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RESEARCH MANAGEMENT GUIDELINES

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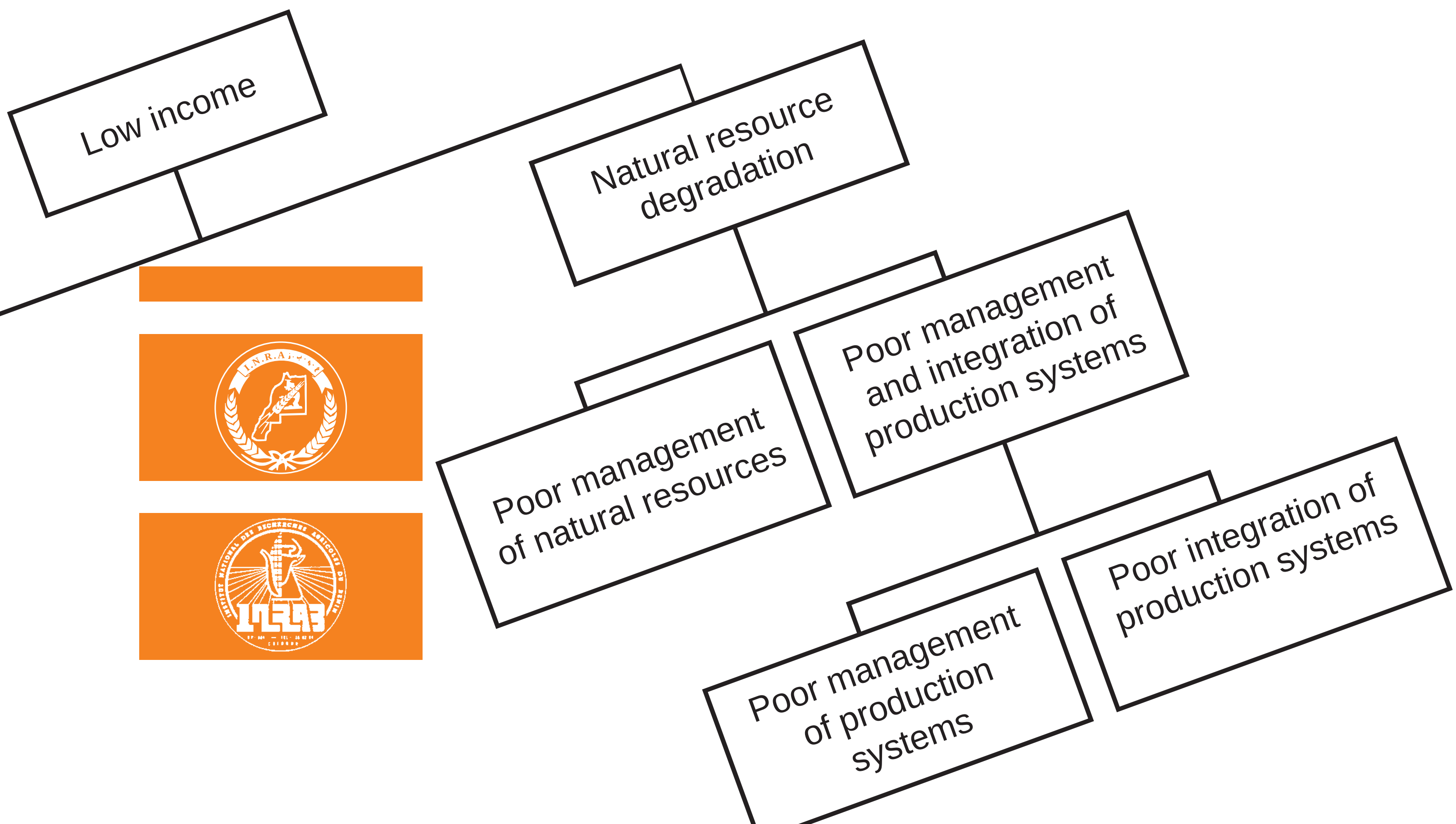
Willem Janssen and Ali Kissi

Planning and Priority Setting for Regional Research

A Practical Approach to Combine Natural Resource Management and Productivity Concerns



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Planning and Priority Setting for Regional Research

A Practical Approach to Combine Natural Resource Management and Productivity Concerns

by
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and
Ali Kissi

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About the Authors

Willem Janssen is an agricultural economist and senior officer in ISNAR's Policy and System Development Program. Since 1993 he has been involved in the design of research planning and priority-setting tools at the national, institute, and program level. He has collaborated with national research institutes in Benin, Brazil, Cameroon, Chile, Kenya, Morocco, and Peru and has taught planning subjects at the anglophone ICRA (International Course for Research in Agriculture) course, ISNAR courses for research managers, and M.Sc. courses. Janssen has focused on the integration of new research approaches, such as biotechnology, postharvest processing, and natural resource management in planning and priority setting. Before joining ISNAR, he was employed by Wageningen Agricultural University, and two other international agricultural research centers.

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About these Guidelines

These guidelines present a method for formulating regional research programs with a mixed perspective — one that combines productivity and natural resource management issues within a regional, decentralized context. Based on earlier work by Collion and Kissi (1994), it has been substantially modified to account for the peculiarities of regional research planning. The method was pilot tested in Benin. It has also been applied in Senegal and Morocco.

Part 1 presents the rationale and background of regional research planning. This section is particularly relevant for institute directors, policymakers reviewing research options, and, of course, for research program leaders. The method for regional research planning is treated in Part 2. In the first five steps of the planning approach, research constraints, objectives, and projects are identified in a structured, logical, and participatory fashion. Step 6 of the research planning approach examines how priorities are established among the research projects. This presentation is aimed specifically at economists involved in research planning and research program leaders. In steps 7 and 8 of the program planning process, the results of the planning exercise are translated into implementable recommendations. Part 2 is focused specifically for program leaders and research institute directors. Part 3 reviews the overall procedures and poses some questions and issues that should be resolved in the future. It may be of interest to all persons involved in regional research planning.

Throughout the document, a series of boxes illustrates the experience of Benin with regional research planning. These boxes aim to provide a clear example of the sequence, organization, and execution of the regional research planning process.

Foreword

Demands on agricultural research are becoming more complex. Productivity concerns are now complemented by food security, equity, and sustainability issues. There is a growing appeal for agricultural research not only to lead to higher yields, but also to ensure that the benefits of research accrue to target groups and maintain the natural resource base. To integrate these trends in national agricultural research programs is a major challenge for research planners. New organizational models are needed—ones that allow participation of users in defining and executing the research agenda. Such models should make use of all available information, from both within and outside the national domain. They should also recognize distributional issues of gender, class, and producer and consumer relationships.

Addressing all these challenges in the traditional framework of the commodity research program is practically impossible. Rather, innovative ways must be sought for organizing research. This book outlines one such way: regional research programs. Regional programs stand close to the user, allow for a systematic diagnosis and planning, can integrate productivity and sustainability issues, and make optimum use of the sometimes limited information available.

Regional research programs provide a comprehensive approach for solving agricultural and environmental problems. Constraints to cropping, livestock production, soil management, forestry, and water management are first identified and their links established. This requires a comprehensive, but concise diagnostic tool. The authors present one such tool based on the constraints tree methodology. But regional program formulation also requires a priority-setting method that recognizes that one research project may have many types of impact. For example, it may contribute to solving cropping as well as livestock and soil management problems. The authors suggest a simple method, low in data requirements, to set priorities research projects in the regional context. Nevertheless, there is no substitute for data. Regional programs should be based on solid understanding of the issues in the region. This knowledge is best obtained by analysis of available data and by involving users in the planning exercise.

These guidelines are the product of fruitful collaboration between Morocco's INRA, Benin's INRAB, and ISNAR. They reflect the fact that research management tools are best developed in practice, in direct interaction with researchers, and in a situation where the results matter. We hope that these guidelines will be of use to many research institutes in defining their response to the increased needs for environmentally sound, user-based research.

