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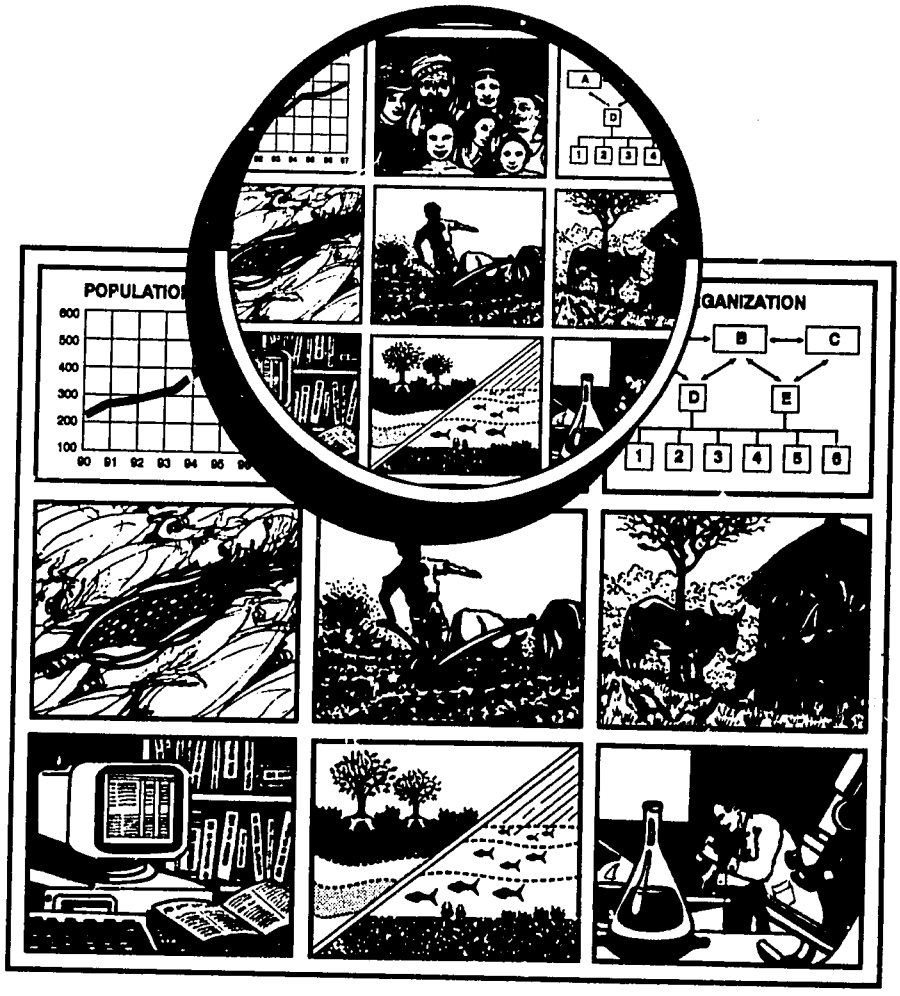
THE SCALE AND SCOPE OF NATIONAL AGRICULTURAL RESEARCH IN SMALL DEVELOPING COUNTRIES: CONCEPTS AND METHODOLOGY

Pablo Eyzaguirre



isnar SMALL-COUNTRIES STUDY PAPER #1

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AGROVOC Descriptors

management; organization of research; planning; research; research policies; small countries

CABI Descriptors

agricultural research; management; organization of research; planning; research; research policy; small countries

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ISNAR Small-Country Project

Introduction

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

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

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

Objectives of ISNAR's "Small-Countries" Project

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

Project Activities

A Global Data Base on NARS in Small Countries

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

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

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

Country Case Studies

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

Regional Studies

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

Methods and Concepts

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

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

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

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

Managing Scientific Information

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

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

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

Dissemination of Results

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

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

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

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Preface

The methodology for the analysis of national agricultural research systems (NARS) in small countries consists of three parts. Part one contains the statement of the problem, the definition of small-country NARS, and the sample of countries that are the focus of the study. It also defines the objectives of the study.

Part two is the analytical methodology. It defines the concepts to be used in the study, provides common terminology, and classifies the areas of information needed to conduct the analysis. The approach is to employ concepts that allow us to match information about the demand, capacity, and objectives of national agricultural research with the broader regional and global environment in which it takes place.

Part three defines specific categories of information needed to substantiate the analysis and conclusions of the study. The data fields as defined in part three are also used to compile a global data base on agricultural research in small countries that can be used in decision-making frameworks or to generate working hypotheses about maximizing the effectiveness and efficiency of small-country NARS.

The ideas in this document were presented for discussion at the International Workshop on Issues and Methodology for the Analysis of National Agricultural Research Systems in Small Countries, held from 29 January to 2 February 1990 at ISNAR in The Hague. A distinguished group of external advisors, case-study leaders, and ISNAR staff participated in discussions on the problems of agricultural research and the concepts that were presented. The result of these discussions was a more concrete method to analyze the constraints and to explore the potential for effective and efficient agricultural research systems in the service of national development. I thank the group for their contributions, and any weaknesses in the approach being presented are the responsibility of the author. It is hoped that continuing work with research leaders in developing countries will bring us even closer to our goal of improved research and more appropriate technological solutions to the problems of poverty and low productivity in the agricultural sectors of small developing countries.

The value of the methodology presented here is to be measured in the usefulness of its application. Are the issues identified those that affect the development and organization of research systems in small developing countries? Are the concepts presented applicable for the analysis of the conditions that affect our sample NARS? Are the concepts, as defined, likely to be understood and applied in comparable ways across the diverse range of countries and situations we are considering? Finally, do the categories of information as identified and classified here correspond to the information that is needed and available? These are the major areas in which the methodology is to be evaluated and applied.

This methodology is being used in seven country case studies: Honduras, Jamaica, Togo, Sierra Leone, Lesotho, Mauritius, and Fiji. In any collaborative research enterprise such as this, there is a trade-off between defining the fields of inquiry as narrowly as possible in order to ensure the comparability of results and to allow sufficient degrees of freedom to let the empirical situation tell the story. We have attempted to allow for comparison and to create a common analytical language and procedure.

Each case examined under the common framework should tell a different story. The lessons, however, should be a point of reference for all the countries with which we are concerned. Where small scale has been a constraint to growth, this study should contribute new strategies and a set of options to enable NARS to play the strategic role that has been assigned to them in agricultural development.

Part I

Project Description and Objectives

Background

Importance of Agricultural Research in Small Developing Countries

Agricultural research systems in developing countries play a vital role in creating and adapting improved agricultural technologies, as well as advising national governments on agricultural development policy. To carry out these tasks, national agricultural research systems (NARS) not only need a strong scientific base, in the form of good scientists and equipment, but they must also be able to plan and manage their organizations, programs, and resources efficiently and effectively.

Farmers and researchers in small, low-income countries have the same needs and face the same range of problems that confront farmers and researchers in other developing countries. The small size of a country bears little reflection on the size and variety of the problems it faces. Geographically, small countries may contain several major agroecological zones. Their farming systems are often diverse and can include estate-based export agriculture, subsistence farming, and commercial food production. A demographically small country may also be ethnically and culturally diverse, which can be an obstacle to institution building and communication. The strong feelings of national autonomy and independence and the problems these entail in promoting regional cooperation are no less influential in small countries than in larger ones.

Producers in small countries need the technological benefits that agricultural research generates, but the resources available to a small country's NARS are much less than those available to a larger country, and this necessarily limits the scope of the research effort. New strategies must be developed so that NARS in small countries can not only make the benefits of research available to their own farmers, but also contribute to the world knowledge on agriculture.

Small countries need to find ways to take full advantage of the scientific and development resources available at regional and global levels. One important option they have is to borrow technology from outside the country. To do this wisely and efficiently, small countries must identify their specific needs, the potential of their agricultural sectors, and the socioeconomic conditions of their producers and consumers. However, because small countries face problems that are just as complex as those of larger countries (if not more so), they often must invest an even higher proportion of their resources into understanding specific local problems and obtaining and testing internationally available technologies than larger countries. It is also probable that the relative allocation of resources to research and the national scope of research may be different for small countries.

Defining a Small Country

Small is a relative term that can be applied to a wide range of countries, depending on how it is defined. Any definition of a *small country* is valid only in relation to its intended use and context. For the purposes of this project, a particular country has been defined as small because the absolute size of the economy and agricultural sector, as well as available human and financial resources, is likely to place limits on the size and type of agricultural research system that can be maintained. Because of this inherent limitation in research scope and capacity, the tasks, functions, and priorities of small-country NARS may need to be quite different from those of larger countries.

If the term *small* is to be used consistently in this ISNAR project, it is important to begin with objective criteria. In order to identify small, low-income countries in which agriculture is key to economic development, five criteria were applied to all independent countries in the world, using 1980 statistics.

Population

Countries that had fewer than five million inhabitants, based on the 1980 census, meet our first criterion. Ruttan has argued that these countries pose a special case for the structuring and organization of research systems (Ruttan 1986, p. 321). Major international organizations that compile statistical data on the problems of small developing countries, such as the Commonwealth Secretariat, have consistently used five million as the cut-off point in defining countries whose small size poses a distinct problem for economic development (Commonwealth Secretariat 1989).

Per Capita Income

Countries where the per capita income is less than $2,000 (1980 US$) meet the definition for low-income countries for our purposes. This level of income also serves to direct attention to those countries most in need of assistance.

Economically Active Agricultural Population

Countries that have an economically active agricultural population that is equal to or greater than 20 percent of the total economically active population are countries with relatively large agricultural populations. This means that a significant sector of the population will be affected by improvements in agricultural productivity and agricultural income.

Agricultural GDP

Countries with an agricultural sector composed largely of low-income farmers are selected when the per capita income of the economically active agricultural population is less than or equal to $2,000 (1980 US$). This corresponds to ISNAR's priority for assisting countries based on need and equity.

Agricultural Domestic Product

Countries where the agricultural domestic product is greater than or equal to 20 percent of GDP have significant agricultural sectors. Promoting agricultural productivity through research is therefore likely to have a significant impact on national development. This parameter also eliminates small but mineral-rich countries that have the financial resources to invest in agricultural research and training, should agriculture assume importance in their development plans.

Appendix table 1 lists the parameters used to define the initial category of small countries that the project will address. Appendix table 2 provides additional information on the size and expenditures of

the small-country NARS. For some countries, there were no data available on all the criteria for selection. These countries were not excluded on this basis, however. Indeed, the dearth of reliable information on small countries justifies the focus of the project. One of the project's immediate goals is to gather, validate, and interpret information relevant to agricultural development, research policy, and organization in these countries.

It should be noted that statistical parameters such as those used here should always be used with caution. Available data measure only a fraction of the agricultural activity in most of the small developing countries. Furthermore, the data are subject to the varying definitions and counting techniques used in developing countries. And, finally, the economic picture of small countries can be significantly distorted by development aid, a few high-value exports, or tourist industries when officially compiled aggregate statistics based on national accounts are used.

