraisal questionnaire to be filled in by all who have links with a network, including people such as donors.

Also included is a series of questions that could be used in designing additional questionnaires to collect information on:

- Philosophy, mandate, and strategy;
- Operational strategy and regional program management;
- International technical and financial cooperation;
- Constraints; and
- Results obtained and projection of the network program.

Valverde cautions evaluators to:

- Time their assessments so that they do not clash with events critical to the network operation;
- Become acquainted with all previous documentation;
- State clearly the assumptions underlying the evaluation based on terms of reference;
- Involve as many network members as possible in the analysis and evaluation; and
- Include the assessment within the network's budget and make it economical.

A systematic analysis and evaluation should provide an accurate list of weaknesses, strengths, threats, and opportunities, which can be used to recommend appropriate adjustments to the various network components. A series of key questions are suggested by Valverde, and these serve as a guide to properly assessing a network.

The exercise should result in a concise, integrated report containing comments, conclusions, and recommendations addressed to the terms of reference. In general, the report should cover at least:

- Achievements in relation to the mandate, objectives, and strategy, and the benefits and impact of the network;
- A prediction of the impact and direction of a network especially if it goes beyond the initial objectives;
- The effects of the network's strengths and weaknesses on management, research output, and exchange activities;
- Recommendations to overcome any networking constraints;
- Details of links and benefits from joint efforts between NARSs and IARCs or other institutes;
- Descriptions of whether and how members' expectations are fulfilled; and
- Explanations about financial and long-term commitment to the network.

These methods were developed for external assessments of a network. Such reviews serve two main purposes, encouraging network organizers to do the best job they can and, more importantly, injecting new insights. In addition, the recommendations can serve as strong support for things such as increased external financing that the network has deemed necessary for some time but has not been able to attract.

My experience is that donors mainly want to measure the impact of a network on providing new technology to farmers and on strengthening NARSs. One evaluation gave a weight of 50% to improved productivity of the rural sector, 35% to improving research capacity of NARSs, and 15% to ease of achieving objectives. This evaluation did little to consider the actual operation of the network but did help to focus attention on activities needed to meet these outcomes.

10

The Future

The roles of NARSs and IARCs in networks have been shifting over the years (Baum 1986), as NARSs gain the experience, facilities, and resources to take on more research, management, and coordination functions. The IARCs, which were established to fill the gap in agricultural research in many countries (Flinn and Denning 1982; Baum 1986; Remenyi 1987), have succeeded in providing desperately needed technology and in forging links between countries (Borlaug 1983; Dalrymple 1985). In the meantime, NARSs have increased their expertise and have boosted the numbers of their trained scientists (IARCs alone have trained a total 17 000 NARSs scientists during 1962-84) (Bunting 1985).

In 1964, only three African scientists worked in the governmental agricultural services in Kenya, Tanzania, and Uganda, whereas by 1982, more than 300 worked in Kenya alone (Remenyi 1987). The Agency for Agricultural Research and Development in Indonesia had 42 postgraduate staff in 1975; by the end of 1984, the number was 499 (Nestel 1985). In Latin America and the Caribbean, the increases were similar, with the total of 1400 research workers in 1960 rising to 8000 in 1980 (de Janvry and Dethier 1985).

The increases have enabled NARSs to expand their roles in network planning, management, and other activities. WAFSRN was a NARS initiative, and the numbers of similar networks are bound to grow.

IARCs still have a major responsibility to collect germplasm world wide and maintain the collections for their mandated crops. They will also continue to breed, select, enhance, and distribute plant materials, and they will employ multidisciplinary teams to conduct strategic research. Collaboration among IARCs is likely to increase (IDRC 1983). Thus, they have a continuing role as a backstop for networks, offering expertise, information, and training opportunities not available elsewhere. Because of their resources, they often also provide the coordination unit for networks. The West African cowpea network, for example, contracted coordination and communication components from the International Institute of Tropical Agriculture (IITA), and EARSAM called on ICRISAT for similar functions.

Institutions and laboratories in industrialized countries are increasingly playing roles in networks such as AGLN and I see this as a continuing trend. They will provide strategic research in working groups organized to provide answers to particularly vexing problems facing a network such as peanut stripe virus or acid-soil tolerance. Innovative networks will also increase the input from private industry research.

Donors will have more in-depth understanding of networks to use them appropriately to fund agricultural development in NARSs. At present, the networks sometimes compete with each other to attract the same scientists. Efforts such as those by SPAAR in Africa need to be increased to prevent unnecessary duplication of research by networks as well as better coverage of questions (SPAAR 1987a). Initiatives such as SPAAR will focus donors' support onto effective networks and reduce unnecessary overlap and duplication.

Many NARSs have become strong enough so that they are now working in networks as equal partners with IARCs (Sawyer and Riestra 1987), and some networks (such as WAFSRN and the bamboo-rattan network) do not even involve an international centre. The increasing strength of NARSs has removed the urgency for starting new IARCs, and networks can substitute for new IARCs in certain situations.

The day when research can produce a Green Revolution using assured input in extensive core agricultural areas is fading. This centralized research that can be easily applied elsewhere has decreasing relevance. Increasingly, the network model will have advantages over the IARC model, with an impact that is direct and site specific. Researchers are becoming more aware just how crucial site-specific research is for improving agriculture in the hinterland where the next technological breakthrough is needed (Rambo 1983; Rambo and Sajise 1985). Researchers are also becoming increasingly aware that new technology—whether it is a small change or massive breakthrough—makes little difference until it gets to the farmer. Spurred by donors' insistence, networks are responding by shifting more emphasis to on-farm adaptive research to prove and move technology to farmers. This shift will inevitably lead to closer researcher-extension worker-farmer contacts. Increasingly, the farmer's first approach is gaining acceptance and can be expected to influence networks (Chambers et al. 1989).

Other factors that will affect networks are new communication and data-processing equipment. The costs, power, reliability, and availability of new systems augurs well for networks, promising increased efficiency for the communication component and improved statistical analysis and records maintenance for the research component.

Modern networking theory and practice are new and most networks are still young. One evidence of networking's value is that few CARNETs have folded. However, the number of networks is stabilizing as organizations take stock. Their evolution continues, but usually within existing networks. It will be interesting to see if networks become more similar or different as they evolve. As networks mature and coordinators gain more experience, they need opportunities to share successful revitalizing ideas. Outside evaluations will increase as networks mature, identifying more clearly factors associated with strong and weak networks—information to be also used to revitalize them.