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Director, INRA	Director General, ISNAR	Former Director, INRAB

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Developing a set of practical guidelines requires the interaction and collaboration of many people. This document is no exception. The authors therefore acknowledge the contributions of the many participants that were involved in planning the regional research programs in Benin and in other countries. Researchers, farmers, extension agents, lecturers, employees of NGOs, and personnel from ministries of agriculture have all been represented. We express our thanks to Dr. Moïse Houssou, Director General of INRAB (Institut National de la Recherche Agricole au Benin), and Mr. Ange Aclinou, Head of INRAB's Planning Unit. Our collaboration with Dr. Raymond Voudouhé, Dr. Marcellin Ehouinsou, and Mr. Alphonse Yehouenou, who led the formulation of the regional programs in Benin, was essential. Ms. Clemencia Acacha and Mr. Anicet Mouzourri provided excellent logistical support. Finally, we thank the members of the "Programme Aridoculture" in Settat, Morocco, who helped us develop the ideas that were later elaborated with the team from Benin, and the participants in the program formulation process at ISRA (Institut Senegalais de la Recherche Agricole), where the method was further refined and validated.

In the writing of the manuscript we benefited from the input of Gerry Toomey, who simplified our English and translated some parts from the original French. In addition, Gerry became our first reviewer, producing critical questions on the logic and the flow of argument. Melina Tensen provided extensive secretarial support, drawing the original figures, and managing the master file. In ISNAR's Publications Unit, Michelle Luijben, Fionnuala Hawes, and Richard Claase transformed the manuscript into a finished book. The document benefited extensively from comments, made by Govert Gijsbers, Peter Goldsworthy, Matthias Hitzel, Brad Mills, Paul Perrault, Willem Stoop, and four anonymous reviewers.

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Executive Summary

The rationale for regional research planning

Regional research programs can be part of an answer to trends that many agricultural research systems are facing:

- Concerns over the management of natural resources. Agricultural research cannot take a mere productivity perspective. It has to ensure that the quality of the natural resource base is not affected in the process of increasing productivity, and it also has a responsibility to enhance the quality of natural resources for future generations.
- Decentralization of government to the regional level. As part of an effort to improve public accountability, countries are increasingly bringing government closer to citizens. Agricultural research has to respond to decentralized public decision making by also getting closer to the user.
- Emphasis on adaptive research. With the improvement of communication and information mechanisms, strategic, applied, and adaptive research results from many parts of the world may be available and applicable in the local context. To resolve production and resource management problems, the testing and adaptation of solutions developed elsewhere becomes an increasingly feasible and cost-effective strategy.

What is a region? A region is a contiguous area within a country, characterized by a certain homogeneity in agroecological, socioeconomic, and administrative characteristics.

The objectives of regional research programs. Regional research programs provide improved technology for a specific region. They aim to optimize current agricultural production and natural resource management systems or exchange these systems for more advanced ones. The overall objective is to help improve people's living standards in the region, while maintaining or enhancing the quality of natural resources.

The place of regional research programs in the national research plan. Research on agronomy, animal husbandry, resource management, diagnostics, and institutional strengthening is very suitably placed in regional research programs. Genetic improvement and postharvest research are better undertaken in commodity research programs (e.g., a maize program) or disciplinary research programs (e.g., a food technology program). Other research activities, such as crop protection, policy research, or resource classification studies can be feasibly undertaken within a regional research program, but may be more suitable to other program types, such as production-factor programs or disciplinary programs.

Regional research should complement other types of research programs within the national plan. The objectives of regional research are therefore defined in relation to expectations of other research programs. Where overlaps exist, responsibilities and interactions should be as clearly defined as possible. Ideally this is done before the regional research programs are planned. If it is done afterwards, research projects identified can be transferred to the most suitable program type.

The boundaries of regional research programs. Three sets of criteria can be used to define the boundaries of a regional research program. These are agroecological, socioeconomic, and administrative criteria. Many countries have divided themselves for development strategy and administrative purposes into a small number of regions, often taking into account socioeconomic criteria. If these divisions make any sense for agricultural research, they should be followed to allow for the best interaction between research and other development activities. The agroecological criteria can then be used to check the relevancy of the divisions, or to suggest subregions, in case of very large areas. This procedure is preferred over the development of a research-specific zonation, because of its then limited relevancy to other development activities. Geographic information systems can help in determining the possible boundaries of a regional program.

Participation in regional program planning. Regional research programs have the advantage of being close to the user. It is essential that this advantage be used from the start, that is, in the planning process. Representatives of farmer organizations, staff of the extension service, personnel from development projects, NGO members, regional government officials, and of course, the researchers themselves should participate in the formulation of the regional program. Ideally, the group should not have more than 25 participants with a balanced distribution of disciplines and perspectives.

Stepwise planning of regional research programs

Regional research programs can be planned in eight sequential steps. These steps combine analytical processes based on knowledge from various disciplines with more creative processes that require the input of people with different perspectives. The steps can be organized (but not necessarily) around two or three workshops. These promote interaction among the different participants.

Step 1: Regional review and analysis of regional development objectives. This step provides a comprehensive overview of the region and its technological demands. The analysis normally leads to a document that provides knowledge on the development goals of the region. This document can be presented to the participants at the start of the first workshop. Responsibility for the regional analysis lays normally with a socioeconomist, who may also be a program member. Though the analysis is normally prepared by the program planning committee, it is shared and discussed by all participants in the planning process. The regional review is usually based on secondary information. But it may be complemented with rapid rural appraisals to collect first-hand knowledge. The review should be started three months before the first workshop, and will occupy a socioeconomist full time.

Step 2: Constraints analysis. In this step the information from the regional review and the knowledge of the participants in the planning process is combined to define the technological constraints and opportunities for agricultural development and sustainable resource use in the region. This step ensures that the regional program is based upon clearly defined and strongly felt problems within the region, rather than on the scientific ideas of the researchers. The research program leader normally takes responsibility for this step. But its successful completion is critically dependent on full-fledged participation of the whole planning group. It is especially important that the nonresearchers speak out at this stage. Constraints analysis can be enhanced by using constraints tree methodology. This is especially useful for regional research programs, since the constraints tree becomes a sort of holistic cross-section of regional problems. Developing a complete constraints tree takes one to one-and-a-half days of the first workshop.

Step 3: Evaluating past research. Before any decisions on research projects are taken, it is useful to know what research has already been done in the region, and what research has been done elsewhere that is applicable to constraints faced within the region. Step 3 helps the research program avoid duplication of previous work and increases the effectiveness of research projects. The output of this step may be a document that can be presented in the first workshop. Normally a member of the program committee with a technical background is responsible for the past research evaluation, but this person is supported by other researchers, both from within and outside the regional program. Annual reports, scientific publications, and bibliographic searches are useful sources of information. If there is a management information system, this may also be explored. Normally the evaluation of research should start three months before the first workshop, but it can only be finished after the first workshop.

Step 4: Defining research objectives. Once the constraints facing the region's agricultural development are defined and an inventory has been made of previous research achievements, the research program may define what it wishes to achieve during the planning period. Objectives are most usefully defined at two levels: at the level of the overall regional research program and at the level of specific technological constraints. Research objectives provide answers to the constraints identified earlier. In defining these answers, both researchers and other stakeholders play a major role. Researchers assess the technical feasibility of the objective (for example, is varietal resistance a more relevant objective than chemical control?). The other stakeholders assess the adoption potential of the technology that will be obtained if the objective is achieved (for example, will resistant varieties be adopted by farmers more easily than chemical control methods?). Defining research objectives is the process through which the research program sets out its major directions.

Step 5: Identifying research projects. In this step the researchable constraints and the research objectives are matched with a research approach. A coherent set of indispensable research activities is defined. Each activity is required to attain the objective. For each activity the required human resources, the location, and the duration are defined. Research projects do not need to be spelled out in great detail, but their overall shape should be determined at this stage. The program researchers, with the guidance of the program leader, are principally responsible for identifying research projects. They may do this in the time between the first and the second workshop. Two types of projects may be identified: technical projects that help to overcome specific constraints in the region, be they in cropping, livestock, forestry, soil management, or any other field; and support projects that improve the scientific base of the technical projects and thereby increase their chance of success. Once projects are identified a first screening may be made to define whether a certain project is best undertaken in the regional program or in an other program type.

Step 6: Choosing priority research projects. The resources available for the program do not usually allow for the implementation of all the projects identified. Thus priorities for implementation need to be defined. The responsibility for this step is with the socioeconomist, who with the support of the program leader designs the approach for priority setting and obtains the required data. All the planning group members contribute their knowledge and judgment to the exercise. While many methodologies are available for setting priorities, in these guidelines we propose a simplified cost-benefit analysis, which integrates some elements of trend analysis and resource valuation. The socioeconomist requires at least one month to prepare background data, and the workshop participants will need one to one-and-a-half days in the second workshop to achieve results.