Nonetheless, these parameters provide a useful starting point as a relative measure of the size of small developing countries with significant agricultural sectors, as well as providing a basis for ranking them.

The end result was a group of 50 small countries (see the map on the next page). Each country had a 1980 population of fewer than five million and met at least three of the four remaining criteria..

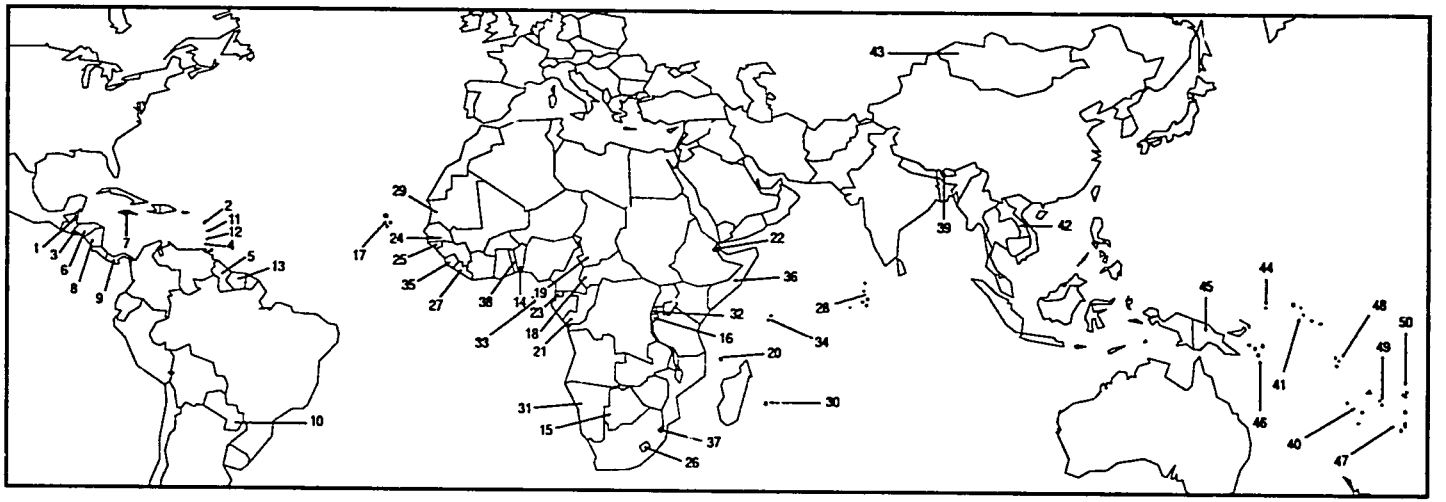
ISNAR's Role in Developing National Agricultural Research Systems in Small Countries

ISNAR's mandate is to assist in strengthening the capacity of developing countries to plan, organize, and manage their agricultural research systems. The need to strengthen NARS in smaller developing countries has been recognized as an important part of that mandate, and the critical importance of ISNAR's role in developing NARS in small countries has been widely recognized (Ruttan 1986, p. 323).

As part of ISNAR's advisory service to NARS, reviews to identify research system constraints in the areas of policy, organization, and management have been carried out in Burundi, Fiji, Laos, Papua New Guinea, Solomon Islands, Western Samoa, Guyana, Panama, Rwanda, Lesotho, and Botswana. There has also been a review with CARDI (the Caribbean Agricultural Research and Development Institute). Assistance in research policy and planning has been provided to the agricultural research systems in The Gambia and Guinea-Bissau. As a result of both system reviews and follow-up activities, ISNAR continues to improve its capacity to assist NARS in small countries.

As part of its training program, ISNAR cosponsored an international workshop on agricultural research policy and organization in small countries in 1984 (ISNAR 1985). Regional workshops are another valuable tool used by ISNAR to develop the organizational and management capacities of NARS leaders in small countries. For example, in 1987 IRETA (Institute for Research, Extension and Training in Agriculture) and ISNAR presented a workshop on the organization and management of agricultural research in the South Pacific region which was held at the University of the South Pacific. In 1988, ISNAR and SACCAR (Southern Africa Centre for Cooperation in Agricultural Research) presented a two-week regional workshop on agricultural research management for re-

SMALL COUNTRIES : A GLOBAL STUDY OF AGRICULTURAL RESEARCH SYSTEMS



LATIN AMERICA & CARIBBEAN

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

AFRICA & INDIAN OCEAN

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

ASIA & THE PACIFIC

39 Bhutan
40 Fiji
41 Kiribati
42 Lao P.D.R.
43 Mongolia
44 Nauru
45 Papua New Guinea
46 Solomon Islands
47 Tonga
48 Tuvalu
49 Vanuatu
50 Western Samoa

Source : ISNAR 1990

search leaders from Botswana, Lesotho, and Swaziland.

To further address the challenges and constraints facing agricultural research systems in small developing countries, as well as to help them exploit some of their inherent advantages, ISNAR has launched a two-year research project. It is a collaborative effort aimed at developing management strategies, tools, and organizational mechanisms that NARS managers can use to make the benefits of agricultural research fully accessible to their countries.

Donors and technical assistance agencies have also had to cope with the high costs of assisting small-country NARS in relation to the size of the research system and agricultural sector. The need to develop a special approach for work in small countries is clear (TAC Secretariat, FAO, CGIAR 1985). This project will also produce guidelines that will help donors as well as ISNAR target assistance more efficiently to small-country research systems.

This is imperative, given the growing demand for agricultural research in the developing world and the limited resources that ISNAR, donors, and development agencies have to respond to the demand.

The objectives of the ISNAR study are

1. to create and maintain a data base on 50 small countries, containing information on their agricultural research needs and national agricultural research systems;

2. to devise ways of measuring and classifying key factors related to agricultural research in order to analyze and compare NARS of small countries. These factors include agroecological zones, the scale of the research system (e.g., sizes and types of institutes, kinds and quantity of local research programs and expertise), internal demand for technology, external sources of information on new technologies, and linkages to those sources;

3. to identify suitable organizational models for NARS, as well as mechanisms and strategies for setting priorities and allocating resources to research;

4. to evaluate national and regional research environments in order to help small countries exploit opportunities for acquiring new technologies from outside;

5. to identify mechanisms to enable NARS to manage their links with policymakers, local producers, and external sources of knowledge and technology;

6. to identify the skills needed by small-country research leaders to manage the alternative strategies available.

Critical Issues for Small-Country NARS

Work at ISNAR has uncovered several issues that are critical to the operation of NARS in small developing countries. The project research team will study these issues in detail, so that they can develop practical guidelines to assist NARS leaders in planning, organizing, and managing their organizations.

Borrowing Technology: Sources, Links, and Adaptation

Since small-country NARS depend heavily on external sources of knowledge and technology, the project will review and analyze the effectiveness of the various types of research networks in small countries. We expect to find a variety of networks with differing foci and advantages, depending in large measure on the national and regional contexts of the countries concerned.

There are a number of strategic considerations that small-country NARS must keep in mind if they are to exploit the benefits of external sources of knowledge and technology:

1. What should their level of research be? Should it be applied/adaptive/testing, adaptive/testing, or testing only?

2. For what purpose are they interpreting world science and technology?

   a. Is it to keep policymakers better informed?

   b. Is it to help in determining choices for borrowing technology?

   c. Is it to help with networking and to increase benefits from research spillovers?

3. How and to what extent should they cooperate with the NARS of neighboring large countries in similar agroecological zones? And how will this cooperation affect their own autonomy and identity?

4. Should they work to develop a consortium of small-country NARS within a region (i.e., Pacific Islands/Caribbean/Indian Ocean/West Africa/ Southern Africa)?

   a. How are the problems of limited resources handled in such a group?

   b. What kinds of problems are there with communication and administration?

   c. How can they organize political cooperation? And what kinds of problems can be expected from linguistic, historical, and cultural differences?

5. What research capacity do small countries need in order to borrow technology?

   a. Can their research needs be met by technology transfer from international agricultural research centers and developed-country research systems?

   b. Would their research needs be better met by local research adapted to the low-input agriculture and/or specialized or restricted markets of small countries?

Size and Structure of NARS in Small Countries

A research system must already be in place before technology can be borrowed and adapted. Experience has shown that the ability to screen, borrow, and adapt scientific knowledge and technology requires essentially the same

capacity as it does to invent new technology (Ruttan 1986; Evenson 1977). The fact that a small-country NARS does not conduct basic or applied research does not obviate the need for an effective research system to deliver the appropriate technological products to farmers, regardless of the source.

Once the tasks and goals of small-country NARS have been defined in relation to their agricultural sectors and external sources of technology, the implications of these goals for the size of the NARS will be analyzed. The project will test the hypothesis that small-country NARS need to allocate a greater share of their resources to linkages — with external sources of knowledge and technology at one end and with producers at the other end.

Links to Producers

A small-country NARS must develop a thorough knowledge of its agricultural sectors and technologies if it is to identify specific needs for new technologies and appropriate methods for testing and adapting these new technologies.

Furthermore, collaboration with local farmers on research into existing agricultural practices, indigenous crops, and local resources may also enable scientists to identify ways to boost the economic value and productivity of traditional crops. This, in turn, can contribute to expanding the scope of agricultural development by diversifying the resource base and including a wider range of farmers.

Links to External Sources of Knowledge and Agrotechnology

Once a NARS has determined the need for new agricultural technology, it must identify sources of the technology and evaluate its potential for adaptation to local conditions. For small countries with limited potential for earning foreign exchange or highly elastic demand for their agricultural exports, it is crucial that a new technology not consume more foreign exchange than it generates or saves, regardless of net increases in production.

The following points should be considered whenever the possibilities of adopting new technology are being examined:

1. Sources of low-external-input agrotechnology may be more difficult to identify and obtain internationally than other forms of agrotechnology. It may be possible for small countries to do the research on this kind of technology themselves in a cost-effective manner.

2. The small-country NARS must have the capacity to evaluate, select, and adapt new technologies. Small countries need to define the level and costs of maintaining these links and information systems.

Internal Linkages of NARS and Links with Policymakers

Because of their small size, NARS in small countries may have a comparative advantage in efficiency and organizational effectiveness. A comparison of various types of organizations with a range of research programs will p ımit us to identify the organizational models that maximize the advantages of small-scale institutions.

Research Spillover and the Scope of Small-Country NARS

The project will identify ways for small-country NARS to take advantage of research spillovers.

Generally, NARS managers should do the following:

1. Identify the areas of regional and international research most likely to produce spillovers that can be captured at low cost by the national system (e.g., commodity, basic research) and ensure that such research is not being duplicated by the NARS. In this international division of labor, the needs and priorities of the small-country NARS should be in harmony with those of the international agricultural research centers.
2. Classify national zones by agroecological and agrarian characteristics in such a way that typologies that promote research spillovers can be developed within and across regions.
3. Determine the minimum levels of research, the institutional capacity, and the types of programs needed to borrow technology, exploit research spillovers, and benefit from research networks.
4. Evaluate the inherent limitations of a research system that depends on outside sources for its applied technology.