I have been associated with the AGLN for 6 years. I saw it conceived, midwifed its birth, and watched it grow from a tentative beginning, search for its place, and grow to its present robust structure. It has been accepted by the legume scientists in over 11 Asian countries, who increasingly ask that its "mandate" include more legume crops supported by ICRISAT's Legumes Program scientists (ICRISAT 1989a). The AGLN has recruited the services of agronomists, soil scientists, and economists from ICRISAT's Resource Management Program. Likewise, input has come from germplasm botanists, biochemists, training officers, computer and statistical scientists, and information officers. In fact, there are very few staff members at ICRISAT who have not had input into the AGLN. Likewise, in the national programs, input has come from many disciplines. As the network matures, it increasingly emphasizes:

- The use of working groups of specialists including those from industrial country institutions to solve specific problems for the network;

- Screening for resistance using NARSs' "hot spots";
- Use of special funding;
- Involving NARS scientists in research and training;
- Systems approach and sustainability;
- On-farm adaptive research;
- Specific projects in NARS;
- Visiting scientists; and
- Collaboration with regional and international institutes and other networks.

Inevitably, the AGLN grows larger, requiring more staffing and funding, but at the same time depending on additional direct scientist-to-scientist contact and splitting of the network into self-sustaining subnetworks. I will be interested to see if I study networks again in the future if they have had similar trends as they have matured.

Reviewing the literature for this book and sharing my experiences and ideas has helped me understand the networking process better. I hope that reading it has helped you appreciate how networks can be used more effectively as tools for development.

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Appendix 1

Review of Networks

Collaborative research

Collaborative research, the basis of many research networks was extensively used before the term network was common. For example, the United States Department of Agriculture (USDA) stationed staff at university land-grant colleges and state research stations to conduct collaborative research with state and university staff and their colleagues at other USDA research stations (Moseman 1970, quoted in Plucknett and Smith 1984).

A similar research system was developed in Canada starting in 1986 by the Research Branch of the Canadian Department of Agriculture (Anstey 1986). Canadian agricultural research is now coordinated by the Canadian Agricultural Services Coordinating Committee (CASCC) with several Expert Committees of leading scientists (Wasik 1985). The Expert Committee on Cereals and Oilseeds, for example, brings together cereal scientists from federal, provincial, university, and industrial research organizations to coordinate testing of advanced breeding material and recommend release of ones that are superior to existing varieties. The committee members also share their research results. These committees often have an observer from the USDA. The Cereals Committee meets with the expert committees on Grain Quality and on Plant Pathology to develop variety-release recommendations.

The All India Coordinated Research Projects (AICRP) have demonstrated the value of collaborative research by making India's Green Revolution possible (Randhawa 1979; Plucknett et al. 1990a). Many more examples of within-country collaborative research programs can be found with all the components of collaborative agricultural research networks (CARNETs). The intracountry format of these collaborative programs gives them stronger administrative and funding control than most CARNETs.

Earlier examples of collaborative research groups more similar to present CARNETs were the colonial government research organizations, such as those found in the British areas in Africa and Asia, the Dutch in Indonesia, and the Portuguese, Belgians, and French in Africa. These research organizations worked mostly to improve the production of export crops, such as tea, coffee, jute, cotton, cocoa, groundnut, and rubber.

Most research was organized on a country or regional basis, but others, such as the Commonwealth Cotton Corporation, coordinated research across many regions. These research systems usually depended on input from expatriate staff most of whom left when these countries became independent. They left few if any indigenous scientists to carry on the research (Desai 1982).

Of these former colonial governments, France has maintained the greatest interest in collaborative research across countries. When international agricultural research centres (IARCs) were advocated by most nations for the rapid development of new technology for developing countries, France supported collaborative research in its former West African colonies as a viable alternative (Baum 1986). Experience is demonstrating that the two systems can be complementary. However, the large number of networks developing in West Africa with donor and IARC backing must collaborate their efforts with the existing French-sponsored "networks" to succeed (SPAAR 1986a,b).

The examples that follow—of the diversity of network themes and structures—are not necessarily the best but come from networks with which I am familiar.

Network support groups

Networks and collaborative research are organized to strengthen national agricultural research systems (NARSs) (USAID 1972; Kauffman et al. 1982; CIP 1984; Yudelman 1985; CGIAR 1987; ISNAR 1987a; McWilliams 1987; Sawyer 1987; Faris and Ker 1988).

There are many good examples of NARSs that have developed their own mechanisms for coordinating national agricultural research. The recently reorganized Instituto Nacional de Investigationes Forestales y Agropecuarias (INIFAP) in Mexico brings together all university and state research stations under one controlling body, and amalgamates forestry, agricultural, and animal sciences into one service to reduce duplication of facilities. INIFAP has national and regional experts who act as commodity coordinators to plan and oversee research at a commodity level. These experts face difficulty in instilling a team spirit among their workers, because few workers have advanced degrees that normally improve their understanding of teamwork and also because a shortage of resources makes coordination difficult.

These experts look to collaboration with international networks as a means of alleviating problems within their own collaborative research network. However, some of these experts told me that the national program's role in an international network, and the benefits it might expect, are often poorly spelled out. Mexico has a relatively strong national program and has made a useful contribution to several regional networks such as the Programa Regional Cooperativo de Papa (PRECODEPA).

The Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD) develops integrated collaborative project plans for all agricultural research institutes in the Philippines, based on submissions received, and recommends funding proposals to the government to carry out these plans (PCARRD 1983). The Council provides an excellent contact with international networks because its staff can act as within-country network coordinators who have contact with all researchers in the country and can readily coordinate the activities of those taking part in an international network.

The AICRPs are an excellent example of networking activities within a NARS. The All India Coordinated Maize Improvement Project was established in 1957 in collaboration with Rockefeller Foundation (ICAR 1979). It was the first of the many AICRPs that were established by the Indian Council of Agricultural Research (ICAR) (Randhawa 1979). These projects, unique when first established, have all the components of a network. The membership consists of scientists of all disciplines in state and central government institutes working on a specific crop or problem area.

These scientists work as equal partners in drawing up and implementing a coordinated program based on soil-climate rather than political boundaries. Each project has an annual workshop to review past experiments, draw up new plans, and recommend release of new varieties; has a full-time coordinator to ensure the project's smooth operation; and has used the appropriate world collection to screen for resistance to yield constraints. ICAR provides extra funds where needed to remove disparities. This system has avoided duplication, obtained maximum benefits from investments, sped-up research progress, and played the pivotal role in India's Green Revolution (Randhawa 1979).

France's strong support of agricultural research in its former colonies in West Africa has resulted in the Conference des responsables africains et francais de la recherche agronomique (CORAF). CORAF was organized in 1986 after a series of meetings among francophone countries in Africa to discuss the possibilities of research and technical cooperation (Schilling 1988). Under CORAF's steering committee is a series of research networks in Africa. These networks, covering maize, rice, groundnut, cassava, and drought resistance, are intended to share scientific and technical cooperation on an international basis through networking. In July 1988, there were 15 francophone countries plus France in CORAF but they intend to bring in other countries.