In priority setting for a regional program, the challenge is to combine and compare research benefits in many different dimensions. For example, one project (developing productive combinations of yam and tree species) may affect crop production and forestry production. A second project (introduction of forage species in crop rotations) may affect crop production, livestock production, and long-term soil quality. A third project (identification of improved pepper varieties) may only affect crop production. A priority-setting method is required that combines the benefits to these different dimensions in a simple and straightforward manner. To do this, crude assumptions are made to estimate the expected value of technological improvement by trend analysis for crop, livestock, and forestry production and by resource valuation for soil quality. Workshop participants afterwards assess the validity of these assumptions, and define what share of the expected technological progress would arise from the regional program (as opposed to other types of research programs).

Once there is agreement on the benefits that the regional research program can expect to achieve in each of the benefit dimensions identified as important, each proposed research project is assessed for its contribution to the total. The feasibility of research and the expected rate of adoption for the results of each project are estimated as well. With these data the expected impact of each research project can be calculated. By comparing the expected impact with a cost indication of each project, we can calculate which projects have the highest impact per unit of cost. The ranking that results is assessed and discussed by workshop participants in a plenary session. After modifications are made to account for considerations not included in the procedure, a final rank order is accepted.

Step 7: Human resource gap analysis. Once the priority research projects are defined, the program should assess whether it is equipped to implement them. The main concern is that the program has the right disciplinary mix of people. The human resource requirements are aggregated and compared with the human resource availability. Gaps are identified where staff should be hired or contracted from other units. This process is led by the program committee, with support of the human resource department. The required data are available from the earlier steps (5 and 6, in particular). A matrix can be drawn up that shows human resource requirements by projects in descending order of priority. This step does not require much time. It can be finished in one to two weeks after the second workshop.

Step 8: Preparing for implementation. Finally, the conditions for successful implementation of the program need to be established. Key is that the support of senior management is obtained, and that stakeholders endorse the program formally and meaningfully. This is best done through a half-day workshop in which the finalized program plan is presented to senior management and other stakeholders. The plan should be made available to them, in written form, two weeks before the workshop. This validation workshop can be held four to six weeks after the second workshop.

Some final observations

Regional research programs are one possible answer to the changing needs of the present times, in which stakeholder participation, problem solving, and resource management concerns are taking on major importance in agricultural research. In these guidelines we expose a method for planning regional research programs. The method is not so much a final product as starting point for thinking about regional research. Many questions still need to be resolved. The practice of regional research programs will certainly help to provide answers. Some of these questions are: How can the results of regional research planning be used for purposes other than research? How can the use of geographic information systems be improved? How can the time dimension be adequately accounted for? How can the factual database for regional programs be improved? How should regional programs be linked with international ecoregional research efforts?

Acronyms

GIS	geographic information systems
IFDC	International Fertilizer Development Center
INFORM	Information for Agricultural Research Managers
INRA	Institut National de Recherche Agricole (Morocco)
INRAB	Institut National de la Recherche Agricole au Benin
IPM	integrated pest management
ISNAR	International Service for National Agricultural Research
KARI	Kenya Agricultural Research Institute
NGO	nongovernmental organization
NRM	natural resource management

PART 1

Rationale, Background, and Issues

1.1 Why Formulate Regional Research Programs?

Three types of concerns favor the development of regional research programs. *Firstly,* concerns over natural resource management have gained attention over the last decade in both developed and developing countries. Many people worry that agriculture is exploiting resources in an unsustainable manner, or at the cost of nonagricultural users. These concerns have several common factors (Crosson and Anderson, 1993; Janssen, 1995a). Many practitioners think the potential contribution of natural resources to development is not sufficiently understood, and that available resources could be used more effectively. Also, there are concerns that the impact of economic development on the natural resource base isn't properly reflected in decision making. Here the worry is that present economic growth is based on resource degradation, which will constrain future growth. In addition, there are concerns that the impact of resource use by one user on another (the question of so-called externalities) are not taken into account.

Agricultural research is reacting to these concerns by putting more emphasis on issues of natural resource management (NRM). However, paying more attention to NRM in an isolated manner isn't enough. Negative impacts on the natural resource base may be the unintended effects of well-intentioned technological change in commodity production. For example, high-yielding varieties may be developed with large nutrient absorption needs. Also, NRM research cannot be isolated from other factors governing resource use. Products of isolated NRM research on hillside soil erosion, for example, may not be effective if they don't provide short-term benefit to the farmer. Such research might also neglect to account for the policy and market context in which the farmer operates.

The successful integration of NRM issues in agricultural research thus requires a new research perspective. A more holistic view is needed, one that allows us to understand the potential for improving both the quality and the productivity of agricultural resources within the context of non-agricultural resource use, the socioeconomic setting, and long-term trends in production and resource management.

Secondly, many countries are trying to increase the democratic content of their governments by decentralizing public structures to the regional level. In these decentralized systems, citizens have influence in deciding what the government undertakes in their region or city. People are closer to their representatives and are more directly involved in public debates. They thereby obtain an increased awareness of the utility and relevance of the public sector. Agricultural research must follow this trend by allowing technology users a larger voice in the planning and execution of the research program.

A *third* development that favors regional research programs is the increased emphasis on adaptive research. With the advent of improved communication and information systems in the 1990s, countries' ability to import and test new agricultural technologies has increased rapidly. As a result, the relative attractiveness of adaptive research over more strategic research has increased, certainly for those research areas in which the country does not choose to make a major investment. In addition, many development thinkers believe that strong adaptive research programs are the only way to guarantee that research results are effectively translated in useful technologies for end users.

At the level of the individual research project, systems approaches and participatory technology development have become popular ways to provide a decentralized, adaptive NRM perspective (van Duivenbooden, 1995). At the program level, the strategy has been to de-emphasize commodity research in favor of programs with a geographic focus. Such programs are known under different names. In Morocco, for example, the program for the semiarid zone is called an "agro-systems" program; similarities among production systems provide the common denominator (INRA, 1993). Among international agricultural research centers, the term "ecoregional" is used, emphasizing that the boundaries of a region are usefully defined by ecological characteristics. Benin, Burkina Faso, and Mali have set up "regional" programs, based on a mixture of ecological and administrative criteria.

These guidelines present a method for formulating regional research programs with a mixed perspective—one that combines productivity and natural resource management issues within a regional, decentralized context. Based on earlier work by Collion and Kissi (1994), it has been substantially modified to account for the peculiarities of regional research planning. The method was pilot tested in Benin. It has also been applied in Senegal and Morocco.

1.2 What is a Region?

A region is defined here as a contiguous area within a country characterized by a certain homogeneity in its agroecological, socioeconomic, and administrative characteristics. Elements that may define the homogeneity of a region are discussed in section 1.5. It is important here to observe that a country is normally made up of several regions. This contrasts with the use of the word "region" in the international context, where it normally refers to a grouping of countries in a certain part of the world (e.g., the Southern Cone of Latin America).

A country may be divided into a small number of regions for the purpose of agricultural research planning. A large country with a large agricultural research system may be able to support a substantial number of regional research programs. In a small country, there will likely be fewer regional programs. For example, in Benin three regions were defined for the purposes of agricultural research, whereas in Senegal there are seven.

The regional concept can be most easily applied if agroecological, administrative, and socioeconomic conditions are highly associated, as is the case in Benin. In other countries, regional programs may need to be defined in a different manner. For example, in mountainous countries the concept of a region is more difficult to apply because agroecological conditions change markedly with the altitude. Across a transect of 50 kilometers three or four completely different ecosystems may be found. In this situation it may be difficult to reconcile administrative and agroecological boundaries in one regional classification. There may be a need to consider distinctive ecosystems within the region, which could lead to the planning of sub-programs.

If several sub-programs were concerned with very similar agroecologies, the decentralization argument in favor of regional programs might be undone in favor of an ecosystem approach. Based on this reasoning, Morocco used the methodology presented within these guidelines to plan programs in which the agroecological, and not the administrative, dimension was dominant for defining program boundaries. The interaction of socioeconomic, administrative, and agroecological constraints should be, again, emphasized. Many research projects have failed precisely because they did not consider socioeconomic and administrative conditions.