Agroecological and Agrarian Typologies and the Transfer of Technologies and Information: Implications for the Size and Organization of NARS in Small Countries

In order for the NARS to borrow effectively, national agroecological and agrarian zones must be properly classified. Once this has been done, the NARS will be able to adopt technology that was developed in and for comparable settings. NARS in small countries must therefore have a thorough knowledge of their respective agricultural sectors. This information should then be communicated to relevant

networks, centers, and other NARS. The project will investigate the type of organization and resources required for small-country NARS to perform this critical function.

Successful technology transfer depends ultimately upon the capacity of a country's agricultural sector to use it and benefit from it. The small countries that concern this project share a common constraint: they do not have the capacity to generate the foreign exchange required to obtain and use high-external-input technologies.

While considerable global research on low-external-input agriculture is under way, it has yet to be determined whether this type of technology and information are easily transferred and adapted, and if so, under what conditions. There are important organizational implications for the NARS if it turns out that the products of research on low-external-input agriculture are not easily transferred and that this research must be performed by the NARS itself.

The project will investigate the organizational structure and resources that NARS in small countries require to conduct this level of research. The analysis will also suggest possible alternative arrangements in the event that the size and resource constraints on small-country NARS limit the conduct of research on low-external-input agriculture.

Developing and Allocating Human Resources in Small-Country NARS

We can assume that small, resource-poor developing countries will at best have small agricultural research systems. The small scale of the NARS's component institutions produces a particular set of management problems. This project will identify these problems and develop strategies that exploit the advantages of small systems and minimize the human resource constraints inherent in small NARS. The following issues are important considerations for the project:

1. What are the relative demands placed on researchers by non-NARS institutions and nonresearch activities? Are these greater in small countries?

2. Is the human resource base (actual and potential) too small to permit a functional division of labor within NARS?

3. What constraints are there that would affect the ability to mount a viable research team for serious work on a single (major) commodity within the country?

4. What is the best allocation of human resources to effectively interpret world science on agricultural research and advise policymakers on the adoption of technology and on where to seek advice and borrow technology?

5. What is the best allocation of human resources to effectively define the scope, needs, and priorities for small-country NARS?

The following section outlines the four major concepts and the methodology to be employed in analyzing these issues. The method can then be tested in the planning and management of small-country research systems on a national or regional level.

Part II

Methodology: Analytical Concepts and Framework

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Introduction

The goal of the methodology is to analyze the factors that determine the scale of agricultural research efforts in small countries and relate them to existing and potential research objectives and activities. The methodology begins by defining the analytical concepts to be used. Given the range of countries that concern us, the use of common terminology and methods to generate comparable fields of information is essential. The concepts will be applied to the structure and environment of national agricultural research systems.

The result will be distinct levels of information that can be brought together under a single methodological framework. This framework can then be used to analyze the potential for agricultural research in small countries and the constraints it faces. Using this framework, research leaders and planners can structure their institutions and set their scope to bring the benefits of new agricultural technology to their farmers.

The procedure in applying the methodology is to collect, analyze, and match information from several broad areas. The following will be done:

1. Information will be collected about the demand for agrotechnology and the scale of the research efforts in our sample of small countries.

2. Information will be collected about the scale of the research system and about the national research objectives and activities that define the scope of the NARS.

3. The scale and scope of the NARS will be matched with global technology flows and regional technology gradients.

4. The scale and scope of the NARS's research efforts will be matched with its organization and structure.

5. Research activities that operate through linkages to external sources of knowledge, technology, or resources will be evaluated and matched to the organization and structure of the NARS.

Following the definition of concepts and mode of analysis, the methodology will identify the specific categories of data needed to complete the analytical and comparative fields of information.

This information is being compiled and stored in a large relational data base, which will be made available to establish a decision-making framework for NARS leaders. They will be able to use it to maximize the contributions their agricultural research institutions can make to agricultural development in their countries and regions.

One major justification of this project and approach is to bring small-country NARS into a full and active partnership in the global agricultural research system, but the methodology goes further. There may be niches of comparative advantage that small, efficient research organizations could occupy, and this methodology provides a basis for small research systems at optimal levels of effectiveness to find these niches.

Below is a list of some of the major analytical concepts to be used in the study of national agricultural research systems in small countries

- scale

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- scope
- technology gradients and information flows
- typology of agrotechnologies and research topics
- economies of scale
- economies of scope
- linkages to knowledge systems

Definition of the Scale and Scope of National Agricultural Research

Scale

Scale is a measure applied to the size of a research system, based on the level of available resources — human, financial, physical — and the way they are brought together to establish a given research capacity.

There are several terms that are linked to scale:

- resource availability
- size
- capacity
- potential output

The amount of financial, human, physical, and managerial resources that a small country with limited resources can allocate to its entire agricultural research program may not be as much as that given to four or five important commodity programs by larger countries. Small countries are faced with stiff competition for their limited resources from development programs, such as health, education, and social infrastructure, that are equally as important as agricultural research.

It is this small potential scale of the NARS that is the constraint that defines our sample of countries. And this size constraint obliges us to develop new models that will help NARS provide services to their clients in government and to the agricultural sector as effectively and efficiently as possible.

The project methodology considers the identification of scale as an objective measure, and it is the first step in the analysis. This entails careful consideration of the relevant criteria, such as availability of resources, the structure of research institutions, and the potential contribution of agriculture to national development.

The project data base on small-country NARS will contain these basic data, which can then be analyzed to determine the existing research capacity of a country. The principal output of the data collection and analysis will be a realistic determination of the scale of the national research effort, based on resource allocations that are sustainable over the long term.

Scope

Scope is the range and intensity of research activities that can be sustained by the NARS with the resources it has available to meet specific objectives of the system (Collion 1989; Dagg and Eyzaquirre 1989). This is normally measured as the number and type of commodities and research topics that are covered.

Terms that are linked to scope:

- objectives
- coverage
- focus
- program orientation

The question of scope is somewhat more subjective than the question of scale, and it requires informed judgment by research managers on how to set the scope, i.e., what types of research to conduct, which technologies and programs to focus on, etc. Scale denotes relatively fixed capacity or parameters and primarily concerns the availability of existing resources that can be allocated to a variety of objectives. Scope, on the other hand, is always defined by objectives and by the activities required to meet those objectives. The important thing about the determination of scope is that it is done after scale or capacity has been identified.

An examination of the choice of research goals is the first step in defining the scope of a research system. A realistic scope should define an area where relatively unhampered activities take place to achieve planned objectives. The scope should also be consistent with the mandate and role that government has assigned to research.

Identifying the Scale, Setting the Scope, and Improving the Effectiveness and Efficiency of Research

A major constraint on the scale of research capacity is finance. Several formulas have been developed for determining a sustainable level of resource allocation to agricultural research. The most widely used is expressed as a percentage of the agricultural domestic product (AgGDP). The World Bank has asserted that annual expenditure for research should be on the order of 2% of AgGDP (World Bank 1981). While the conceptual and empirical bases for such recommendations are not clearly established, it is nonetheless clear from applying this formula that low-income countries for whom increasing agricultural productivity is an important goal spend considerably less than 2% of their AgGDP on research. This level is in marked contrast to that spent by developed countries (Pardey et al. 1988). The problem of the scale limitation for small countries is that for many of them, their level of AgGDP is so low that even if they

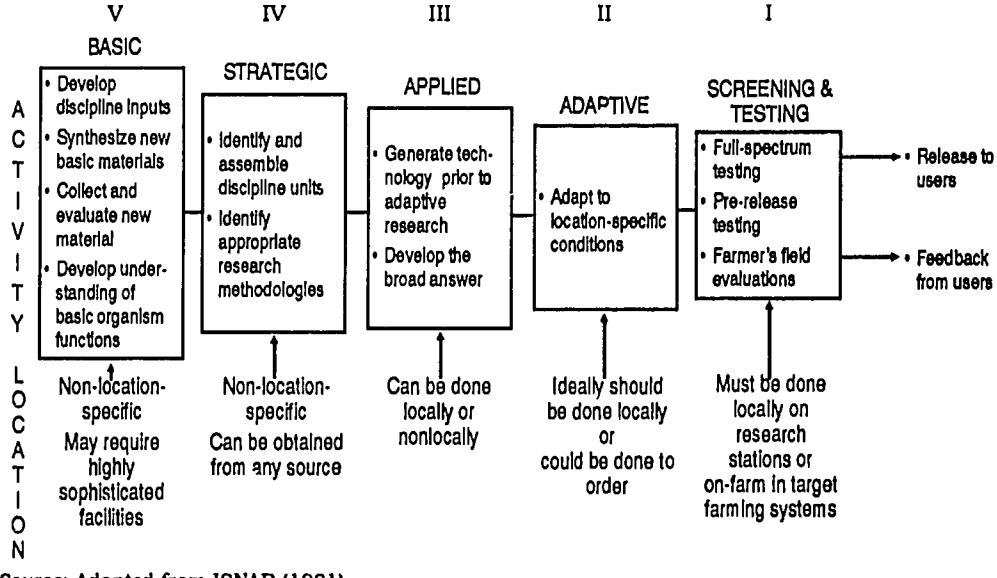
were spending the recommended 2% on research, it would still not be enough. Even with 2% of AGGDP, most of the NARS in our sample would not be able to sustain a research system capable of linking to world sources of knowledge and identifying appropriate technologies for their agricultural sectors.

For other countries in our sample, where agricultural earnings are greater and account for more than half of the GDP 2% of AgGDP may not be a realistic target for investment in research. This is because of the relatively large size of the agricultural sector and the limited fiscal capacity of the country as a whole.

In general, it is not realistic to expect major increases in the financial support for research to come from the public sector in developing countries (Elliott and Pardey 1988). This places an inherent limitation on research — one that must be taken into account in determining a sustainable scope and realistic intensity for a national research effort.

Scale Limitations and Type of Research

Small developing countries are not likely to have the scale of resources necessary to conduct basic research. Globally, most basic research is concentrated in larger, more industrialized countries, and even in those countries, basic research projects tend to be concentrated in a few institutions that can assemble the necessary resources and expertise. This leads us to conclude that the limited capacity and level of resources available in smaller developing countries imposes a rather fixed constraint on the types of research they can conduct. Most of their agricultural research will involve the adaptation and testing of technology. In some cases, applied research may be possible, particularly in areas of natural resource management.



Source: Adapted from ISNAR (1981).