The CORAF networks depend on a common will and understanding of the concerned countries to:

- Facilitate the development of NARSs of African countries and give them a regional or international dimension;
- Provide the conditions for cooperation among regional and international organizations; and
- Identify high-priority research needs within the terms of each network for project support by international sponsors.

CORAF's groundnut network is organized around a general assembly with one representative from each country—the groundnut program of the International Crops Research Institute for the Semi-Arid Tropics' (ICRISAT) Sahelian Center (ISC) had an observer at the network meeting in Dakar in March 1989. The assembly is supported by a permanent secretariat responsible for coordination, exchange of information, organizing meetings, representing the network to other groups, and publishing a semiannual newsletter. The network is coordinated by the Institut senegalais de recherches agricoles (ISRA) of Senegal in collaboration with a "correspondent" at the Institut de recherches pour les huiles et oleagineux (IRHO) who is responsible for relations with French institutions.

Many authors writing about agricultural research networks are associated with the Consultative Group on International Agricultural Research (CGIAR) system. Don Plucknett of the CGIAR Secretariat along with Nigel Smith of the University of Florida have been the most prolific (Plucknett and Smith 1984, 1986a,b, 1987) and have done much to advance the concepts of networking. Others include Alverez (1988) of the International Institute of Tropical Agriculture (IITA), Baum (1986) of the CGIAR, Greenland et al. (1987) and Kauffman et al. (1982) of the International Rice Research Institute (IRRI), Kirkby (1988a) of the Centro Internacional de Agricultura Tropical (CIAT), Sawyer and Riestra (1987) of the Centro Internacional de la Papa (CIP), Valverde (1988) of the

International Service for National Agricultural Research (ISNAR), and Winkelmann (1987) of the Centro Internacional de Mejoramiento de Mafz y Trigo (CIMMYT).

IARCs have played an important role in the development of the concept and use of CARNETs. IARCs contain ready made interdisciplinary teams of scientists that can provide the backstopping and technology needed to make the research component of a new network viable. Although some NARSs have similar teams, IARCs generally can more easily make available the staff and resources needed to administer and support the coordination and communication components of networks. This includes providing coordinators and training, hosting workshops, covering communications costs, and publishing results, proceedings, and literature. Each IARC has used collaborative research and CARNETs in their own way, depending on their mandate, their situation, their staff, the philosophy of their administration and Board of Governors, and the countries with which they are most closely associated. For example, ISNAR has concentrated on the management of networks and their use to strengthen NARSs (Valverde 1988) and has dealt with networking at some of its workshops (ISNAR 1987a,b).

The International Center for Agricultural Research in the Dry Areas (ICARDA) is unique because it developed from the Arid Lands Agricultural Development (ALAD) project, itself a network of projects dealing with agriculture in arid areas of West Asia and North Africa. The West Africa Rice Development Association (WARDA) started by bringing together several rice projects in West Africa to work collaboratively. Right from its inception, CIP has been a strong advocate of networks run by national programs. Most IARCs have taken longer than CIP to develop networks that effectively involve NARS input.

Many universities in developed countries have an international agriculture program. Often these programs conduct basic research, such as the laboratories in Italy and other countries associated with the Barley Yellow Dwarf (BYD) Network at CIMMYT (CIMMYT 1984). These universities also provide training to NARS scientists—usually for advanced degrees—because networks can identify promising candidates and arrange their support. Many universities have contracts to conduct projects including coordinating networks in developing countries. One example I have seen is the International Programs group associated with the College of Tropical Agriculture and Human Resources at the University of Hawaii (University of Hawaii n.d.). This program has a coordinator to develop projects, provide administrative help, and give training. The International Benchmark Sites Network for Agrotechnology Transfer (IBSNAT) is among several projects associated with this program. I found similar active international programs in virtually every university I contacted. Sometimes, universities band together to form consortiums. Thus, universities in developed countries provide a rich resource for network operators.

The Food and Agriculture Organization (FAO) and other United Nations organizations have been important proponents of networking (FAO 1975,1985; UNESCO 1982; UNDP n.d.). FAO networking activities appear under its Technical Cooperation Among Developing Countries (TCDC) programs (ESCAP 1983). One good example is the RAS/89/040 project for Food Legumes and Coarse Grains that links together research activities on these crops in several countries of Asia (Chomchalow 1989; RAS/89/040 1990).

The Special Program for African Agricultural Research **(SPAAR) Working Group on** Networks has contributed to networking concepts **(SPAAR** 1987a). **SPAAR was formed** by donors interested in strengthening NARSs in Africa. It works to minimize unnecessary duplication of effort among donors and ensure that important problems are not bypassed (SPAAR 1987a). It has identified 15 networks in Africa as Information Exchange, 18 as Scientific Consultation, and 30 as CARNETs (SPAAR 1986b). It has listed criteria **that it** feels are important for effective CARNETs (SPAAR 1987b). These include an important objective, a well-defined common theme or strategy, a source of improved technology, a coordinating group, a steering committee of participating scientists, regular meetings, information exchange, free exchange of information and materials, training opportunities, and financial support. The networks presentation for SPAAR was prepared by **Ralph** Cummings, Jr. and Calvin Martin of the United States Agency for International Development (USAID) in Washington (Plucknett et al. 1990a). This input is not surprising, as USAID has been interested in agricultural research networks (ARNETs) for several years (Moseman 1970; USAID 1972). The SPAAR Secretariat is located in the World Bank Offices in Washington, and the SPAAR Executive Secretary has been provided by France, a country long associated with networks in Africa (Baum 1986). The World Bank has shown an increasing interest in supporting ARNET activities (Yudelman 1985), especially those with activities associated with IARCs (World Bank 1987).

The International Development Research Centre (IDRC) has used networking extensively since it was founded in 1970 (Hulse 1982; Dupont 1983; Ker 1987). Nestel et al. in their 1980 review reported that 43% of IDRC's program budget, or a total of about CAD 65 million, was associated with networks. The importance that IDRC still attaches to networks is emphasized by Dr. G. Hawtin in the Foreword to this book. IDRC activities are a rich source of information about the organization, operation, and effectiveness of networks.

A major use of networking by IDRC has been to link similar projects together, either to have a critical mass of scientists for more rapid progress, such as the Oil Crops Network (Omran 1988), or to provide a common methodology to support the activities of the scientists of several projects in the network, such as Red de Investigaci6n en Sistemas de Produccidn Animal en Latinoamdrica (RISPAL) (IICA 1986b). IDRC chiefly supports within country projects. Several networks similar to RISPAL have been organized and coordinated by NARS scientists backstopped by IDRC staff. To do this, IDRC has six regional offices—in Africa, Asia, and Latin America—and project staff in six other countries. IDRC, like other donors, supports networks associated with IARCs—for example, the Asian Rice Farming Systems Network (ARFSN) at IRRI, Red Internacional de Evaluaci6n de Pastos Tropicales (RIEFT) at CIAT, and Programa Andino Cooperativo de Investigaci6n en Papa (PRACIPA) with CIP—and with other organizations, such as RISPAL where the coordination unit is at the head offices of the Inter-American Institute for Cooperation on Agriculture (IICA).