1.3 Objectives and Features of Regional Research Programs

Regional research provides improved technologies for a specific region. It aims to optimize agricultural production and natural resource management systems or exchange them for more advanced ones. The overarching goal is to help improve people's living standards in the region, while ensuring maintenance of the natural resource base.

Regional research programs contribute to agricultural development in a number of fields:

- the rational exploitation of natural resources (water, soil, vegetation, genetic resources);
- the integration of cropping, livestock, forestry, and possibly fisheries activities, and of the region's agricultural production systems;
- the elimination of specific constraints in the region's cropping, livestock, forestry, and fisheries systems;
- the institutional aspects of agricultural production and use of resources such as credit, marketing, extension, and producer organizations.

Regional research programs take a different perspective from commodity-oriented or production-factor research programs. Each of these approaches has its advantages and disadvantages. The challenge for national agricultural research systems is to find the optimum mix of research approaches and program types. For regional research programs three features merit special mention: their NRM emphasis, proximity to users, and their problem-orientation.

NRM emphasis

In many parts of the world, agricultural productivity and profitability are constrained more by the quality of the available natural resources than by the production potential of the crops being grown. Soil quality, water availability, and vegetative cover strongly affect productive potential. Moreover, for many of the world's populations, especially the poor, survival depends on exploiting natural resources. This is true whether for farmers, fisherpeople, or cattle-herding nomads.

There is often competition for resources between agriculture and other uses. Examples of potentially competitive uses are water for irrigation versus human consumption, and land for forest cover versus cropping. Developing rural areas often depends on the rational exploitation of available resources. But this can only be achieved by adopting a holistic perspective on the various kinds of resource use. Regional programs can provide research with that perspective.

Production-factor research programs (such as a soil management research program) also have a resource emphasis. But since the resource's role within the overall production system is less explicitly studied, such programs may be less effective than regional programs in helping bring about changes in resource management.

Regional research programs take into account the different ways in which natural resources are used, by farmers and others, and the links between resource use and resource quality. This is a potential strength, but also a potential weakness. Collaboration and integration of researchers within the program should be high, but that demands careful management of program resources. The integrated nature of regional programs can easily result in a lack of focus in research projects. In this case, the risk exists that the program may concentrate too much on diagnosis and understanding without arriving at testable solutions.

To minimize problems of management and focus, it is vital that regional programs, even more so than commodity and production-factor programs, be carefully formulated.

Proximity to the user

Since regional research focuses on a well defined geographic area, the problems of the area's inhabitants can be clearly analyzed. The research program should produce concrete, specific solutions to these problems. This is made easier because the regional context offers enhanced opportunity to build participatory on-farm approaches into the research program. Working at the regional level, researchers can achieve more intensive contact with farmers, other resource users, government institutions, and development organizations than they could at the national level. Interaction on the problems to be addressed is therefore more straightforward.

In the past, such proximity to users often resulted in researchers being somewhat isolated from the international scientific community. There was some uneasiness among researchers about the scientific quality of their work and professional recognition among peers. With present communication and information media, especially fax, e-mail, CD-ROM, and the World Wide Web, and with greater emphasis on NRM issues in the international community, this concern no longer exists. Regional research should now be able to produce results of similar scientific quality to that of commodity programs, and with widely recognized relevance and value.

Whereas regional research programs may have excellent contact with resource users, commodity programs will normally have better links with other agents in the commodity marketing chain, such as processors and traders. Once again, this underlines the fact that regional research shouldn't replace commodity research, but be rationally combined with it.

Problem orientation

Regional research programs tend to be problem oriented. In this respect, they are somewhat of an extension of more traditional on-farm research approaches. For example, the planning approach for on-farm research by Tripp and Woolley (1989) takes a stepwise approach comparable to the one presented in these guidelines. But the framework of analysis in their approach focuses on the farming instead of the regional system. For regional research programs the different farming systems of the region must be put in the context of the overall use of natural resources. For solving the unique problems that are then found, the adaptation of technologies available from other parts of the country or the world may be sufficient, in which case there is no justification for duplicating strategic research.

Nevertheless, regional problems may also require more sophisticated technological innovation methods. This is the case when there are no adaptable solutions available, or when it concerns a solution to a particularly complex problem. In the second case, the best approach would not necessarily be to do upstream research relying on very advanced scientific methodologies, but to develop an integrated approach that allows for continuous and comprehensive evaluation of the different impacts of the innovation. Such innovation is, again, best managed in close interaction with users.

Organization of regional programs

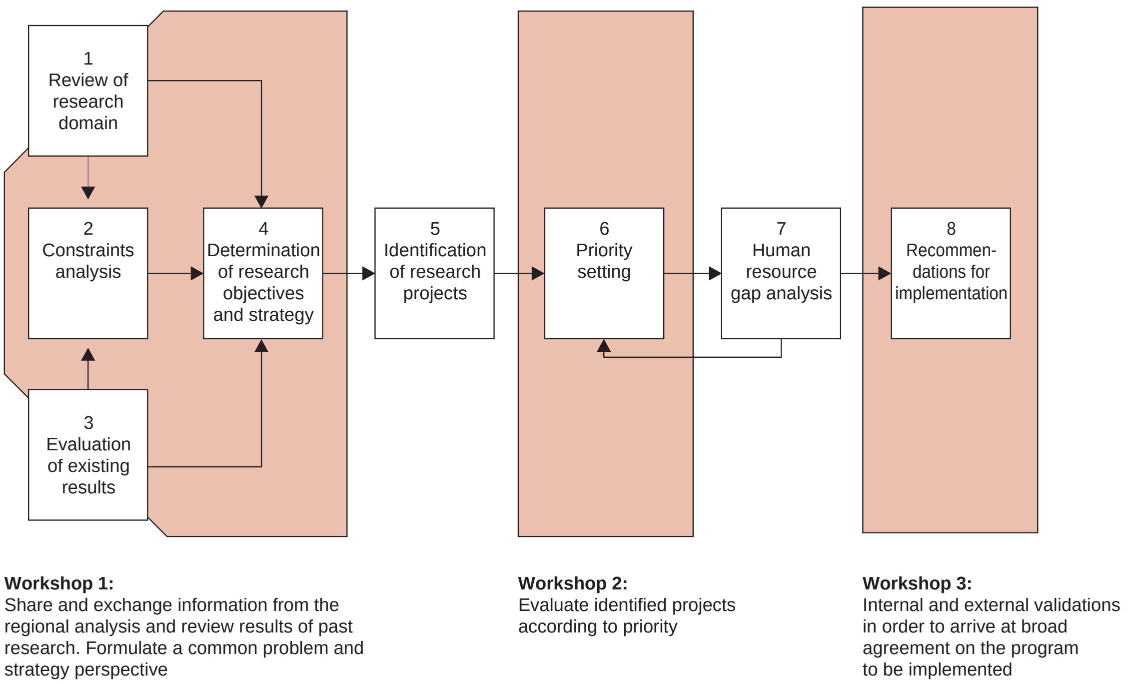
Regional research can be organized in specific programs, as will be elaborated in the remainder of this document. However, in cases where research is strictly organized along other lines, for example, commodity programs or disciplinary programs, this regional approach to research planning could still be effective. In such a situation, representatives of different programs would sit together to jointly review problems and opportunities in the region, and jointly plan and prioritize research interventions.

The main difference between this and a strict regional program would be that the control over the human resources, the equipment, and the money would not be with a regional program leader, but would remain with the other program administrators. Such a situation represents a compromise in which NRM, proximity to the user, and adaptive concerns are taken seriously by the research system leaders, but have not led to the decentralization of decision making on research. The present guidelines can be used to plan such research, if some additional thought is given to the coordination of the resulting research program.

1.4 The Basic Methodology for Formulating Research Programs

Our point of departure in laying out a method for planning regional research is the sequence of program-formulation steps described by Collion and Kissi (1994). Readers' knowledge of that approach is, therefore, clearly an advantage. For those unfamiliar with the method, in this section we provide an overview and a brief explanation of how the method can be adapted to account for the integrated nature of regional programs and the various types of benefits these programs may produce.

Contributions of skills and knowledge from many different people and disciplines are needed in order to formulate an agricultural research program. However, combining these various types of information, scientific disciplines, and human skills can be a daunting task. Use of a stepwise procedure helps guide this process. In each step, new information is incorporated. The balance between creative and analytical thinking may change from step to step. In some steps, economics skills are key to furthering the procedure; in other steps, technical skills from, say, agronomy or animal sciences are essential. Figure 1 presents the eight steps in agricultural research program formulation as initially outlined by Collion and Kissi (1994) along with a way in which the steps can be organized in a set of meetings.