Figure 1. Phases of agricultural research within a global agricultural research system

Table 1. Hypothetical Research Expenditures as Percent of AgGDP

Country	Ag GPD (1986) (X 1000 US$)	2% Ag GDP (X 1000 US$)
Belize	41,020	820
Benin	653,017	13,060
Botswana	44,919	898
Burundi	635,543	12,710
Bhutan	107,100	2,142
Cape Verde	27,930	558
Central Afric. Rep.	371,643	7,432
Chad	386,400	7,728
Comoros	63,840	1,276
Congo	114,669	2,293
Dominica	19,380	387
Djibouti	13,760	275
El Salvador	807,400	16,148
Equatorial Guinea	37,720	754
Fiji	225,310	4,506
Gambia	27,790	555
Guinea-Bissau	74,720	1,494
Guyana	110,300	2,206
Honduras	976,725	19,534
Jamaica	149,270	2,985
Kiribati	5,670	113
Laos	1,836,900	36,738
Lesotho	48,300	966
Liberia	368,000	7,360
Maldives	11,310	226
Mauritania	253,630	5,072
Mauritius	177,800	3,556
Nicaragua	668,133	13,362
Panama	478,600	9,572
Papua New Guinea	862,583	17,251
Paraguay	994,617	19,892
Rwanda	737,998	14,659
Sao Tomé & Príncipe	11,880	237
Sierra Leone	481,400	9,628
St. Lucia	22,635	452
St. Vincent	18,190	363
Surinam	93,260	1,865
Swaziland	97,060	1941
Togo	317,643	6,352
Vanuatu	23,460	469
Western Samoa	33,480	669

Source: World Tables (converted from LCU to US$ using the converston factor given in the World Tables).

Table 2. Percentage of External Funding for Agricultural Research 1984 or Latest Available Year

Country	Research Budget (1000 US$)	External Funding (%)
Benin	1,583	21[a]
Bhutan	350	80[a]
Burundi	4,300	75[b,c]
Cape Verde	120	85[a]
C.A.R.	4,200	90[a]
Chad	752	65[a]
Congo	5,500	62[a]
Fiji	5,830	25[c]
Kiribati	360	46[c]
Lesotho	1,451	81[b,c]
Liberia	1,650	75
PNG	6,096	22[c]
Sierra Leone	1,393	71
Solomon Islands	1,154	79[c]
Togo	2,777	39
Tonga	280	30[c]
Vanuatu	920	100[c]
Western Samoa	300	44[c]

Sources: West Africa Agricultural Research Review, World Bank, 1987.
Agricultural Research in the Asian and Pacific Region, Asian Development Bank, 1988.
a. 1984–1985.
b. ISNAR Review.
c. 1987–1988.

Establishing the Appropriate Scale for Research and Deriving Economies of Scale

ISNAR's project on small-country NARS should allow research managers to establish the upper level of research capacity in a given country. Efficiency and savings in the operation of research can then be calculated in relation to scale.

- Efficiency of scale implies utilizing close to the full capacity, since capacity is normally based on fixed or recurrent costs that must be paid whether they are being used or not. Underutilization is therefore costly and inefficient.

- Attempting to conduct operations on a scale that goes beyond the existing capacity of available facilities and institutions is also inefficient. When this is done, the objectives of the system are not likely to be met and the resources expended will be largely wasted.

Many of the small countries in our sample do not have universities with faculties of agriculture capable of producing agricultural scientists with postgraduate degrees. Developing the required scientific manpower therefore depends on donor inputs to train nationals. In many countries, a large percentage, if not the bulk, of operating costs for research is already borne by external donors, and much of the

infrastructure for agricultural research in small countries has been created with significant contributions from external donors. Some countries also have research facilities that were inherited from the colonial period, when these institutions also had a larger regional mandate.

Matching the external resources available to the NARS with a scale of effort and infrastructure that the country can sustain is a major task for NARS, and it remains a central aspect of strategic planning efforts in small developing countries. ISNAR's project on small-country NARS will provide an analytical framework that can be used to identify the relevant areas of information needed to set the appropriate scale or upper planned capacity of national agricultural research.

One way the scale limititation can be overcome is through a pooling of resources at the regional level — through collaborative research activities and regional networks and the establishment of regional research institutions. The effectiveness and feasibility of such an approach deserves closer scrutiny, however, particularly in regions where there are severe limitations on the resources available to research among *all* the collaborating countries, as in the case of the South Pacific. Another problem of aggregating national efforts at the regional level concerns the problems of priority-setting and division of labor among NARS within the regional context.

These types of collaborative activities pose specific problems for the management of NARS in small-countries.

Setting the Scope to Maximize the Efficiency and Impact of Research

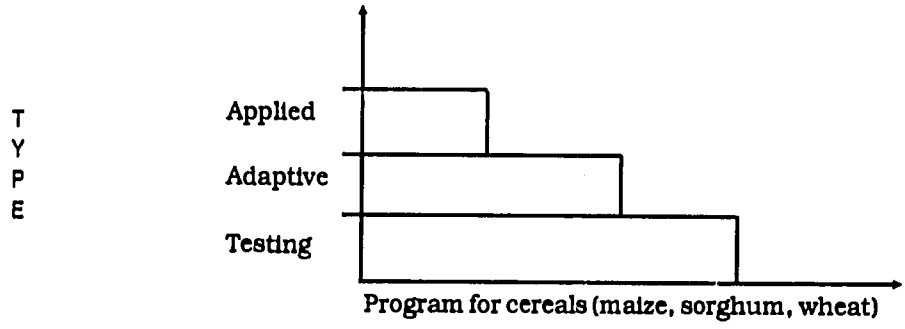
Setting the scope operates on two dimensions. One is the type of research, whether it is basic, strategic, applied, adaptive, or testing. The other is the range of possible programs and disciplines that can be covered by the given research capacity (scale). Important factors that must be considered in choosing among the range of programs are the actual technologies to be developed and the existing flows of information, resources, and technology that are available for the particular program or focus.

While scale places fixed limits on the level of research, there is a wide range of choice as to where the research operations should be focused and how they should be organized. These are decisions that research managers must make in consultation with policymakers, stakeholders, and clients. It involves selecting among a range of possible research programs and objectives, organizing them, and then making the appropriate links (to components in government, to the agricultural industry, and to direct clients) in order to achieve their goals. Just as there are economies of scale based on making full use of existing capacity, there are economies of scope that involve selecting areas of research in which the NARS is likely to achieve its goals, make the best use of linkages and technology flows, and have the greatest impact.

The choice of scope will always be limited by scale. However, even at a small scale, 20 to 40 researchers, the system can work efficiently and provide many new agrotechnologies, depending on how the scope is set. Setting the scope, therefore, involves selecting and grouping research activities — programs — in order to maximize the effectiveness and efficiency of the research system.

We can consider a simple matrix of possible research objectives — in the form of programs and types of research: applied, adaptive, testing.

This matrix schematically demonstrates that at any given scale or research capacity, the scope of effective research narrows as NARS engage in higher-level work. For example, let us say that two breeders,



and one soil scientist, plant pathologist, entomologist, and socioeconomist are available for work on cereals. With the same level of resources, the team can maintain wide scope or coverage at the testing level.

At the adaptive level, coverage would be less wide. And at the applied level, only narrow coverage could be maintained. In other words, at the applied level, priority may have to be given to only one of the three cereals that are crucial to the nation's food security.

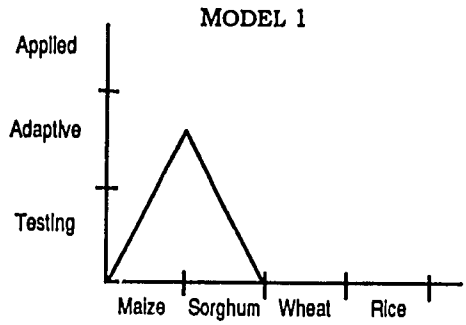
Even at the level of the individual commodity program, the question of scope must be considered when research is planned. Consider the example of a single, maize research program that is targetted for more than one agroecological zone. In addition to the scientific team for screening and adapting appropriate varieties, this program will require soil and water management teams, plus agronomic and socioeconomic research to address the diverse conditions of the target zones. All of this entails additional resources (such as technicians to supervise the trials, transportation, fuel, land, etc.) to run multilocational trials.

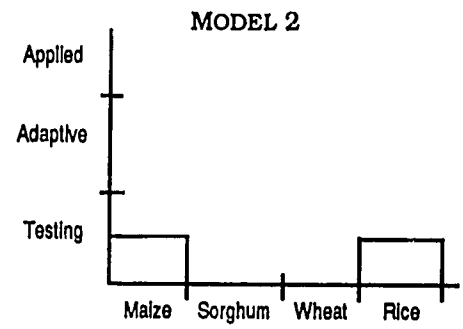
If these resources are beyond the scale of the existing research capacity, the activities will be hampered and the objectives will not be met. If this is the case, we must conclude that multilocational trials in diverse agroecological zones are beyond the scope of this NARS. By carefully considering the potential scale of operations, based on available resources, we can determine a realistic scope, one where the resources are available to allow the program to achieve its set goals.

Deriving "Economies of Scope"

Understanding how the concept of scope operates is important, not only to avoid overextending the research effort beyond its level of capability, but also to employ it to derive "economies of scope." To explain this concept, we may model the

problem in a slightly different way. Continuing with our example of the cereals program, we can set the scope to take account of potential spillover benefits between commodity programs.





By setting the scope of the program to cover two commodities with related requirements, such as maize and sorghum, the same resources in soil sciences, socioeconomics, pest management, and even breeding could be used to cover the testing level in both commodities and could also engage in some adaptive research. However, attempting to cover two commodities with widely different requirements, such as maize and rice, at this same level would go beyond the scale capacity of the system. This option is illustrated in model 2, which would have to maintain two separate teams of researchers to meet the testing and maintenance needs of maize and rice. This is because the technical requirements of research and production are quite different for these two commodities.

As one moves farther out the list of potential programs, there are fewer possibilities for economies of scope from sharing resources and spillovers between programs. The models illustrate where and how researchers and managers can decide on the appropriate scope and level of research, given the available resources, in order to take advantage of these economies and increase the effective coverage of the research system. This study of national agricultural research systems in small countries puts forward a decision-making framework that operates on the basis of economies of scope that are determined at the national program level — i.e., determining where spillovers between programs can increase research capacity at the same level of resources.

Identifying External Sources of Technology and Information

Having access to external sources of knowledge and technology is crucial to the development of small-country research systems. Sources of technology and information for research are varied and numerous (Biggs 1990). Identifying these sources and the mechanisms needed to evaluate their relevance and gain access to them are key functions of small NARS. Research leaders and

managers need to consider ways that regional flows of new technology and information may expand the scale or alter the scope of their research efforts. For example, if there is a regional international center producing technology for environments similar to those in country *A*, then the planned level of research in country *A* may be reduced to a testing level, provided that good linkages are maintained with the sources of technology. This may permit the NARS in country *A* to allocate greater resources to problems that are specific to the country but that are bypassed by existing flows of agricultural technology.

Classification of Research Topics and Agrotechnologies

To complete the model for determining the scope of NARS, we must include regional and global sources of agrotechnology and knowledge. The first step is to define and group agrotechnologies according to the existing network of technology sources, flows, availability, and distribution. In addition, the classification considers the processes that are intrinsic to the various research subjects, i.e., crops, natural resources management, socioeconomics, etc.