Donors such as IDRC also encourage networks to interact and collaborate with each other. Examples are the flow of pasture plant material from the RIEPT network into the RISPAL network (CIAT 1987d) and the collaboration between IRRI and CIMMYT in the Rice-Wheat Cropping Systems project of ARFSN (Carangal and Guo 1987).

Donors support networks of crops with economic potential that are receiving little if any support from IARCs. IDRC support is given to the Oilseed Network for East Africa and South Asia based in Ethiopia (Omran 1988); the International Network for the Improvement of Banana and Plantain (INIBAP), a worldwide network headquartered at Centre de cooperation internationale en recherche agronomique pour le d£veloppement (CIRAD) at Montpellier, France that works through a group of regional networks (INIBAP 1987); and the Bamboo-Rattan Network (IDRC 1986). IDRC's cassava network is an example of a research network set up by IDRC in conjunction with an IARC and research laboratories in developed countries that was subsequently taken over by IARCs—in this case, CIAT and IITA (Nestel and Cock 1976).

IDRC is usually not the sole or even the major source of funding for the networks with which it is associated (IADS 1982). Rather, IDRC tries to collaborate with other donors, NARSs, IARCs, and research groups in developed countries to encourage the establishment of a needed program or network as was seen for the cassava network.

Network types

CIMMYT and IRRI pioneered the use of international trial nurseries (IRRI 1980) that provided high-yielding varieties to developing countries throughout the world and played a major role in the Green Revolution (Dalrymple 1985). The success of these nurseries has been greatly helped by programs at CIMMYT and IRRI to train NARS collaborators so they are better able to conduct effective trials (Greenland et al. 1987). With farmers' acceptance of the high-yielding material, these nurseries have been adjusted to sustain these high-yield levels and identify types adapted to new areas (Borlaug 1983) by providing more material resistant to constraints such as diseases, insects, and acid and alkaline soils that interfere with stable high yields (Rajaram et al. 1984). Because many of these constraints are site specific, centres have developed their activities, such as monitoring tours and workshops, in association with these nurseries to provide feedback from NARSs. Trial organizers use this feedback to constitute nurseries that more nearly meet each particular situation (Greenland et al. 1987). These nurseries, especially those at IRRI, benefit greatly by material entered into them by NARS scientists (Seshu 1988). All other IARCs with crop-improvement programs have developed and use international nurseries. Similar yield-trial nurseries have been used by national programs such as the AICRP and by regional organizations such as Southern African Development Coordination Conference (SADCC). These nurseries started as simple networks where a centre sent material directly to NARS scientists, often with little feedback. Now, most trial networks contain all the components of a CARNET with coordinator, steering committee of NARS scientists, reports, workshops, training, and so forth (Seshu 1988).

The International Network on Soil Fertility and Fertilizer Evaluation for Rice (INSFFER) organized by IRRI is an example of a single factor network. Its original aim was to improve the efficiency of fertilizer in rice production (IRRI 1981). Its 12 international trials included long-term trials, trials on nitrogen and phosphorus, and on acid soils in around 22 countries. By 1985, INSFFER had trained 171 prospective collaborators from 17 countries (IRRI 1987b). In 1988, it was renamed International Network on Soil Fertility and Sustainable Rice Farming (INSURF) in line with its new thrust to sustain high rice yields through maintenance of soil fertility. Besides NARS scientists, this network has inputs from industrialized countries, non-CGLAR centres such as the International Board for Soil Research and Management (IBSRAM), IBSNAT, and the International Fertilizer Development Center (IFDC), and other networks at IRRI—the International Rice Testing Program (IRTP) and ARFSN. INSURF has subnetworks run by NARSs with special research capability, such as that in China for azolla, and has a 12-member Advisory Committee of NARS scientists.

The BYD Network is one of several disease-based networks associated with CIMMYT. Its main objective is to provide BYD-resistant material for CIMMYT's breeding programs. An important component of this network is an extensive series of basic studies on BYD conducted by a network of five laboratories in Italy and five in other industrialized countries. The network coordinator is stationed at CIMMYT. In addition to coordinating network activities, he is responsible for research projects in eight developing countries in Africa, Asia, and South America funded by Italy through the network. The network is screening material for resistance to BYD at CIMMYT and in industrialized and developed countries. Examples are cooperators in Morocco, New Zealand, and Spain and in the USA with USAID funding, and in Canada with IDRC funding. ICARDA's barley-breeding program is associated with the network. There is a proposal to associate this network with the Western European BYD Virus Network. This network deals with a single disease, but includes a wide range of activities. These activities were reviewed and plans made at a workshop held in Italy (CIMMYT 1984). This type of network needs considerable input from the coordinator because of the diversity of approaches of its members to the topic of the network. Because of the wide range of inputs, it is a type that should effectively show results.

The Nitrogen Fixing Tree Association (NFTA), headquartered in Hawaii, demonstrates a single-factor network that deals with many species. It is organized and coordinated by a nongovernmental organization (NGO). Its objective is "to encourage more and better use of nitrogen fixing trees ... [by] small farmers in the developing tropics" (NFTA n.d.). It collects, enhances, and distributes germplasm, has a research component to backup its cooperative planting program of trials, sponsors workshops, and provides training and a database on the environmental requirements of nitrogen-fixing trees. This association links in with agroforestry and farming-systems networks.

Systems networks provide a broader perspective to agricultural research (Flinn and Denning 1982). The West African Farming Systems Operational Scale (OPSCAR) Project, for example, which has the essential components of a network conducts experiments to test a specific farming system. This system involves animals (for draft), crops (legumes and cereals), animal production (sheep), fodder for the animals, fertilizer (P), and the economics of the systems. In this network, ISC collaborates with the International Livestock Centre for Africa (ILCA) and several NARSs in West Africa while Institut national de recherches agronomique du Niger (INRAN) confirms the technology with farmers. A workshop was held in September 1988 to examine the trials and decide on the appropriateness and form of the network (Renard 1988).

The West African Farming Systems Research Network (WAFSRN), based on a professional association of researchers, was created in 1982 at a workshop in Ibadan, Nigeria (Faye 1988). It has a steering committee and a secretariat, and holds biennial symposia. The secretariat is headed by a coordinator who has been posted, since November 1987, within the Semi-Arid Food Grain Research and Development project (SAFGRAD) through a protocol of agreement signed with the Scientific, Technical, and Research Commission (STRC) of the Organization of African Unity (OAU). WAFSRN activities in 1988-89 included establishment of a scientific and technical information system, training activities and technical workshops, a symposium, and support for national research systems.