Source: Collion and Kissi, 1994, with modifications by the authors

Figure 1. Steps in research program formulation

Brief overview of the eight steps in program formulation

Step 1: Review of the research "domain." While certainly in the past, the research domain was often a commodity, in regional research programs it is a region within a country. The review of the research domain, therefore, consists of analyzing the agricultural production and NRM situation within the region. It results in an overview of the constraints on, and opportunities for, agricultural development and improved management of natural resources. It should also clarify the objectives for regional development, because it is to these objectives that agricultural research should respond.

Step 2: Constraints analysis. In this analysis, the review of the region is further elaborated and constraints to development are identified. For a regional research program, constraints relate not only to production limitations, but also to marketing problems, deficient social and institutional organization, and poor management of water and land resources.

Step 3: Evaluation of existing research results. To formulate an efficient and effective research program, it its important to know which problems or constraints have already been researched and what the outcomes of that research were. That means not only successful research. Also unsuccessful efforts to solve a constraint through research are good to know, in order to avoid repeating the failure.

Step 4: Determination of research objectives and strategies. Once constraints are identified and past research evaluated, an initial effort can be made to define the objectives of the regional research program. These objectives guide decisions later in the program formulation process.

Step 5: Identification of research projects. Research projects are the building blocks of the research program. In this step, projects are identified to help overcome the constraints defined in step 2. Projects don't have to be spelled out in great detail at this stage, but for each one, an objective should be formulated. Major research activities and their location also should be identified in this step, and the human resources needed to do the work should be estimated.

Step 6: Priority setting among research projects. Typically, more projects are identified than can be implemented. So the most important ones for achieving the research program's objectives must be selected. To do so, evaluation criteria that take into account the special nature of a regional research program are established and elaborated on.

Step 7: Human resource gap analysis. Once priority projects are identified, the aggregate human resources required to implement these projects are estimated. By comparing required human resources with available human resources, it becomes clear where the program needs to be strengthened.

Step 8: Recommendations for implementation. Once project priorities have been set and human resource requirements identified, the program is ready for implementation. In this step, other measures needed to make the program operational are defined and the conditions needed for the program to succeed are described. Measures to stimulate adoption of research results are also discussed.

Stepwise program planning is strongly recommended at the start of a program. Typically, every five to seven years an update should be made. Updates can be done in a more continuous manner if the program is able to sustain a clear record of how and why it has been changing its objectives and activities and if stakeholders are involved.

Participation

Formulating a research program is not only an analytical task but also a creative one. The outcomes are strongly determined by who participates. Therefore, program formulation should benefit from a variety of perspectives and respond to the concerns of farmers and other natural resource users. The best way to bring together these different perspectives is through workshops where representatives of all stakeholder groups are present. Careful selection of participants, however, is crucial to the quality and relevance of such events.

Wide participation brings another advantage. Once people have been involved in developing a plan, their willingness to support its implementation is higher. Participation, thus, improves both the outcome of the program on paper and the chance of its being successfully executed.

Organization

The program formulation procedure requires a program committee to organize meetings and prepare the necessary background information. The committee is normally headed by the research program leader. Two other research program members should be on the committee, one with a background in socioeconomics, the other trained in agronomy. The fourth committee member should be a representative from the unit responsible for research planning. This person contributes knowledge of program formulation procedures and ensures that the program under formulation is consistent with the overall direction of the national agricultural research system.

The program planning exercise can be organized around three workshops. The first, over a period of about three days, covers steps 1 to 4 of the program formulation process. It requires considerable preparation, mainly because of the large volume of information to be collected for steps 1 and 3. The first workshop produces a set of research objectives formulated in the light of the regional environment, constraints on production and NRM, and past research results.

Between the first and second workshops, research projects are identified by program committee members (step 5). Background data required to set priorities are collected and analyzed. The program committee should also use this time to record the preliminary results of the first four steps.

In the second workshop, lasting about two days, the research projects are prioritized. The overall priority rankings of the various projects are discussed and modifications are made to account for any considerations that could not be included in the previous steps. Recommendations for implementation are formulated.

After the second workshop, the program committee estimates human resource requirements and assesses the gap between what is required and available. The committee writes the program document, which is then submitted to external validation in a third workshop of approximately one day.

Essentially, the regional program planning method analyzes what needs to be done (steps 1 through 4), formulates creative solutions (step 5), then evaluates, rationalizes, and finalizes the program (steps 6 through 8). This is an over-simplification of the procedure, but it underlines the "analyze-formulate-evaluate" sequence necessary to plan any major human undertaking. Before we describe the method step by step, we should discuss the necessary preparations and issues to keep in mind before starting the planning process.

1.5 Preparing for Regional Research Program Planning

Four very different issues must be resolved before regional programs can be adequately formulated. The first is strategic in nature. It concerns the role of regional research programs within the national research plan. The planning of regional programs depends explicitly on the national agricultural research strategy.

The second issue is the geographic focus of the regional research program. It is vital to define clearly the boundaries of the zone being served.

The third issue is participation in the program formulation exercise. Although the proposed procedure tries to maximize objectivity, we should be aware that the more creative elements of program formulation, such as designing research projects in response to constraints, are highly subjective. The outcomes and credibility of the program formulated, as well as the program's prospects for being implemented, are strongly influenced by which stakeholders have participated and which research disciplines have been represented.

The fourth issue relates to ease of communication. In a participatory procedure, some people interpret the same words differently. To avoid misunderstandings, it's useful to define and adopt a common vocabulary at the outset. One guide to appropriate definitions of important terms is the glossary starting on page 62 of this book.

Placement within the national agricultural research plan

Regional research programs cannot substitute for commodity or production-factor programs; they complement them. They do provide an effective NRM perspective and may be very close to the user. However, their orientation is less disciplinary and they cannot take into account consumption and marketing issues as well as commodity programs (table 1). The challenge is to combine several research themes in the national research plan and build on the respective strengths of each.

Regional research programs may well exist alongside commodity or production-factor programs. In such cases the objectives and responsibilities of each type of program should be clearly defined. For example, in the development of Benin's agricultural research plan, although regional research programs were considered an important answer to concerns about NRM and user participation, they were still combined with programs that were more discipline oriented or commodity based. Box 1 provides a summary of the program structure proposed in Benin.

After the strategic orientation of various research programs within the agricultural research plan has been defined, more specific interactions between the regional program and other programs can be identified. Here, a key point is to decide on which research each program will concentrate. This decision is based on two factors: the suitability of program types for certain research hemes, and the relative importance assigned to different program types. Table 2 indicates the suitability of program types for different research themes.

Before program formulation starts, it's important to consider how research themes will be distributed over program types. There are three main reasons for doing this. First, it avoids duplication of effort in developing the program. Second, it helps managers decide which program type is most appropriate for a particular research project and transfer projects to the most appropriate "home". Third, clearly defining at the outset the research themes to be used in each program type can reduce the need for coordination once the program starts. Box 2 shows the initial distribution of research themes adopted in Benin.