The rationale for this typology is based on similarities in the density and distribution of technology generation and transfer with respect to a set of agricultural commodities. Other noncommodity-based research themes or topics are also grouped according to the criteria of density and distribution of research activities and the transferability of research outputs. A diverse set of commodities may thus be included within a single category based on the fact that as a group, research on those commodities is either more or less available and widely diffused than it would be for another grouping.

Below is a list that groups and classifies agricultural research topics and commodities in order to identify the technology gradients and information flows that influence the scope of national research (see table 3).

- **Global staples**
  Global staples are major food crops with a global distribution, both in terms of production and in the distribution of sources and transfer of new technology. Typically, these crops are the focus of work by the international agricultural research centers. NARS and the private sector are also significant sources of technology information on these commodities. Information for research on these commodities is intensive and widely available to NARS.

- **Traditional exports**
  This category includes fibre, gum, and oil crops, stimulants, medicinal plants, and spices. These crops are historically produced for the global market, and research is distributed worldwide, with important contributions from the private sector. Within a more restricted channel, information on these commodities is widely and quickly available.

- **Minor food crops**
  These are crops that are locally important to the food producing sector within a country and are not a major com-

Table 3. Categories of Research Topics and Subjects

Global Staple	Traditional Export	Minor Food Crop	High-Input, Non-traditional Export	Livestock	Socioeconomics and Rural Engineering	Natural Resource Management
Bananas	Cashew nuts	Apples	Asparagus	**SMALL RUMINANTS:**	Farm production & management	Agroforestry
Beans	Cinnamon	Barley	Broccoli	Goats	Farm structures	Fisheries (fresh-water/marine)
Cassava	Cloves	Breadfruit	Brussels sprouts	Sheep	Farming systems research	Forestry
Cowpeas	Cocoa	Broad & mung beans	Cardamom		Marketing research	Pests, diseases, weed control and management
Groundnuts	Coconuts	Cabbage	Citrus	**LARGE ANIMALS:**	Postharvest and storage	Plant genetic resources
Maize	Coffee	Carrots	Flowers/ornamentals	Cattle	Machinery/tools/power irrigation	Range/pasture management
Potatoes	Cotton	Castor beans	Fruits	Horses	Rural engineering	Seed technology
Pulses	Oil palm	Chick peas	Ginger	Camels		Soil (fertility/erosion/conservation)
Rice	Rubber	Citrus fruits	Grapes	Donkeys		Irrigation/water management
Sorghum	Sisal	Date palms	Grapefruit			
Soya	Sugar	Figs	High-value vegetables	**POULTRY/SWINE:**		
Wheat	Tea	Fruits (local use)	Jojoba	Chickens		
	Tobacco	Garlic	Kava	Ducks		
		Lentils	Mangoes	Turkeys		
		Melons	Papaya	Swine		
		Millet (*Elusine, Digitaria*)	Passionfruit			
		Mustard (seed)	Peaches	Animal traction		
		Nectarines	Pineapples	Dairy technology		
		Oats	Plums	Diseases and pests		
		Okra	Pyrethrum	Husbandry and management		
		Onions	Quinquina	Nutrition/fodder/forage		
		Pandanus	Ramie (textile fiber)	Zootechnology		
		Peas (garden-)	Sour sop			
		Pears	Strawberries			
		Peppers	Sunflowers			
		Pigeon peas	Vanilla			
		Plantain	Ylang-Ylang			
		Radishes				
		Safflower (oilseed)				
		Sesame				
		Soya				
		Sunflowers				
		Sweet potatoes				
		Swiss chard				
		Taro (*Xanthosoma, Colocassia*)				
		Tomatoes				
		Triticale				
		Turnips				
		Vegetables (local use)				
		Yams (*Dioscorea*)				

ponent of a country's agricultural exports. New technology on these crops is either less readily available or is not specifically targetted to developing countries. Often, small countries have difficulty obtaining relevant information on these crops or find this information to be completely unavailable.

- **High-input nontraditional exports**
  These are crops that are grown primarily for export to consumers in developed countries. The major emphasis in production is on quality, uniformity, and timing, which necessitates a high level of inputs, controlled conditions, and special handling. Post-harvest considerations are particularly important. The private sector plays a major role in the generation and transfer of technology for these crops. Small-scale production may be economic, provided the distribution and marketing system is present. The private sector is a major source of new technology for this group of commodities.

- **Natural resource management**
  This category includes research topics that are not commodity based but are concerned with managing an existing resource, such as soil, water, plant, and fish stocks, with the aim of increasing, extending, or conserving the productivity of that resource. There is an inherent logic in conducting this type of research within the country, but it can be complex, even at what can be considered an adaptive level. Nongovernment organizations have played an important role in this type of research, with recent involvement of international agricultural research centers.

- **Livestock**
  Livestock research includes all topics related to animal production, i.e., zootechnology, animal diseases, fodder, nutrition, livestock management, etc. Principal sources of technology are international agricultural research centers and the veterinary services in more-developed countries.

- **Socioeconomics/rural engineering**
  This category includes research topics dealing with the management and allocation of resources to farm enterprises. It covers socioeconomic studies of farmer's choices and preferences, production, constraints, farming systems research, marketing research, storage, and farm structure. This research is country-specific and employs widely applicable methodologies.

We can illustrate the use of this classification scheme by considering the first group, which we call major global staples. These are the basic grains and foods that are the staples of rural peoples in many parts of the world, and the international network of agricultural research centers provides substantial coverage of them. Because of the global markets for these staples, the private sector also plays an important role in the applied and adaptive research on these commodities. In addition, most NARS in the developing world devote a major share of their resources to these crops. Consequently, the flow of technologies for the major global staples is vast, with gradients reaching nearly all developing countries.

In addition to the work of the CGIAR network, there are other centers of technology generation and diffusion (including many in the private sector) that conduct important work in edible oils, coffee, cocoa, tobacco, cotton and fibers, spices, and latex.

Each of the other types of agrotechnology is likely to have its specific sources and flows. New technology for high-value, nontraditional exports will probably have a more narrow range of sources, with greater participation from private-sector research. This means that a NARS may have to invest considerably more in establishing the linkages required to gain access to this technology and adapt it. In

other cases, such as in the smaller countries of Central America that export high-value vegetables, the private sector is able to provide an entire technological package — one that needs little or no adaptation.

The coverage of this global system of technology generation is vast, but what has yet to be mapped are the flows of new technology and the impediments to these flows. This knowledge is essential if national research systems are to develop the research policies and capability that can maximize the use of spillover from global sources of technology. What this methodology will provide to planners and managers in NARS is a basis for estimating the type of effort required to focus on and gain access to particular types of technology based on the structure of global sources and supply.

Agricultural Technology Gradients and Information Flows

A *technology gradient* refers to the different intensities in the generation and transfer of new agricultural technology from one country to another within the same region. In order for a national system to set the scope of its research, it should take into account the sources and flows of agrotechnology and information in the region. The *technology gradient* is defined in terms of those countries in a region that are foci for generating or introducing new technology and those countries or zones to which that technology can be easily transferred. For example, there are some countries that have a sizable capacity to introduce new technology to meet a strong demand from their agricultural sector, and they may have neighboring countries who could benefit from sharing this capacity. This flow from countries and centers where technology is generated to areas where technology use is less intensive is referred to as the *gradient*.

The approach taken in this study is to identify the factors that determine the gradient and govern the flow of specific technologies. The principal factor is the existence of technology-generating institutions within the region. These may be national or international in character, public or private. Their research focus may be general or confined to a single commodity or topic. And they may be, and often are, located in larger countries, where there is a greater research capacity and stronger demand for new technological inputs.

Zimbabwe in the Southern Africa region is a good example. It is a country that has a greater capacity to generate and introduce agrotechnology in maize than its smaller neighbors. There is also a high rate of adoption and diffusion of the new technologies it generates. We could say, therefore, that there is a steep gradient in maize technology between Zimbabwe — a high-intensity generator and user - and its neighbors in the region.

We employ the term *gradient* because it implies that agricultural technologies and information flow from countries where technology use and generation are highly intensive to those countries where it is less intensive, but there are certain conditions that must also be present:

Conditions That Define a Technology Gradient

1. The presence of institutions that generate agricultural technology among countries of the region with differing intensities of technology generation and use;

2. The kinds of agricultural technology being generated and its global and regional distribution;

3. Similarities in the agroecological conditions and agrarian structure of the countries involved.

Conditions That Affect the Flow of Technology and Information

1. Similar institutional arrangements and traditions in the organization of national institutions of science and technology, including the NARS;

2. Common language and similar sociocultural environments;

3. Political compatibility, especially among countries in a region.

The example of Zimbabwe was given above, and we can apply these conditions to its situation. A common language and traditions of science and technology are shared between Zimbabwe and the smaller countries of the region. The existence of the Southern African Development Coordinating Conference (SADCC) creates a favorable political and institutional climate for the flow of technology. And the countries involved have roughly similar environments for producing food grains.

Insufficient attention has been paid to specifying the institutional and historical factors that promote and facilitate the flows of technologies within a region and those actions that research planners or leaders may take to improve the flow. For example, it is often assumed that because of agroecological homologies and similarities in the agrarian systems and sociocultural practices of farm communities in the Sahel, technology will flow easily from research centers in northern Nigeria to research centers and extension in Niger or Chad — the neighboring francophone countries. We may find, however, that the results of agricultural research in northern Nigeria flow more easily to The Gambia and Sierra Leone because of the similar institutional backgrounds and common language of the NARS in those countries.

Where the technology gradient is very steep, we may find that there are few institutional factors or little culture or history to impede the flow. For example, the availability and use of agricultural technology in the Republic of South Africa is much higher than it is in the small countries that surround it. Despite the political cleavages and lack of institutional framework for collaboration in agricultural research and development, a great deal of new technology is informally introduced from the Republic of South Africa into the smaller SADCC countries.

The socioeconomic conditions of agriculture in the Republic of South Africa is markedly different from that in the SADCC countries, so the NARS of these countries must still play an active role in monitoring the flow of new technologies. If it is not adequately monitored, farmers might adopt new technologies that could prove inappropriate and wasteful, with grave consequences for the long-term productivity of the resource base (see ISNAR 1989).

Regional technology gradients need to be taken into account when countries are planning their national research. For example, Botswana, Lesotho, and Swaziland do not need to do any major restructuring of their systems in order to take advantage of new food-grain technology from Zimbabwe. This is because of their position on the gradient in the region. Because a gradient exists, the flow of technology will tend towards the

countries with less technology (Botswana, Lesotho, and Swaziland) as their demand grows. Relatively minor adjustments are all that are needed to direct the flow and then test and adapt the technologies.

Incorporating Technology Gradients, Defining Areas of Complementarity, and Deriving Economies of Scope

The methodology we are presenting provides analytical concepts along with a regional focus. This will enable us to understand the conditions that define the gradients for specific technologies that are the focus of research. There are several ways in which economies of scope can be realized. These include (1) understanding technology gradients in order to take advantage of research spillovers, (2) grouping researchers into commodity or systems programs, and (3) networking. NARS managers in small countries must be able to maximize these benefits in order to conduct efficient adaptive research. They should be able to use this framework for analyzing regional technology gradients as well as the required organizational linkages and institutional factors. And our principal areas of concern here are primarily policy, organization, and management.