ARFSN has been well documented (Banta 1982; Hoque 1984; Carangal 1985; Carangal and Guo 1987; IRRI 1987a; Ker 1987). Its base is the on-farm methodology developed by IRRI in collaboration with NARSs (Zandstra et al. 1981). Its multidisciplinary research approach includes the farmer in the research and the execution. The network members have used and modified the methodology as necessary. This network's objective is to expand the options available to rice farmers in Asia and to improve the quality of their life. To do this, ARFSN has many projects associated with it including Cropping Pattern Testing, Women in Rice Farming (IRRI 1985), Crop-Animal Systems Research, Rice-Wheat Cropping Systems, Prosperity with Rice, Rice-Fish Farming, and Impact of Cropping Systems Research (IRRI 1987a). These can be considered subnetworks of the main ARFSN. This network uses key sites to develop technology for the different projects: technology that is then incorporated and tested on-farm within the rest of the network. ARFSN has input from many scientists at IRRI as well as from several other IARCs, international and regional research groups, and NARSs. The network's methodology has become an integral part of the research programs of some NARSs in Asia which enables them to make significant contributions to the network.

A working group of national administrators and scientists mould the ARFSN's overall plan, which is carried out by a very effective coordinator. Network results are shared during monitoring tours (IRRI 1986) and workshops that each highlight specific aspects of the network's activities. Training is an important facet to this network. Its wide interests means that this network has a large number of members.

Groups such as ARFSN have encouraged several NARSs to develop their own farming-systems research program. Examples are the On-Farm Technology Verification Scheme in the Philippines and the Farming Systems Research Institute (FSRI) in Thailand.

The scheme in the Philippines draws together institutions interested in collaboration on overcoming a problem. These include PCARRD, universities, provincial and federal departments of agriculture, the Philippines Seed Board, and the National Science Technology Authority. These groups meet at Regional Integrated Agricultural Research and Development Review and Planning Workshops to agree upon plans. The procedures they use for verification are based upon the on-farm cropping-systems research methodology developed at IRRI (Zandstra et al. 1981).

The philosophy, organization, and operation of the FSRI in Thailand is also firmly based on those of the ARFSN. The Institute has seven regional stations. These have little government owned land associated with them because virtually all their research is done on-farm. FSRI has its own coordinated research program that includes participation in the ARFSN. Some of the ARFSN key-sites are associated with the FSRI regional stations.

Agroforestry Research Networks for Africa (AFRENA) associated with the International Council for Research in Agroforestry (ICRAF) has used yet another systems approach that deals with long-lived plant species (Torres 1987a,b; Ngugi 1988). The long-term nature of its experiments makes results inconvenient and expensive to obtain; thus, agroforestry technology tends to be less advanced than many other subjects. Yet, because of increasing pressure on land, increasing danger of serious erosion and low crop yields as new land is cleared, and increasing shortage of cooking fuel, there is a pressing need to provide agroforestry technology. Certain agroforestry technology packages, such as breeding for insect resistance, the development of agroforestry research methodology, and the collection, maintenance, and distribution of tree species can be done at a centre of excellence such as ICRAF. Agroforestry technology, like that of farming systems, tends to be site-specific and related to local farmers' needs, so it must be developed for each agroecology. Because agroforestry research units were scattered and poorly supported in sub-Saharan Africa, ICRAF encouraged each country there to develop and identify financing for its own agroforestry research project. Because there were few scientists trained in agroforestry before the networking activities started, most scientists in the region are recently trained and their projects new. Working with each other and with ICRAF, these scientists have planned four ecological based networks. Three AFRENA networks are operational: the Southern Africa, the East Africa, and the Tropical Humid Lowlands. By giving support to develop the units that will come together in a network, even before ICRAF had developed its own wealth of agroforestry technology, ICRAF has helped develop a strong network system for collaborative agroforestry research in Africa before it might have been expected. Each member is capable of making a significant contribution to the network, while, at the same time, providing strength so that their NARSs can conduct site-specific research.

IBSNAT is another systems-approach network. It is a follow-on of the Benchmark Soils Project, a project designed to test the hypothesis that agrotechnology could be transferred from one location to another on the basis of similar soil families (Beinroth et al. 1980; BSP 1982). IBSNAT has extended the idea of agrotechnology transfer from a process of analogy to one of systems simulation. Its objective is to find ways to effectively transfer agroproduction technology from the technology's site of origin to new similar locations, particularly in the tropics and subtropics, and to assess the long-term effects of agricultural practices on soil resources (IBSNAT 1985,1986).

The network has a research component that develops simulation growth models. The core of this component is a technical advisory committee of six experts and collaborators in about 30 institutions, who are testing and adjusting the models. The collaborators are also adapting the models to more crops. It has a collaborative advisory panel of decision-making staff from developing countries to keep the coordinator in touch with the needs of their countries. The coordinator keeps a low profile, but the network has attracted enthusiastic participation despite the small amount of funding provided for network and research activities. Part of the network's success is the wide interest in its topic and part is because the coordinator actively strives to make each participant truly feel that the network belongs to them.

The Southeast Asian Universities Agroecosystem Network (SUAN) is associated with the East-West Center at Honolulu, Hawaii (Rambo and Sajise 1985). This systems network joins a small group of universities in the study of the human factor in the management of rural resources in the hinterlands of Southeast Asia (Rambo 1983). The organizers point out that the Green Revolution has involved the highly populated, fertile core areas of Southeast Asia. This core covers about 5% of the land area, and is relatively uniform in land form and population, compared to the remaining upland or hinterland within each country. The core area has benefited from the research at the IARCs, as it is where the Green Revolution has taken place. New technology for the hinterland will be much more difficult to develop because in these areas, where yields tend to be inherently lower, resources such as irrigation and fertilizer are less readily available, and technology innovations will need to be much more site specific. This means that research must be location specific. These locations can benefit from using methodology developed by IBSNAT to transfer technology from one place to another. Research in SUAN is aimed at the cultural and economic conditions so as to understand how to identify appropriate new technology for hinterland areas.

Systems networks have provided technology directly related to farmers and to their marketing systems (Denning 1985). The target group for many international research groups such as ICRISAT are resource-poor farmers (Denning 1988). To reach this target, the international groups must collaborate with NARS scientists to adapt the technology to the local conditions in the NARS scientist's country (Baum 1986). Systems networks such as ARFSN can give NARS scientists the methodology needed to do this. For example, ARFSN's methodology identifies problems, selects target areas and sites, describes sites, designs and conducts farming-systems and on-farm trials, and tests new technology for final release to the farmers through production programs (Zandstra et al. 1981). This methodology helps IARCs work collaboratively with farmers so the IARC scientists will understand through feedback how new technology must be designed to meet the farmer's problems and fit the farming system. These systems networks also serve to strengthen NARSs.