Table 1. Relative strengths of regional and commodity research programs

Regional Programs	Commodity Programs
highly user oriented	fairly user oriented
highly perceptive to NRM issues	not perceptive to NRM issues
fairly well recognized disciplinary quality	well recognized disciplinary quality
low market orientation	highly market oriented

Defining the region

Three sets of criteria—agroecological, socioeconomic, and administrative—can be used to set the boundaries of the region covered by the regional research program. Agroecological criteria define a target area that is relatively homogeneous in its agricultural and resource management patterns. Socioeconomic criteria define homogeneity in even more detail (for example, by incorporating

Box 1: Program structure proposed in Benin's agricultural research plan

Regional research programs

Southern Region
- *Constraints:* Low fertility, sedimentation, limited diversification
- *Objective:* Increase income-generating potential of natural resources
- *Relative importance:* High

Central Region
- *Constraints:* Low fertility, deforestation, poor cropping practices
- *Objective:* Consolidate productive potential
- *Relative importance:* Medium

Northern Region
- *Constraints:* Deforestation, erosion, poor cropping practices, but ample land available
- *Objective:* Develop socially and ecologically sustainable production systems
- *Relative importance:* High

Commodity research programs

Staple foods
- *Constraints:* Breeding and plant protection problems
- *Objective:* Make improved varieties available to different production regions
- *Relative importance:* Medium

Cotton
- *Constraints:* Poor cropping practices but high export potential
- *Objective:* Improve long-term profitability
- *Relative importance:* Low

Oil palm
- *Constraints:* Poor integration in production systems, few traditional uses
- *Objective:* Strengthen role in village economy
- *Relative importance:* Low

Nontraditional exports
- *Constraints:* Low exploitation of favorable exchange rate and emerging commercial sector
- *Objective:* Support development of a trading sector
- *Relative importance:* Medium

Disciplinary research programs

Postharvest technology
- *Constraints:* Postharvest losses
- *Objective:* Increase value added to agricultural production
- *Relative importance:* High

Policy analysis
- *Constraints:* Funding shortages brought about by structural adjustment
- *Objective:* Contribute to improved policy environment
- *Relative importance:* Medium

Source: Plan Directeur de la Recherche Agricole au Bénin, Vol. 1.

factors such as market access or farm size, or by distinguishing ethnic groups). Administrative criteria ensure that the area of intervention for research is congruent with that of other public and private interventions, such as extension, credit, and rural development programs. It is difficult to judge the relative importance of these three sets of criteria, but it appears that administrative boundaries have often received insufficient attention (Janssen, 1995b).

Agroecological criteria

The target area of a regional program should be relatively homogeneous with regard to climate, soil, natural resource endowment, and land use. Climatic uniformity can be defined in terms of mean temperature (or average minimum and maximum temperatures) and rainfall pattern (millimeters per year and distribution). However, other parameters may also be relevant, such as evapotranspiration, insulation, hydric deficit, or average difference between day and night temperature. The choice of the key parameters should be left to local experts.

Soil uniformity can be defined in terms of soil type (clay or sand), topography (flat, gently sloping, mountainous), soil depth (shallow, intermedi-

Table 2. Suitability of program types for selected research themes

Research Theme	Program Type			
	Regional Program	Commodity Program	Production-Factor Program[1]	Disciplinary Program[2]
Plant genetic improvement or animal breeding	–	+	–	–
Crop protection or animal health	±	±	–	–
Agronomy or animal husbandry	+	±	±	–
Postharvest research	–	±	–	+
Diagnostic studies	+	±	±	±
Policy research	±	±	–	+
Institutional strengthening	+	±	–	±
Resource management	+	–	±	–
Resource classification	±	–	+	–

Key: + very suitable, ± somewhat suitable, – not suitable.

[1]A production-factor program works on the different dimensions of a production factor, for example, soil improvement, water management, or machinery use.
[2]A disciplinary program is made up of staff with the same educational background. For example, most policy programs mainly employ economists; most postharvest research programs mainly employ food technologists.

ate, deep), and soil fertility. In special cases other soil factors may be included.

Natural resource endowment concerns the availability of water resources, the proportion of the area covered by primary or secondary forest, the diversity of plant species, and the amount of land available per inhabitant.

Land-use criteria incorporate the human element. They show how people respond to climate, soil, and natural resource endowments within the existing institutional and socioeconomic environment. Land-use criteria include variables such as production systems, the role of livestock, cropping and forestry activities, rotation and shifting cultivation practices, land management practices (such as fertilization and erosion control).

Because land-use criteria reflect human reactions to existing agroecological conditions, they are a good way to understand which agroecological criteria most strongly influence de facto variability between regions. Where land-use data do exist, they may supply the most suitable criteria for setting agroecological boundaries. Unfortunately, such information is often not available in sufficient detail to serve this purpose.

Box 2: Importance of program types for various research themes in Benin

The West African country of Benin, with a population of five million, has a relatively small agricultural research system. It has no production-factor research programs (such as soil quality or water management) and livestock research was recently absorbed into regional research programs. As we saw in box 1, Benin uses three research program types: regional research programs (south center, and north), commodity research programs (staple foods, cotton, oil palm, and nontraditional exports), and disciplinary programs (postharvest technology and policy analysis programs). The disciplinary programs are dominated, though not exclusively, by a certain discipline (in this example, food technologists and economists respectively). The regional programs were given high or medium priority.

Research Theme	Program Type		
	Regional Program	Commodity Program	Disciplinary Program
Plant genetic improvement	*	***	
Crop protection	*	***	
Agronomy	***	*	
Animal breeding	**		
Animal health	***		
Animal husbandry	***		
Postharvest research			***
Diagnostic studies	***	*	**
Policy research	*		***
Institutional strengthening	**		**
Resource management	***		
Resource classification	**		

More asterisks indicate increasing importance.

As the table shows, the regional research programs are of principal importance for agronomy, animal health and husbandry, diagnostic studies, and resource management. It is of secondary importance for work in animal breeding, institutional strengthening, and resource classification. For plant genetic improvement, crop protection, and policy research it is of only occasional importance.

Socioeconomic criteria

Population density and farm size, income level, market access, urbanization, ethnic composition, and gender are important socioeconomic criteria for defining regions. In densely populated regions the demand for agricultural technology is normally geared toward innovations that improve land productivity. In sparsely populated areas the emphasis is normally on technologies that improve labor productivity. The effect of farm size on technology demand tends to be similar to that of population density.

Income levels also create large differences in technology demand. With increasing income levels, consumption tends to shift from cereals to animal products and other "high-quality" food. Also, the minimum increase in labor productivity that a new technology must deliver in order to be considered by farmers for adoption increases with income.

Market access defines the extent to which farmers are interested in new commercial options. Although nearly every farmer in the world is now in contact with the market, some get their produce to market readily at low cost, while others cannot. For farmers with poor market access, technologies that reduce input requirements or focus on commodities with a high value-to-volume ratio are most attractive. Farmers with good market access are likely to be interested in technologies that improve product quality and, hence, price.

Urbanization is closely linked to market access. In highly urbanized areas, agriculture tends to be more commercialized. At the same time, farmers may have access to alternative income sources, which improves their capacity to finance agricultural investments. Urbanization also changes their long-term perspective in that they may not feel as dependent on the farm for their future livelihood as do people in largely rural areas.

Ethnic divisions and gender are important because they may be associated with traditional differences in land use and labor distribution. They may therefore require alternative approaches to on-farm research and diffusion strategies (for instance, related to language, sex of the on-farm researcher, or timing of visits).

Administrative criteria

Most countries have different layers of political administration. Large countries such as India, Nigeria, Brazil, Mexico, and China are first divided into states. Most countries (or states within big countries) are divided into provinces or departments, and those are further divided into municipalities. Since these divisions normally form the framework for implementing public policies, developing private business strategies, or passing laws, the effectiveness of a regional research program is enhanced by respecting administrative borders.

Combining the three sets of criteria

Geographic information systems (GIS) can be used to overlay geographically referenced data on such criteria as those just described. GIS is a useful tool for animating a discussion of the criteria for defining a region (Wood and Pardey, 1994). With GIS, it's possible to distinguish, for instance, low rainfall areas (say below 600 millimeters per year) from high rainfall areas (more than 600 millimeters per year) and areas of low population density (e.g., less than 50 persons per square killiometer) from areas of high density (more than 50 persons per square killometer). Figure 2 is an example of a data overlay. It is based on work by the priority-setting working group of the Kenya Agricultural Research Institute (KARI, 1995).

Overlays allow relatively homogeneous regions to be defined. The quality of the resulting regional delineation depends, of course, on the relevance of the criteria. For example, is 600 millimeters per year the amount of rainfall at which cropping patterns tend to change? Is 50 persons per square killometer the threshold at which production systems become more intensive?