Economic studies have emphasized the importance of an international and regional perspective and the identification of benefits from research spillovers (Davis et al. 1987; Evenson 1989). The methodology for incorporating intercountry or international spillover effects into analyses for setting priorities has been developed and tested in various contexts. There is, however, considerable variation in the intensity and efficiency of research efforts between countries and among commodities or research topics. In order to have a workable approach to priority setting, we need to do the following: (1) carefully map the specific technology flows and gradients between countries according to the commodities and topics that are the focus of research, (2) match this information with the scale and scope of national research systems in a region, and (3) consider the organization and structure of the research systems involved in order to evaluate the effectiveness of the linkages between technology-generating institutions.[1]

By classifying agrotechnologies into groups based on their global importance and distribution, we can begin to identify the programs that can be effective at a low testing level linked to existing technology flows. Other research programs in areas where the problems are country-specific and for which external sources of technology are not available will require a higher level of effort. The areas of agricultural

1. In applying the global framework for priority setting that considers intercountry research spillovers (Davis et al. 1987), an important assumption is made that makes it somewhat difficult to apply this framework to the small-country NARS with which we are working. The current model assumes that research output per unit of expenditure is likely to be constant. This assumption may be difficult to operationalize in NARS that are in the early stages of system building. Level of training, capacity, and output varies greatly among countries and even among commodities and is nowhere near the level of efficiency of the Australian Centre for International Agricultural Research, upon which the assumption is based.
We need to have more specific information about the research process and institutional arrangements within the NARS of small developing countries. Filling this gap in knowledge is a major objective of this study. The methodological approach is to match specific information on the structure and scope of a NARS with global technology flows and regional technology.

resource management, such as soil and water management, range and pastures, agroforestry, etc., are usually country-specific. Developing appropriate technological packages for these topics depends largely on a thorough understanding of the farming systems, ecology, and socioeconomics of land use in a specific country. In practice, resource management techniques are more difficult to transfer than new crop varieties or production inputs such as fertilizers, insecticides, and herbicides (TAC/CGIAR 1989).

All agricultural research systems, large or small, need to gather and assess basic data on the natural resource base of their own country in order to determine what technologies need to be developed or introduced. They must also constantly monitor their resource base, mainly soil, water, and vegetation, so that new problems may be identified and the potential of the research system may be addressed. Research at the national level on agricultural resource management is likely to spill over into other programs, thus making this type of research even more valuable.

Thorough knowledge of the agricultural resource base of the country will also contribute heavily to the success of any national research strategy based on borrowing and adapting existing agrotechnologies. This is because it enables researchers to select those technologies that are most appropriate to the agricultural environments and potential of the country. Inadequate knowledge of the resource base and the socioeconomics of agricultural production systems often results in poor choices, with inappropriate technology being borrowed and introduced to farmers.

With respect to natural resource management, this project will consider the minimum and optimum levels of effort required by a NARS. This study will also consider the possibilities of overcoming size constraints by considering the research scope according to agroecological homologies. Implementing a policy that recognizes results produced by research teams in ecologically homologous zones as immediate inputs to the NARS would permit a greater allocation of NARS resources to priority areas where no readily available technology exists.

By way of illustration, we may suggest that a small-country NARS make the following hypothetical changes in scope: (1) establish complementarity with externally generated technology that is suitable, accessible, and easily adapted to local conditions, (2) maximize spillover benefits, and (3) expand the scope of national research in the areas of comparative advantage.

The preliminary survey of research topics in our sample of small developing countries shows that many national systems tend to focus their efforts along lines similar to the global system in general, i.e., in breeding programs in global staples and traditional exports. There is at the same time a pronounced deficit in those areas where technology is not readily available or has not been adapted to small developing countries or in those areas where research needs to be location-specific. We propose the following schematic diagram of a national agricultural research system that seeks complementarity with technology gradients and maximizes the comparative advantage of in-country research efforts.

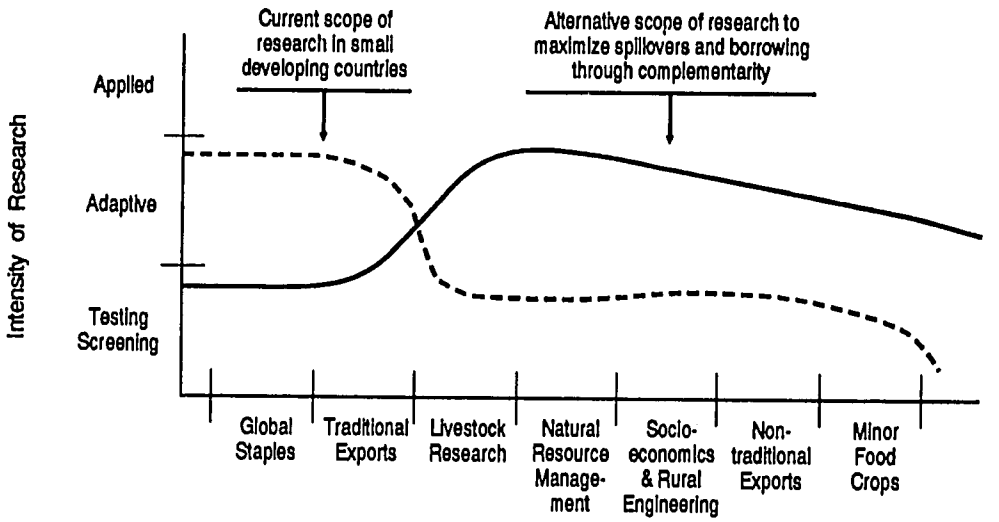


Figure 2. Schematic diagram of the scope of national agricultural research in relation to regional and global flows of agrotechnology

Linkages to External Sources of Technology and Knowledge

Determining the NARS Capacity to Borrow Intelligently

Borrowing technology has been widely accepted as the strategy for small-country NARS, but the criteria for determining the research capacity that needs to be in place for small countries to borrow effectively have not yet been specified. What we do know is that the capacity to make use of existing sources of new agricultural technology is often not present in small-country NARS. Even collaborative research networks tend to bypass smaller countries with weaker research systems (Ruttan 1988).

The methodological approach of this project will contribute to developing workable criteria for identifying the research capacity needed for effective borrowing. This will be done by matching empirical information from the following four levels:

1. the existing national scientific capacity in terms of the scale of the research effort (based on availability of national resources for agricultural research);

2. the flow of technologies that affect the existing and potential supply and demand for research from the agricultural sector, and the relative complexity of the structure of that supply and demand (based on global and regional technology flows and gradients and the agroecological, agrarian, and economic conditions of agriculture in the country);

3. the structure and organization of the NARS and its internal linkages to policymakers and users;

4. the external linkages that affect the NARS (i.e., that provide resources and influence NARS policy and program focus).

External linkages with world sources of technology and knowledge are extremely important for small-country NARS that concentrate on adaptive research and testing (Gilbert and Sompo-Ceesay 1988). However, many small-country research systems are not presently set up to form or use these linkages effectively. One problem is that the scientific capacity required has been underestimated. This capacity is necessary for appropriate decisions about borrowing technology to be made and for external sources of technology to be identified. It is a common misconception that since researchers in small countries do not generate technology, most of them do not need training above the level of the BSc, with a minority of MSc holders, and very few PhD holders.

This misconception is confirmed by the preliminary data available in our data base, which shows that researchers in our sample of countries have a lower level of training than those in developing countries in general. However, the implications of our analysis are that the complexity of the tasks and decisions to be made in small-country NARS call for highly trained researchers who can manage a wide range of linkages and a broad research agenda. In a small system, each researcher is required to operate at a higher level within the national policy environment, as well as serving as a link with the global community of agricultural scientists.

External Linkages and the Building of a National Research Capacity

NARS in small counties participate in many collaborative efforts. They are linked to regional research networks, networks of international agricultural research centers, and commodity and subject-matter networks. Given the limited scale of small-country NARS and the demands of networking on their scarce resources, there are several questions that need to be answered by this study.

1. What research capacity does a a small country need in order to benefit from a research network (without risking its own scarce resources to test technologies that it will not use)?

2. What criteria are needed for deciding when to enter into a collaborative network and upon which subject or commodity to focus?

3. What organizational mechanisms will allow a small country to participate as a full partner in a network involving larger countries?

4. How can several small countries with limited NARS merge their efforts to create a regional technology-generating capacity that will meet the major goals of all of them?

The methodology will gather information and examine the range of linkages and networks in which our sample countries participate. The national research capacity invested in networking will then be compared with the capacity invested in priority research areas at the national level. The study can then look at ways to determine how a research network contributes to expanding the scale of the NARS in a manner that is consistent with national research objectives — without expanding the scope of the NARS beyond the level of long-term sustainability.

The Organization and Structure of NARS and the Implications for NARS Linkages

Given the size limitations for NARS in small countries, they tend to focus on the adaptive and testing level. There are specific implications for NARS linkages at this level because this kind of research requires close collaboration between researchers, extension workers or district agricultural officers, development projects, and farmers.

Another premise of this approach is that the linkages between the NARS and external sources of knowledge and technology will have to be strengthened.

NARS in small countries will also need to strengthen their linkage to clients, government, and producers. This is because much of the technological output of the system will be screened and transferred directly to users, with little transformation by the research system. A larger share of the limited resources of NARS in small countries may need to be allocated to organizing and maintaining these two sets of linkages (Sompo-Ceesay and Gilbert 1989).

This study will consider the various types of research organizations in each country, e.g., ministerial departments, autonomous government research institutes and parastatals, as well as commodity boards, universities, foundations, and research divisions within private companies. Each organizational type presents different opportunities and constraints for linking policymakers, producers, and external sources of knowledge and resources. They will be analyzed to ascertain how the ensemble of organizations that make up the NARS can be managed around a national policy for developing agricultural potential and maintaining the productivity of the available natural resources.

The link to policy is a key factor of organizational structure in small-country research systems. Research institutions have a major role to play in advising governments on options for agricultural development. Even in those areas where they do not themselves conduct research, public research organizations should play an important part in setting policy and coordinating the work of projects and other research components. Some organizations are structured in ways that foster dialogue and participation in the policy environment and facilitate the role of coordination. They are normally structured to link to top policy- and decision-making levels of government. Others are structured to maximize flexibility in research management and access to external sources of knowledge and resources but may have weaker links to the policy environment.

In countries where universities play a role in the NARS, there is a greater potential to acquire scientific information from a wide variety of sources, particularly in basic and applied research and the areas

of natural resource management and socioeconomics. Commodity boards and parastatals are particularly effective in linking research to production and in tapping the rich sources of technology and information that exist for traditional export crops such as sugar, coffee, cotton, etc. Private-sector research teams appear to be the best suited to exploit technology sources for high-input nontraditional exports, where marketing and post-harvest research (the socioeconomics/rural engineering category) is relatively more important.