Germplasm, both plant and animal, is an important long-term heritage of every country in the world. To collect, evaluate, and preserve this germplasm is very expensive. In developing countries, germplasm per se rarely makes a large direct contribution to agricultural development and so it cannot be attributed a high research priority (Plucknett et al. 1983, 1987). Germplasm that has characteristics that could be vital in the future can become irretrievably lost if it is not collected now. This problem is exacerbated as new high-performance varieties replace traditional varieties that, because they are low producers, are no longer grown.

Until NARSs have the resources to collect, preserve, and distribute germplasm, IARCs fill the gap for their mandated crops. This has been a major contribution of IARCs to international agricultural development (Hawkes 1985). IARCs have advantages of international status, stability, and resources for this activity. Germplasm activities have been helped by the International Board for Plant Genetic Resources (IBPGR), which was organized by the CGIAR in 1974 (Hanson et al. 1984). Its mandate calls for the establishment of a network of replicated storage centres for major crop species in IARCs, other institutions, and NARSs and to give advice to ensure the germplasm's security. IBPGR also deals with constraints affecting the efficient collection and exchange of germplasm and methods of characterizing, maintaining, and conserving collections (Plucknett et al. 1983,1987).

Regional programs

Considerations of size, ease of communication and travel, and regional agricultural patterns and language groupings suggest that research programs and networks can be more efficient and effective if they are regional rather than interregional or worldwide in scope.

Regional programs developed by IARCs are often in the form of specially funded programs, but most IARCs—such as CIP and ICRISAT (CIP 1984; House 1988)—also use core funding to indicate their long-term commitment. CIP is the commodity-based IARC that has worked most closely with NARSs, setting its research priorities from the beginning based on input from NARSs (CIP 1984, 1987). Input from NARSs has also characterized CIP's regional programs that hand over regional research responsibility to NARSs as quickly as possible. PRECODEPA is an example of this (Valverde and Brown 1985). In this network, the coordinator, steering committee, planning, and research are all the responsibility of the NARSs. Until the network can become completely self sustaining, CIP provides a facilitating role to carry out such activities as disbursement of funds (supplied by a donor), research backstopping, and some training. PRACIPA is a similar network.

Many of the regional programs established by IARCs have been built around IARC-hired staff stationed in regional centres or in NARSs (Baum 1986). In these regional programs, IARC scientists are in close contact with NARS scientists and, through collaborative activities, are aware of the NARSs' problems and research priorities. Networking has provided a way to make these contacts even more effective (Kirkby 1988b).

Regional programs allow IARCs to effectively support networks and NARSs in regions away from the IARC headquarters, while providing research backstopping from the headquarters. The regional research programs have their own research programs and centres that either adapt technologies from their centres to meet regional conditions, or find answers to problems not being dealt with at their centre (House 1988).

ICRISAT developed regional research centres, each containing a multidisciplinary team (House 1988). Each crop in ICRISAT's regional program has a regional network. Thus, there will be a separate network for each of the three crops—sorghum, millet, and groundnut—at the ISC at Niamey, Niger, for West-Central Africa. For southern Africa, there is essentially a sorghum and millet network organized from the SADCC-ICRISAT Center at Bulawayo, Zimbabwe, and a groundnut network from the SADCC-ICRISAT Center at Lilongwe, Malawi (House 1988). Eastern Africa has the Eastern Africa Regional Sorghum and Millet Network (EARSAM), organized for sorghum and millet from Nairobi, Kenya (Guiragossian 1988). Latin America has the Comisi6n Latinoamericano de Investigadores en Sorgo (CLAIS) for sorghum organized from the ICRISAT regional program located at CIMMYT in Mexico (CLAIS n.d.). At ICRISAT Center, the Asian Grain Legumes Network (AGLN) is facilitating ICRISAT's Asian regional legumes, farming-systems, and economics programs. The Cooperative Cereals Research Network (CCRN) facilitates ICRISAT's Asian regional cereals program as well as having a worldwide mandate (ICRISAT 1987).

The Southern Africa SADCC Regional Sorghum and Millets Program at Bulawayo was set up by ICRISAT at the request of the regional body SADCC. ICRISAT received special funding in conjunction with this program to strengthen the NARSs' sorghum and millet programs in the region. Strengthening each country's research structure and providing advanced training releases NARS assets so that the NARSs can effectively participate in the regional network (House 1988).

Staff based at ICRISAT's regional centres interact with NARS scientists throughout each region. This centralized model (Faris and Ker 1988) allows an interdisciplinary group of highly qualified scientists at the regional centre to interact among themselves on a daily basis, and provides the critical mass at one location required for quick scientific breakthroughs. It also provides a good model for NARS research teams to emulate. The intention is that, within 20-25 years, these regional research centres will be completely staffed by regionally recruited staff (House 1988).

In Africa, CIAT has used a diffuse model (Faris and Ker 1988) to establish a regional bean program. Here, they have stationed their own scientists who act as an integral part of certain NARSs in the region (CIAT 1987a; Kirkby 1988b). This permits continuous contact between CIAT and national scientists on all research matters, allowing close collaboration and providing direct support to the NARSs where CIAT scientists are posted.

As well as conducting research in close collaboration with NARS scientists, these regional scientists conduct research as a CIAT scientist to back up the network's needs. Being resident in a country usually makes movement within the country relatively easy and permits more frequent contact than for IARC staff coming from outside the country. In Bangladesh, for example, I found that the CIMMYT regional scientist stationed there was known by virtually everyone at the research stations I visited, and many noncerealists could tell me something about the program for which he was responsible. His practice was to visit each station about once every 2 weeks during the growing season. This practice of frequent visits appeared to be paying off in interest and in the wheat material being developed.

Compared to the diffuse model, the centralized model can be stronger in putting a muitidisciplinary team together and providing it with support needed to interact effectively and to develop the required technology. The diffuse model, on the other hand, can allow IARC and NARS scientists to work more closely. Some of the disadvantages of the centralized model are being reduced by frequent, in some cases daily, telephone contact between scientists, by visits, and by regular meetings, such as workshops, where problems can be discussed in detail and collaborative research planned.

Although the frequent contacts between regional and NARS scientists in the diffuse model may be more effective at strengthening the NARS operations where the regional staff is posted, it can be argued that the reduced contact associated with the centralized model may mean that the national scientists have a better chance to develop self reliance. Both systems lend themselves well to collaborative research and networking (Faris and Ker 1988). It might be expected that the centralized model would be more effective where the NARSs tend to be weak and the diffuse where the NARSs tend to be strong. The attitudes of the regional program and NARS staff probably play a more important role in determining the effectiveness of a network in strengthening a NARS than whether it is a centralized or diffuse model.