In defining target zones for regional programs, the challenge is to arrive at a reasonable number of zones that together cover the whole country. Even for a medium-sized country like Morocco, it would be difficult to envisage more than eight regional programs. But GIS makes it possible to overlay so many types of data that thousands of supposedly "homogeneous" microzones are defined. Only the most important criteria from the list given above are selected. And these are carefully interpreted and applied. The principal criteria for zonification may be defined by identifying those criteria that change simultaneously across the country. For example, when density of population, soil fertility, rainfall regimes, market access, and income levels all change along the same gradient, this may be an important division line. Information from GIS should, therefore, be combined with the assessment of a group of experts, who judge actual similarity across criteria. In our judgment, it is also wise to review what zonation

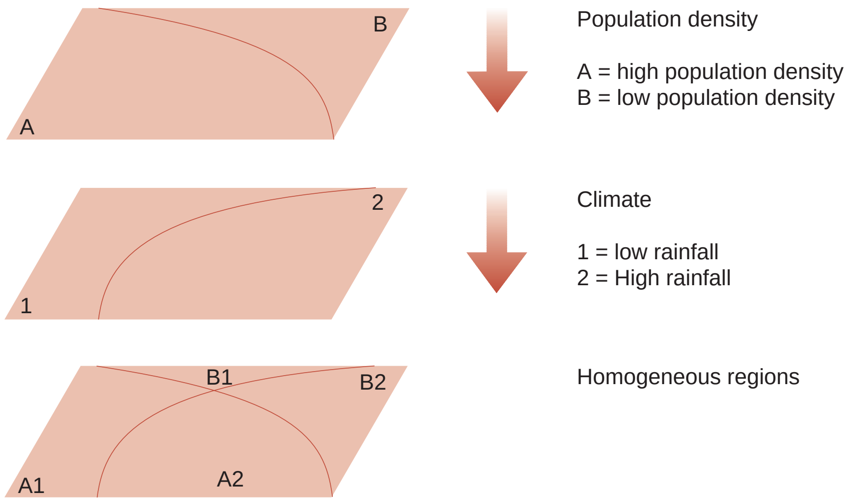


Figure 2. Identification of homogenous regions

has been successfully used in the past or is in use by other organizations before pursuing a new one.

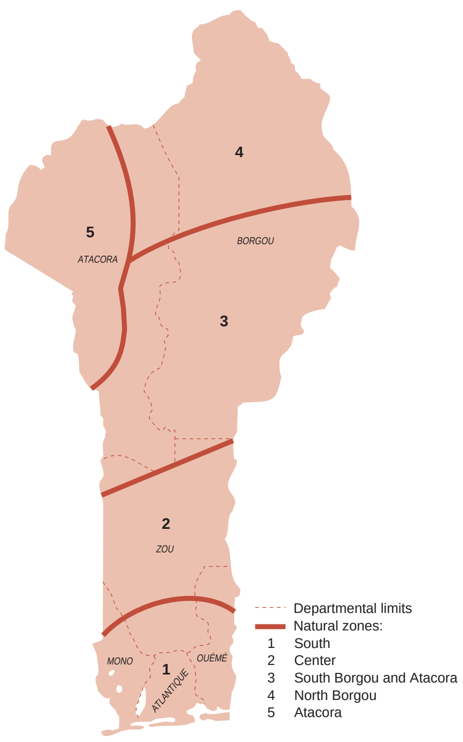
Clear definition of regional boundaries is a step that must precede regional program formulation. Questions should be asked as to whether a country's research system can adequately cover all the different regions. Box 3 describes the zonation process carried out in Benin.

The regional boundaries that are finally accepted should also make intuitive sense. Otherwise there will be lingering doubts and unfocused discussion among participants during the program formulation exercise. Hence, we re-emphasize how important it is to spell out clearly the regional

Box 3: Defining target zones for Benin's regional research programs

In Benin, five agroecological zones were defined by the national institute for agricultural research (INRAB). The principal criterion for zonation was rainfall. Whereas the southern zone (zone 1) is characterized by abundant rainfall distributed over two seasons per year, the extreme north (zone 4) has a semiarid Sahelian climate, with one wet season. The Atacora region (zone 5) was separated from the extreme north because the presence of a mountain ridge changes rainfall and soil conditions. In the Zou region (zone 2), the bimodal pattern changes to a unimodal pattern, and the south of Borgou (zone 3) has a unimodal pattern, like that in the north but less dry.

The initial agroecological classification in Benin also took into account population density and land availability because the south is almost 10 times as densely populated as the north. The borders of the agroecological zones and of the administrative departments did not differ greatly. The five agroecological zones were thus good targets for regional programs. However, for practical reasons (particularly the absence of research infrastructure in the north), INRAB decided to initially merge zones 3, 4 and 5.



boundaries before program formulation begins. Misunderstandings arising from different interpretations about the regional program's coverage could seriously delay progress or render otherwise fruitful discussions useless.

Participants in regional program formulation

A regional program, by its very nature, must take regional development needs into account. As also pointed out by Mills and Karanja (1995), participants in program planning must not only be aware of such needs. They must be able to articulate them. It is therefore prudent to select representatives from the following groups:

- **Farmers.** In cases where producers are represented by farmer organizations, leaders of these groups should be invited to participate. But it shouldn't be forgotten that the characteristics and needs of farmers can vary greatly from region to region. In the case of southern Benin, invitations were extended to organizations representing the interests of farmers and fisherpeople. If no farmer organizations operate in a region, technical staff from the extension service can be asked to participate.
- **Extension services.** These are the main partners of the regional research program, especially when the aim is to ensure the potential impact of new technologies is maximized. Furthermore, extensionists usually have a good understanding of their region's problems.
- **Development agencies or projects.** Regional research programs provide a suitable framework for directly integrating research into other development efforts. The presence of ongoing development projects can help identify the most appropriate research activities, avoiding ones that may have been motivated by other considerations.
- **NGOs.** Nongovernmental organizations often work on highly practical projects and encourage direct contact with end users. So they are key potential allies for research programming purposes.
- **Regional government.** Representatives from regional government play a major role in defining research objectives and help ensure that research harmonizes with other development work. They can also advise on regulatory matters, explaining the potential legal consequences of certain activities in NRM.
- **Researchers.** The success of a research program depends on how motivated researchers are and on their ability to compromise. Identifying and developing projects always demands the input of experienced researchers.

The participants should also represent a cross section of disciplines. Agricultural production sciences, veterinary sciences, forestry, soil sciences, agricultural and resource economics, sociology or organization sciences, and possibly, law are all disciplines that might usefully contribute to formulating the research plan. Normally it isn't possible to combine all these, but for the sake of the quality of the exercise it is important that there be substantial disciplinary diversity. This prevents a single way of thinking from dominating discussions and ensures that those people without a university background are not silenced by the common jargon of one or a few key disciplines. (Where many disciplines are present, there is still a chance of nonacademics being overwhelmed by a more generic scientific vocabulary, but it is substantially reduced.)

The number of participants in the three program formulation workshops should be kept between 15 and 25. With more than 25, communication is difficult and costs escalate. With less than 15, the diversity of opinion is probably less than optimal. The same people should be invited to the first and second workshops.

Sharing the same language

For most participants, formulating a regional research program is an unfamiliar task. Yet their knowledge and experience is the foundation of a good program. If everyone is to communicate effectively and make clear, concise contributions to the discussions, the meaning of a few basic terms must be uniformly agreed on. This makes the job of the program formulation leader much easier, allowing the group to be guided smoothly through the different steps.

Here we describe only a few key terms. A more extensive glossary is provided at the end of the book.

Program: The set of research projects to be undertaken in response to regional development objectives and technology demand by user groups. The aim of the research program is to improve the use of resources available. A program is normally multidisciplinary. The composition is flexible and responds to observed technological demand.

Constraints: The improved use of the region's resources is normally obstructed by a set of constraints. These can be technical (for example, cereal varieties not resistant to a certain disease), physical (low soil fertility), socioeconomic (small farm size), or institutional (poor access to credit). The research program normally aims to eliminate or reduce the effects of such constraints. Constraints may usefully be merged with opportunities. In the case of an opportunity, there is not so much a limitation to be removed as an advantage to be exploited.

Research project: A coherent set of experiments and studies necessary to accomplish a goal, which is normally to remove one of the identified constraints. A research project may aim to develop a technology or methodology and is often executed by a group of researchers with different disciplinary backgrounds. Research projects are the building blocks of the program and provide the occasion for multidisciplinary integration. The number of research projects in a program is normally limited to two or three projects per researcher. At the level of program formulation, a project is characterized by a goal, a set of research activities, a timetable, an expected result, and an estimate of time requirements by discipline. Once a project is selected for implement- ation, it can be described in more detail. Then, monitoring and evaluation parameters should be defined, budgets drawn up, and annual workloads planned.

Activity: A project is made up of activities—individual experiments and studies that aim to generate part of the knowledge required to solve the constraint being addressed. Normally the activities are monodisciplinary and are undertaken by one researcher. A project normally has more than two but less than eight activities.