A recent trend has been to establish private foundations for agricultural research and development. Foundations are often charged with bridging the interests of the private sector and the broad objectives of national development policy. By evaluating the effectiveness of the various types of institutions and the various categories of research topics, it will be possible to incorporate structural considerations that can improve the overall effectiveness and efficiency of the NARS.

CONCLUSIONS

This methodology has brought together four areas of information that are crucial to organizing more efficient and effective research systems in small countries. These areas are the scale of research institutions and resources in the country; the scope of the research efforts, their coverage and objectives; the technology gradients and information flows that are relevant to the national scope of research; and the linkages and organizational structure that maximize the benefits from flows of technology, resources, and information.

The key variables for analysis of the information are applied to each country and explained in the appendix. Applying the method should enable NARS leaders and planners to mobilize and coordinate all the available resources and organizations concerned with agricultural research in a given country. It then becomes possible to set realistic objectives and programs to define a scope that maximizes resources and the benefits from existing flows of technology and information.

Application of this approach is predicated upon the categorization of research topics and commodities into discrete categories. These reflect the way technology generation and transfer is organized globally for the various commodities and research topics. The effectiveness of the linkages needed to gain access to external sources depends on how the gradient for particular groups of technology is structured and the type of organization that links to it.

We hope to achieve two major objectives by applying this methodology. First, the approach should assist small countries in identifying the potential scale of their research efforts and set a scope of research (i.e., objectives and programs) that is consistent with this scale. Second, the method should allow NARS to manage and orient their research organizations in ways that maximize the benefits from global sources of knowledge and external resources.

The final result should assist small-country NARS in participating as full partners in the global agricultural re-

search system, both as beneficiaries of existing knowledge and as contributors of new knowledge on the productivity and sustainability of the world's agricultural resources.

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Appendix

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Appendix Table 1

Indicator Ratios of Economic Indicators, 1986

Country	GDP/TP	AgGDP/GDP	AgGDP/EAPA	EAPA/EAP	TOT POP (TP)
Africa					
Benin	316	49	500	65	4177
Botswana	877	5	178	66	1117
Burundi	254	51	268	92	4864
Cape Verde	334	25	481	46	338
Central African Republic	342	41	428	67	2638
Chad	163	46	270	78	5140
Congo	1,118	6	261	61	1787
Djibouti	956	4	105	79	360
Equatorial Guinea	204	46	370	60	401
Gambia	237	15	94	82	767
Guinea-Bissau	184	45	215	80	908
Lesotho	181	17	78	82	1583
Liberia	482	34	597	72	2249
Mauritania	465	30	652	66	1814
Namibia	560	—	—	38	1650
Rwanda	293	40	255	92	6312
Sao Tomé & Principe	440	27	457	67	100
Sierra Leone	303	42	553	65	3755
Somalia	147	65	319	73	6623
Swaziland	613	23	495	70	688
Togo	322	32	351	71	3055
Asia & Pacific					
Bhutan	151	51	189	91	1389
Fiji	1,879	17	2,299	42	703
Kiribati	—	—	—	—	65
Lao, P.D.R.	767	65	1,402	73	3683
Mongolia	—	—	—	34	1964
Nauru	—	—	—	—	8
Papua New Guinea	704	34	708	71	3605
Solomon Islands	427	—	—	48	279
Tonga	—	32.43	2	17	112
Tuvalu	—	—	—	—	8
Vanuatu	469	34	1,066	48	147
Western Samoa	655	31	4,185	15	165
Caribbean & Latin America					
Belize	1,228	21	1,900	36	167
Dominica	1,325	19	1,762	31	77
El Salvador	821	20	1,362	39	4846
Grenada	1,330	—	—	—	97
Guyana	535	21	1,329	24	971
Honduras	798	27	1,243	57	4532
Jamaica	1,026	6	462	29	2371
Nicaragua	858	23	1,557	42	3384
Panama	2,300	9	2,216	28	2227
Paraguay	909	29	1,623	47	3807

Country	GDP/TP	AgGDP/GDP	AgGDP/EAPA	EAPA/EAP	TOT POP (TP)
Caribbean & Latin America (continued)					
St. Lucia	1,451	12	1,258	30	130
St. Vincent	1,118	15	1,213	31	105
Surinam	2,589	9	4,441	17	380
Indian Ocean					
Comoros	332	42	378	81	458
Maldives	460	13	251	66	189
Mauritius	1,328	13	1,796	25	1051
Seychelles	2,962	7	—	—	60

Source: Small-Country Project Data Base, FAO sources.
Note: GDP=Gross Domestic Product..
AgGDP=Agricultural Gross Domestic Product.
TP=Total Population (in 1000s).
EAP=Economically Active Population (Total).
EAPA=Economically Active Population in Agriculture.

Appendix Table 2

Agricultural Research Expenditure per Scientist (1980 US$)

Country	Expenditure (mill. US$) 1980	AGDP (mill. US$) 1980	Exp./AGDP (%) 1980	No. of Scientists 1980	Exp./ Scientist (1980 US$)
Africa					
Benin	1.641	437	0.38	40	41.024
Botswana	3.298	82	4.02	40	82.462
Burundi	—	477	—	43	—
Cape Verde	—	17	—	—	—
Central African Republic	—	263	—	—	—
Chad	—	282	—	—	—
Congo	—	177	—	—	—
Djibouti	—	—	—	—	—
Equatorial Guinea	—	—	—	—	—
Gambia	—	50	—	—	—
Guinea-Bissau	—	53	—	—	—
Lesotho	—	72	—	—	—
Liberia	—	159	—	—	—
Mauritania	—	270	—	—	—
Namibia	—	—	—	—	—
Rwanda	—	533	—	—	—
Sao Tomé & Principe	—	13	—	—	—
Sierra Leone	—	308	—	—	—
Somalia	—	434	—	—	—
Swaziland	0.687	90	0.76	2	343.260
Togo	4.960	301	1.65	39	127.171

Country	Expenditure (mill. US$) 1980	AGDP (mill. US$) 1980	Exp./AGDP (%) 1980	No. of Scientists 1980	Exp./ Scientist (1980 US$)
Asia & Pacific					
Bhutan	—	—	—	—	—
Fiji	2.518	229	1.10	36	69.933
Kiribati	—	—	—	—	—
Laos, P.D.R.	—	—	—	—	—
Mongolia	—	—	—	—	—
Nauru	—	—	—	—	—
Papua New Guinea	9.518	818	1.16	107	88.949
Solomon Islands	0.350	—	—	11	31.847
Tonga	0.306	23	1.31	9	34.053
Tuvalu	—	—	—	—	—
Vanuatu	—	—	—	—	—
Western Samoa	0.160	—	—	8	19.972
Caribbean & Latin America					
Belize	—	35	—	15	—
Dominica	—	—	—	—	—
El Salvador	2.253	951	0.24	106	21.256
Grenada	—	14	—	2	—
Guyana	—	121	—	56	—
Honduras	0.971	629	0.15	71	13.674
Jamaica	—	212	—	49	—
Nicaragua	1.305	459	0.28	57	22.896
Panama	3.512	317	1.11	64	54.881
Paraguay	2.864	1211	0.24	53	54.032
St. Lucia	—	12	—	—	—
St. Vincent	—	7	—	5	—
Surinam	—	—	—	—	—
Indian Ocean					
Comoros	—	—	—	—	—
Maldives	—	—	—	—	—
Mauritius	—	121	—	72	—
Seychelles	—	—	—	—	—

Source: ISNAR indicator series, supplementary files, 1988.

General Description of the Data Base on National Agricultural Research Systems in Small Countries

The ISNAR Special Project on National Agricultural Research Systems in Small Countries has identified a sample of 50 countries whose size, scale, and limited resources require innovative approaches to NARS organization and strategy. Our goal is to provide a decision-making framework for NARS leaders and managers in those countries so that they can structure and orient their systems to provide crucial agrotechnologies for their agricultural sectors. The decision-making framework is based on information in the four areas outlined below.

There is also a coding for country ID, which is as follows (note that these are all alpha-numeric codes):

1. **Country Code:** The geographic country number code used by the United Nations and World Bank documentation services (AGRIS);

2. **Language:** The official language of the country;

3. **Former Colony:** The name of the former colonial power if the country received its independence after WWII (which covers both former colonies and protectorates).

I. Profile

Background country information and basic data on the economy, agroecology, resource base, and institutional development of each country

The profile data base is used to organize and store information related to the agroecology and economy of each of the 50 countries in our sample. For analytical purposes, the reference year for information gathered within a country must be consistent across fields. Economic statistics such as agricultural gross domestic product (AgGDP) and GDP are to be compiled from the World Bank (and/or Commonwealth Secretariat) tables. The common base year will be 1986, which will provide a complete set of figures across all fields. This will facilitate cross-country comparisons of the agroecology and economy of regions.

Field #	Field Name	Description
1	Total Land:	Total land surface given in thousands of hectares
2	Agricultural Land:	Total agricultural land, including the following: land under cultivation, land lying fallow, land previously cultivated and temporarily idle, and land planted in permanent crops, given in thousands of hectares
3	Irrigated Land:	Total land area purposely provided with water, given in thousands of hectares
4	Rainfed Land:	Total agricultural land minus irrigated land, given in thousands of hectares

Ecological Zones
(Percent of Agricultural Land in Zone)

Field #	Zone	Growing Season
5	WPWT: Warm Perennially Wet Tropics	365 days
6	WWT: Warm Wet Tropics	364–330
7	WHT: Warm Humid Tropics (equatorial)	329–270
8	HTH: Humid Tropical Highlands	365
9	WSDT: Warm Seasonally Dry Tropics	269–210
10	WSATL: Warm Semi-Arid Tropics (long)	209–150
11	WSATS: Warm Semi-Arid Tropics (short)	149–90
12	CTH1: Cool Tropical Highlands, modified by Altitude, Seasonally Dry	209–90
13	CTH2: Cool Tropical Highlands, modified by Altitude, Seasonally Dry	269–210
14	WAT/IT: Warm Arid Tropics/Irrigated Tropics	89–0
15	WST: Warm Subtropics Seasonally Dry	+150
16	WSTSA: Warm Semi-Arid Subtropics	149–90
17	WSTA: Warm Arid Subtropics	89–0
18	CST: Cool Subtropics Seasonally Dry	+150
19	CSTSA: Cool Semi-Arid Subtropics	149–90
20	CSTA: Cool Arid Subtropics	89–0
21	CSTH: Subtropical Highlands, Rainfall and growing season greatly modified by altitude	

Note: Zone description based on FAO agroclimatological data for Africa, FAO, Rome, 1984.

Cultivation System Typology
(Percent of Agricultural Land under Typology)

Field #	Field Name
22	Shifting cultivation system
23	Fallow system

24	Ley/mixed systems
25	Permanent rainfed system
26	Permanent irrigated system
27	Perennial single-stand system
28	Perennial mixed-stand system
29	Grazing systems

Note: See Ruthenberg (1980) for a definition of these typologies.