Five of the eight CIP regional programs have networks associated with them (CIP 1984) that are, as far as possible, coordinated and operated by NARS personnel using special funding. The CIP regional program usually acts as a member of the network, providing backstopping and resources where needed (CIP 1980, 1984). The regional research work plans are developed in conjunction with the NARSs. This has led to research results that are directly useful to answer NARS problems. This model can also be effective for strengthening NARSs because of the lead role that NARS scientists take.

Some regional networks are receiving the backing of groups of national governments. Examples are SAFGRAD in West Africa and Southern Africa Centre for Cooperation in Agricultural Research (SACCAR) in southern Africa. Such networks have benefited by having direct links with administrators who ensure that networks operating in their region meet their needs and that the networks* activities are properly supported within the NARSs. These politically backed groups have also facilitated network activities in its region by helping with such things as the movement of network staff from country to country.

SAFGRAD is a project that comes under the STRC of the OAU. Its coordination office is located in Burkina Faso. SAFGRAD aims to strengthen commodity research networks concentrating on links within and among NARSs. Their coordination office focuses on specific service functions. The main networks it is associated with are the sorghum, maize, cowpea, and farming-systems research networks in West and Central Africa and EARSAM in East Africa. They are, at present, working on integrating the activities of their networks with those created by the French Government through CIRAD in francophone Africa. SAFGRAD has an oversight committee that acts as its steering committee to provide it with guidance. It also has received guidance from the National Agricultural Research Directors' Council of member countries. OAU provides the political umbrella under which the SAFGRAD networks can operate freely in the region.

Both SAFGRAD and SACCAR have a direct interest in networks. It is encouraging to note that they are increasing their input into the research planning in their respective regions, and are even looking for ways to collaborate with each other.

As indicated earlier, this review of network literature published by groups interested in CARNETs is by no means exhaustive but does provide a flavour of a range of networks.

Appendix 2

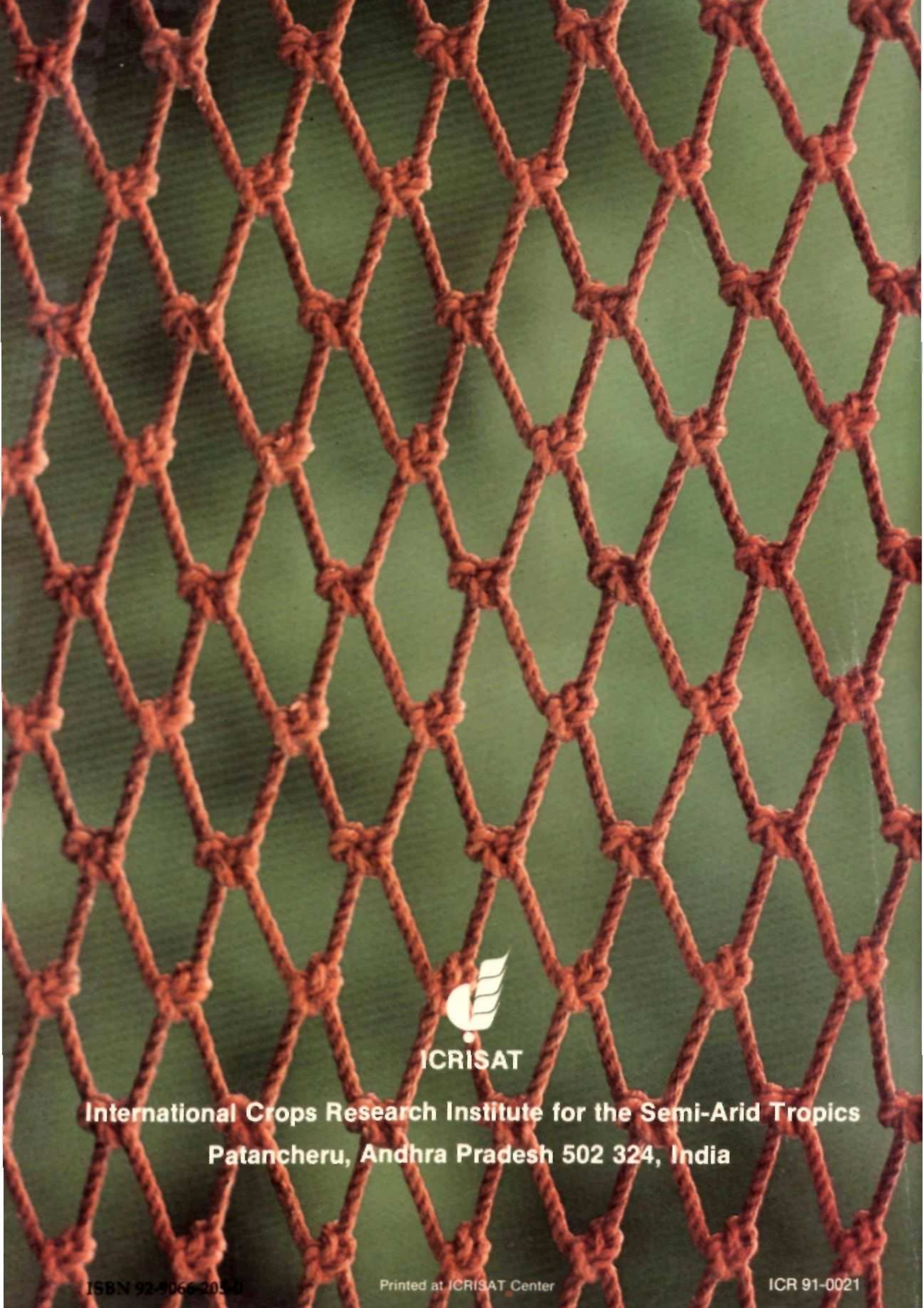
Acronyms

ACIAR	Australian Centre for International Agricultural Research (Canberra, Australia)
AFRENA	Agroforestry Research Networks for Africa (coordination unit at ICRAF)
AGLN	Asian Grain Legumes Network (coordination unit at ICRISAT)
AGRIS	International Information System for Agricultural Sciences and Technology (maintained by FAO)
AICRP	All India Coordinated Research Projects (many locations in India, under ICAR)
ALAD	Arid Lands Agricultural Development (Project) (formed basis for ICARDA)
ALPAN	African Livestock Policy Analysis Network (coordination unit at ILCA)
ARFSN	Asian Rice Farming Systems Network (coordination unit at IRRI)
ARNAB	African Research Network for Agricultural By-products (coordination unit at ILCA)
ARNET	agricultural research network
BSP	Benchmark Soils Project (Honolulu, USA, and Mayaguez, Puerto Rico)
BYD	Barley Yellow Dwarf (virus)
CARNET	collaborative agricultural research network
CASCC	Canadian Agricultural Services Coordinating Committee (Ottawa, Canada)
CCRN	Cooperative Cereals Research Network (coordination unit at ICRISAT)
CGIAR	Consultative Group on International Agricultural Research (Washington, USA)
CIAT	Centro Internacional de Agricultura Tropical (International Center for Tropical Agriculture) (Cali, Colombia)
CIMMYT	Centro Internacional de Mejoramiento de Maiz y Trigo (International Maize and Wheat Improvement Center) (El Batan, Mexico)
CIP	Centro Internacional de la Papa (International Potato Center) (Lima, Peru)
CIRAD	Centre de cooperation internationale en recherche agronomique pour le developpement (Montpellier, France)
CLAIS	Comision Latinoamericano de Investigadores en Sorgo (Latin American Commission of Sorghum Researchers) (Guatemala City, Guatemala)