Agrarian Structure — Land Tenure

Field #	Field Name	Description
30	Agland comm/trad	Percent of agricultural land under traditional commodity export — estate or agroindustrial or plantation system
31	Agland freesmall	Percent of agricultural land under smallholder tenure and production
32	Agland freemedium	Percent of agricultural land under medium-sized smallholdings
33	Agland freelarge	Percent of agricultural land under large-sized freeholds
34	Agland tenant	Percent of agricultural land held under tenant farms
35	Agland estate	Percent of agricultural land held under plantation or estate management
36	Agland state	Percent of agricultural land held as part of state farms or state agricultural enterprises
37	Total Population	Total population in 1000s in 1986 (from World Bank and Commwealth Secretariat Small Country Data Tables)
38	EA Population	Economically active population in 1000s in 1986 (based on most recent estimates in World Bank Development Report and Commonwealth Secretariat Small Country Tables)
39	Ag. Population	Agricultural population in 1000s in 1986 — persons engaged in farming, forestry, fishing, or hunting (based on data from World Bank and Commonwealth Secretariat and from country reports)

Principal Crops
A. Name of crop — ranked by order of magnitude based on total hectares planted with the particular crop (from FAO 1986 production figures)

Field #	Field Name	Field #	Field Name
40	Crop1	45	Crop6
41	Crop2	46	Crop7
42	Crop3	47	Crop8
43	Crop4	48	Crop9
44	Crop5	49	Crop10

Principal Crops
B. Percentage estimation of each crop that is grown for Subsistence (S); Commercial (C) (meaning a cash crop that is primarily for national consumption); and Export (E). Note: the same crop may be classed as a subsistence, commercial, or export crop, based on the country situation.

Field #	Field Name	Field #	Field Name
50	C1S	65	C6S
51	C1C	66	C6C
52	C1E	67	C6E
53	C2S	68	C7S
54	C2C	69	C7C
55	C2E	70	C7E
56	C3S	71	C8S
57	C3C	72	C8C
58	C3E	73	C8E
59	C4S	74	C9S
60	C4C	75	C9C
61	C4E	76	C9E
62	C5S	77	C10S
63	C5C	78	C10C
64	C5E	79	C10E

Principal Crops
C. Of the principal crops identified in fields 39–48, indicate the production statistics (from FAO 1984 production and trade statistical yearbooks)

Field #	Field Name	Units	Field #	Field Name	Units
80	Crop1	000 hectares	92	Crop7	000 hectares
81	Crop1	000 metric tons	93	Crop7	000 metric tons
82	Crop2	000 hectares	94	Crop8	000 hectares
83	Crop2	000 metric tons	95	Crop8	000 metric tons
84	Crop3	000 hectares	96	Crop9	000 hectares
85	Crop3	000 metric tons	97	Crop9	000 metric tons
86	Crop4	000 hectares	98	Crop10	000 hectares
87	Crop4	000 metric tons	99	Crop10	000 metric tons
88	Crop5	000 hectares	100	Lg. Animals	000 head
89	Crop5	000 metric tons	101	Sm.Ruminants	000 head
90	Crop6	000 hectares	102	Swine	000 head
91	Crop6	000 metric tons	103	Poultry	000 birds

Principal Crops
D. Value of export crops in 1000s US$, ranked by value

Field #	Field Name	Field #	Field Name
104	Ag. Export 1	109	Ag. Import 1
105	Ag. Export 2	110	Ag. Import 2
106	Ag. Export 3	111	Ag. Import 3
107	Ag. Export 4	112	Ag. Import 4
108	Ag. Export 5	113	Ag. Import 5

Profile of Agricultural Economy

Field #	Field Name	Unit and Source
114	GDP	1000s of 1986 US$, World Tables
115	AGGDP	1000s of 1986 US$, World Tables
116	BOP	1000s of 1986 US$, World Tables
117	External debt	1000s of 1986 US$, World Tables
118	Intl. Reserves	1000s of 1986 US$, World Tables
119	Development Aid	1000s of 1986 US$, OECD
120	Export Divers.	(Index)
121	Export Concent.	(Index)
122	Cereal Imports	1000s of metric tons, OECD
123	Food Aid cereals	1000s of metric tons, OECD
124	Avg. FoodP/Capita	(Index), FAO

II: NARS

The NARS data base contains information on the national institutions that are responsible for conducting agricultural research. The NARS tables can be called up by the country codes under which they are entered. The tables begin with descriptive information of the whole NARS: information on the governance, and on the level and range of resources available to it. The NARS is labeled according to ISNAR's guidelines and models of organizational structure.

The data base then moves to the institutional level, with descriptive fields on the institutions that comprise the NARS. A system with a single research institution will have only one record; a more complex NARS will have multiple records. The remaining fields serve to give a detailed description of each institution. All statistics must be based on a consistent year, across fields, within a country, but not necessarily across countries. The year will be determined by the latest year of data that is available in individual country reports, not aggregated data sources.

Field #	Field Name	Description
1	Country Code	The code that links all the data tables by country and contains the basic country data
2	OS national (coded C, I, MIN, U, or M)	Here we are asked to indicate, at the national level, which of the following the organization and structure of the NARS best resembles: C = Council model I = Institute model MIN = Ministry model U = University model M = Mixed system P = Parastatal
3	Institution	Identifies the name of the institution within the NARS that is either fully or partially responsible for conducting agricultural research and which is being described in this record (This entry is repeated for each institution in the NARS.)

Information in fields 4–17 refers to the individual component institutions in the NARS.

4	OS INST. (coded C, D, F, A, or M)	The internal organization of the institution is identified in this field. Is it organized around one of the following: C = Commodities D = Disciplines F = Factors of production A = Agroecological zones M = Mixed or matrix of the above
5	Autonomy in managing resources (coded H, M, or L)	This field is included to indicate financial autonomy, distinguishing between high (H), medium (M), or low (L) (This is somewhat arbitrary, and better guidelines must be established to define these three levels.)
6	Autonomy in program (coded H, M, or L)	Here we are thinking about autonomy in terms of program — administering resources + designing programs; again, entered as high (H), medium (M), or low (L)
7	Budget	The budgeted amount of currency devoted to agricultural research, expressed in 1000s of current local currency units — year must also be included
8	Expenditure	Research expenditure figures represent the total amount of currency spent in a given year on research activities, expressed in 1000s of current local currency units — year of information should be consistent with the other financial information for the NARS
9	Recurrent	Recurrent expenditures (i.e., support costs, overhead, salaries, etc.) and opereational expenditures, expressed as percentages of the institution's total expenditure for the given year of the expenditure data
10	Capital	Capital expenditures are expenses that do not recur, often used in the development of the infrastructure of an institution (i.e., buildings, machinery, other equipment, etc.), expressed as percentages of the the institution's total expenditure for the given year of the expenditure data

11	National contribution	The percentage of the total expenditure of a NARS institution that is provided by national sources.
12	Donor contribution	The percentage of the total expenditure by a NARS institution that comes from external donor sources.
13	PhD	Number of PhDs or equivalents who are currently employed within the NARS, calculated in full-time equivalents
14	MSc	Number of MScs or equivalents who are currently employed within the NARS, calculated in full-time equivalents
15	BSc	Number of BScs or equivalents who are currently employed within the NARS, calculated in full-time equivalents
16	Expats	Number of expatriates currently employed within the NARS, calculated in full-time equivalents (This field has been included to assess dependency on external technical support.)
17	Research Type (coded as BS, Ap, Ad, or T)	A distinction is to be made between levels and types of research according to the following codes, which will indicate upon what area an institute has chosen to focus its research activities: BS = Basic/Strategic Ap = Applied research Ad = Adaptive research T = Testing
18	Total Researchers	
19	Technicians	
20-43		These fields have been reserved to identify specific commodities or topics that have been the focus of the institution's research; commodities/topics are grouped according to six separate categories: global staples traditional global exports high-value nontraditional export crops minor food crops animal production resource management research socioeconomics/rural engineering

III: LINKAGES

This data base has been developed to identify external (nonnational) institutions that contribute to or collaborate with the NARS institutions. This typically includes bilateral donor or technical assistance, regional and international centers and institutions, networks, and nongovernmental organizations. Each record will represent a single institution.

Field #	Field Name	Description
1	Country Code	Country codes will be able to recall basic background data common to all the country's data bases
2	Type of external institution	These include the following categories: ARC = Research council (Policy and coordination, not executing body) BDA = Bilateral development agency FOU = Research foundations (private sector) FTRI = French tropical research institutes FUNI = External university (external to the country in question) GOVT = Government (used where no specific institution/mechanism is identified) GRA = Government research organization (with mandate within agriculture) GRI = Government research organization (with mandate beyond purely agricultural research) IARC = International agricultural research center IO = International organization MNAB = Multinational agrobusiness NAB = National agrobusiness NARS = Applied to any organization identified as part of a NARS NGA = National development agency/local NGO PARA = Parastatal research organization/commodity board Proj = Ad hoc framework or projects PVO = Private voluntary organizations/foundations RO = Regional organization (not necessarily research) RRN = Regional research network RRO = Regional research organization RUNI = Regional university UNI = University (national)
3	Name	Identifies the institution — full names must be entered, not acronyms
4	Location	Name of the country in which the contributing or collaborating external institution is based (if it is not an international organization, such as the United Nations and its agencies) — country codes may be entered
5	Duration of collaboration	The exact duration of the formal agreement with the external institution, measured on a project basis (Multiple projects by a single institution will be counted as separate linkages.)

Field #	Field Name	Description
6	Resources 1 - 5	Type of resources obtained through collaboration, coded as follows: T = Technology (i.e., technology that is to be further adapted or developed for the benefit of the small country) F = Funding I = Information P = Personnel PR = Physical resources that are seen as capital goods donated to research activities TR = Training of personnel externally
7	Average Annual Contributions	The value of the contribution to the national system via external linkages, measured in current US$
8	Average annual person years	Detailed description of human resources, where *P* is the resource donated, measured in full-time equivalents; university personnel to be measured as 1/3 of a person

IV: LINKAGES—EXTENSION AND TECHNOLOGY-TRANSFER AGENCIES

This data base contains information on the linkages between the NARS and the national extension and technology transfer agencies. It indicates the institutional variety and focus of the technology transfer agencies. It does not contain information on their strength or capacity.

Field #	Field Name	Description
1	Country Code	AGRIS identification number
2	Name of technology-transfer organization	Name of organization
3	Type of organization	• government extension service • commodity board extension • parastatal • regional development agency • national agribusiness • multinational agribusiness • private voluntary organization • foundation • donor development project • nongovernmental organization
4	Commodity or topic focus of each technology-transfer organization	Refer to classification of commodities and agricultural research topics relevant to that country (see table)
5	Duration of mandate in technology transfer	• permanent • fixed term • occasional/ad hoc
6.	Link to research	This is a qualitative and not necessarily comparable evaluation of the link between the technology transfer agency and the NARS (based on interviews and published accounts): • formal • informal • not present