CORAF	Conference des responsables africains et francais de la recherche agronomique (African and French Officials' Conference for Agricultural Research) (coordination by ISRA and IRHO)
EARSAM	Eastern Africa Regional Sorghum and Millet (Network) (coordination unit at SAFGRAD/ICRISAT, Nairobi, Kenya)
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuaria (National Agricultural Research Enterprise of Brazil) (Brasilia, Brazil)
ESCAP	Economic and Social Commission for Asia and the Pacific (Bogor, Indonesia)
FAO	Food and Agriculture Organization of the United Nations (Rome, Italy)
FSRI	Farming Systems Research Institute (Bangkok, Thailand)
IADS	International Agricultural Development Service (merged as part of Winrock International, July 1, 1985)
IARC	international agricultural research centre (within CGIAR system)
IBPGR	International Board for Plant Genetic Resources (Rome, Italy)
IBSNAT	International Benchmark Sites Network for Agrotechnology Transfer (Honolulu, USA, and Mayaguez, Puerto Rico)
IBSRAM	International Board for Soil Research and Management (Bangkok, Thailand)
ICA	Instituto Colombiano Agropecuario (Colombian Agricultural and Livestock Institute) (Bogota, Colombia)
ICAR	Indian Council of Agricultural Research (New Delhi, India)
ICARDA	International Center for Agricultural Research in the Dry Areas (Aleppo, Syria)
ICRAF	International Council for Research in Agroforestry (Nairobi, Kenya)
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics (Patancheru, India)
IDRC	International Development Research Centre (Ottawa, Canada)
IFDC	International Fertilizer Development Center (Muscle Shoals, USA)
IICA	Inter-American Institute for Cooperation on Agriculture (San Jose, Costa Rica)
IITA	International Institute of Tropical Agriculture (Ibadan, Nigeria)
ILCA	International Livestock Centre for Africa (Addis Ababa, Ethiopia)
INGER	International Network for Genetic Evaluation of Rice (previously IRTP, coordination unit at IRRI)
INIBAP	International Network for the Improvement of Banana and Plantain (Montpellier, France)
INIFAP	Instituto Nacional de Investigaciones Forestales y Agropecuarias (Research Council for Forestry, Agriculture, and Animal Science) (Mexico City, Mexico)
INRAN	Institut national de recherches agronomique du Niger (Niamey, Niger)
INSFFER	International Network on Soil Fertility and Fertilizer Evaluation for Rice (coordination unit at IRRI, forerunner of INSURF)

INSURF	International Network on Soil Fertility and Sustainable Rice Fanning (coordination unit at IRRI)
INTA	Instituto Nacional de Tecnologia Agropecuaria (Buenos Aires, Argentina)
IRHO	Institut de recherches pour les huiles et oleagineux (Research Institute for Oils and Oilcrops) (Paris, France)
IRRI	International Rice Research Institute (Los Banos, the Philippines)
IRTP	International Rice Testing Program (coordination unit at IRRI) [recently renamed International Network for Genetic Evaluation of Rice (INGER)]
ISC	ICRISAT Sahelian Center (Niamey, Niger)
ISNAR	International Service for National Agricultural Research (The Hague, Netherlands)
ISRA	Institut senegalais de recherches agricoles (Senegalese Agricultural Research Institute) (Dakar, Senegal)
NACA	Network of Aquaculture Centres in Asia (Regional Lead Centre, Tigbauan, Philipines, Project Coordinator, Bangkok, Thailand)
NARS	national agricultural research system
NFTA	Nitrogen Fixing Tree Association (Honolulu, USA)
NGO	non-governmental organization
OAU	Organization of African Unity (Addis Ababa, Ethiopia)
ODI	Overseas Development Institute (London, England)
OPSCAR	operational scale research
PANESA	Pastures Network for Eastern and Southern Africa (coordination unit at ILCA)
PCARRD	Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (Los Banos, the Philippines)
PCCMCA	Programa Cooperativo Centroamericano para el Mejoramiento de Cultivos Alimenticios (Central American Cooperative Programs for Food Crop Improvement) (Panama City, Panama)
PRACIPA	Programa Andino Cooperativo de Investigacion en Papa (Andean Co-operative Program for Potato Research) (Lima, Peru)
PRECODEPA	Programa Regional Cooperativo de Papa (Regional Cooperative Potato Research Program) (centred at CIP)
PROCISUR	Programa Cooperativo de Investigacion Agricola del Cono Sur (Cooperative Program for Agricultural Research in the Southern Cone Countries) (Montevideo, Uruguay)
RIEPT	Red Internacional de Evaluacion de Pastos Tropicales (coordination unit at CIAT)
RISPAL	Red de Investigacion en Sistemas de Produccion Animal en Latinoamerica (Latin American Research Network for Animal Production System) (coordination unit at IICA)
SACCAR	Southern Africa Centre for Cooperation in Agricultural Research (SADCC, Gaborone, Botswana)

SADCC	Southern African Development Coordination Conference (Committee) (Gaborone, Botswana)
SAFGRAD	Semi-Arid Food Grain Research and Development (Project) (Ouagadougou, Burkina Faso)
SATCRIS	Semi-Arid Tropical Crops Information Services (ICRISAT)
SMIC	Sorghum and Millets Information Center (ICRISAT)
SPAAR	Special Program for African Agricultural Research (Washington, USA)
STRC	Scientific, Technical, and Research Commission (within OAU)
SUAN	Southeast Asian Universities Agroecosystem Network (Honolulu, USA)
TCDC	Technical Cooperation Among Developing Countries (within UNDP)
UNDP	United Nations Development Programme (New York, USA)
UNESCO	United Nations Educational, Scientific and Cultural Organization (Paris, France)
USAID	United States Agency for International Development (Washington, USA)
USDA	United States Department of Agriculture (Washington, USA)
WAFSRN	West African Farming Systems Research Network (coordination unit at SAFGRAD)
WARDA	West Africa Rice Development Association (Bouake, Cote d'Ivoire)



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