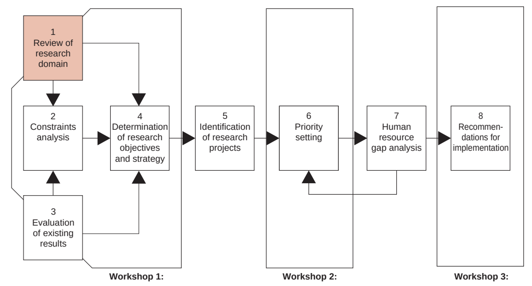
Participants in program formulation should understand that a program is made up of projects, that projects are composed of activities, and that projects respond to constraints. Once they are clear on this, they have the basic tools to contribute efficiently to discussions and decision making.

PART 2

A Stepwise Procedure for Crafting a Regional Research Program

2.1 Regional Review and Analysis of Regional Development Objectives

Detail of Step 1 of the Program Formulation Process, 'Review of the Research Domain'



Source: Collion and Kissi, 1994, with modifications by the authors

Rationale
Formulation of a coherent research plan requires a comprehensive overview of the region

Output
Written and oral presentation on the region and its development objectives

Responsibility
Socioeconomist from program or a social sciences unit

Participants
A program committee prepares the information, which is later discussed by a broad group of workshop participants

Information needs
Socioeconomic and biophysical variables about the region are collected, as well as descriptions of production and resource management systems

Methods
Secondary data analysis, principally from statistical sources and earlier diagnostic work. This may be complemented by rapid participatory appraisals on specific issues

Time and resources
Review should start roughly three months before first workshop. It will be a full-time job for the person responsible. Additionally, a small budget to allow data collection may be required

Step 1 of the program formulation process is the 'review of the research domain'. For a regional research program, the domain is the region. Most participants in program planning will have only a partial understanding of the region and its problems. They may know certain municipalities much better than others, or certain activities (e.g., cropping or cattle production) better than others. Although their personal knowledge is key to an insightful research plan, it must be put in perspective by a "cool" assessment of regional characteristics.

A list of key variables that may be assembled in a regional review is provided in box 4. As discussed in Part 1, the boundaries of the region should by now be clearly established.

The regional review also presents opportunity to ensure that research is integrated with other development activities. It may show, for example, that local government wants to develop irrigation in a set of municipalities. Or that the road system is being upgraded, thereby creating opportunities for marketable commodities. The review should provide a wider context for analysis of specific problems to be identified later. For example, it may identify drought or land-tenure systems as key constraints to agricultural development, or make it clear that diversification and adding value are key development strategies of the ministry of agriculture.

Further, the regional review provides institutional information. It may, for example, highlight the impact of new legislation concerning markets or land ownership. It may identify constraints in the credit system. And it may analyze the institutional setting, identifying potential collaborators for agricultural research.

Box 4: Information to be collected in a regional review

Socioeconomic

- Population size and rate of growth, possibly by ethnic group
- Degree of urbanization and rate of urban growth
- Income per capita and distribution, by income strata and sector
- Contribution of region to national economy
- Contribution of agriculture to regional economy
- Relative importance of cropping, livestock, fisheries, forestry, and other subsectors
- Employment situation, by sex and sector (primary, secondary, tertiary)
- Farm size and distribution
- Principal agricultural commodities and production systems
- Land and water use
- Possible target groups for agricultural research
- Principal constraints on, and opportunities for, regional development

Biophysical

- Geographic boundaries of the region
- Area and topography
- Soil types, plus water, forest, and wildlife resources
- Climate
- Vegetative cover

Institutional

- Regional development objectives and strategies
- Competency of regional government bodies
- Funding availability for research and development at the regional level
- Characterization of agricultural support services (credit, extension)
- Market structure
- Input availability and costs
- Development projects
- Development organizations (public agencies and NGOs)
- Tenure arrangements

The regional review is a key way to ensure that opportunities aren't overlooked. Most of the data needed can be collected before the first workshop by the program committee members. Information may come from regional strategy papers, national statistics, or other sources.

Analysis of regional development strategies

Regional development objectives and strategies are often derived from national objectives. If the region is a homogenous political unit, like a province, regional objectives and strategies may already exist as part of a regional development plan. In this case, they can be used directly in the research planning exercise. Where the region consists of several political units, the objectives and strategies of each one should be compiled. This may require some preparation.

If no regional development objectives and strategies have been explicitly defined, a dialogue within the planning group may be initiated to define them. The following checklist of national objectives, and how they can be translated into regional development objectives, strategies, and actions, may then be helpful (see also Boughton et al. 1995):

- **Improving rural incomes.** National development objectives such as "improving rural incomes" are often translated into regional strategies like agricultural intensification, diversification, enhanced postharvest processing, or market liberalization.
- **Contributing to balance of payments.** Contributions to balance of payments may be expressed at the regional level in strategies to focus extension services, credit facilities, or input supply on export crops (existing or new), or as strategies that aim to reduce input use.
- **Improving food security.** At the regional level, food security objectives are often addressed by improving the potential yield of

staple foods, reducing production losses in years with poor production conditions, developing better storage capacity, or improving sales opportunities for a possible marketable surplus. In regions with a land surplus, developing the frontier may also be identified as a regional food security objective.

- **Improving living conditions of the poor.** By focusing development projects or infrastructure development on regions with many poor people, an equity objective can be pursued. The equity objective may also lead to nonresearch solutions, such as employment programs (like food for work).
- **Managing natural resources.** Sustainable management of natural resources may translate into reforestation projects, anti-erosion legislation and enforcement, watershed management, and the establishment of nature reserves.

In the south of Benin, regional objectives had not been clearly defined in a national development plan. The research planning group thus formulated the following regional development strategies:

- intensify agricultural production
- generate employment in agriculture-related activities
- reduce degradation of the natural resource base

A summary of the regional review for Benin's Central Region is presented in box 5.

2.2 Constraints Analysis

In step 2 of the program formulation exercise, a broad-based group of research stakeholders identifies the central constraints or problems facing the region's sustainable agricultural develop-

Detail of Step 2 of the Program Formulation Process, 'Constraints Analysis'

Rationale

Regional research programs should respond to problems and opportunities clearly felt within the region

Output

Coherent set of principal constraints and their interactions, as well as a definition of the central constraint to be addressed

Responsibility

Program leader and planning facilitator

Participants

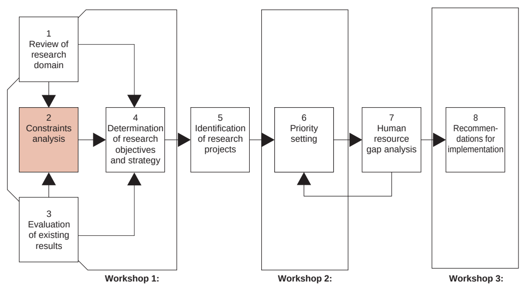
Broad selection of research stakeholders. Special attention should be paid to "nonresearch" partners, for example, farmers, other resource users, and development project personnel

Information needs

Sector review upon which to base initial analysis, as well as the common judgment of participants to identify and relate constraints to agricultural development

Time and resources

Free brainstorming followed by construction of a constraints tree. The workshop should last one to one-and-a-half days for all workshop participants. Time is spent partly in working groups



Source: Collion and Kissi, 1994, with modifications by the authors

Box 5: Summary of the regional review for Benin's Central Region

Benin's Central Region is made up of the municipalities Ouèssè, Savalou, Banté, Djidja, Dassa, Glazoué, Savè, Kétou, Aplahoué, Bassila, and the south of Tchaourou (see map). It covers 15,215 square kilometers and represents a zone of transition from two rainy seasons to one. As a result, there is a season of stable rainfall between April and July and a season of unstable rainfall between October and January. Average rainfall is 1100 millimeters, but may vary from year to year between 700 and 1400 millimeters. The average temperature is 27° Celsius.

The region has a modestly undulating topography, with some hilltops rising above the rest. Several soil types are found, including ferralitic soil, black clay soils, and hydromorphous soils. All are losing their natural fertility. Some 2000 square kilometers are forested, much of it with planted forests. Wildlife diversity has greatly suffered over the years. Water resources are relatively abundant, since the region is crossed by the Ouémé river and two of its tributaries. Because of extensive slash and burn, the Savannah-type vegetative cover that has dominated most of the region is gradually disappearing. More and more land is found in poorly recovering fallow systems.

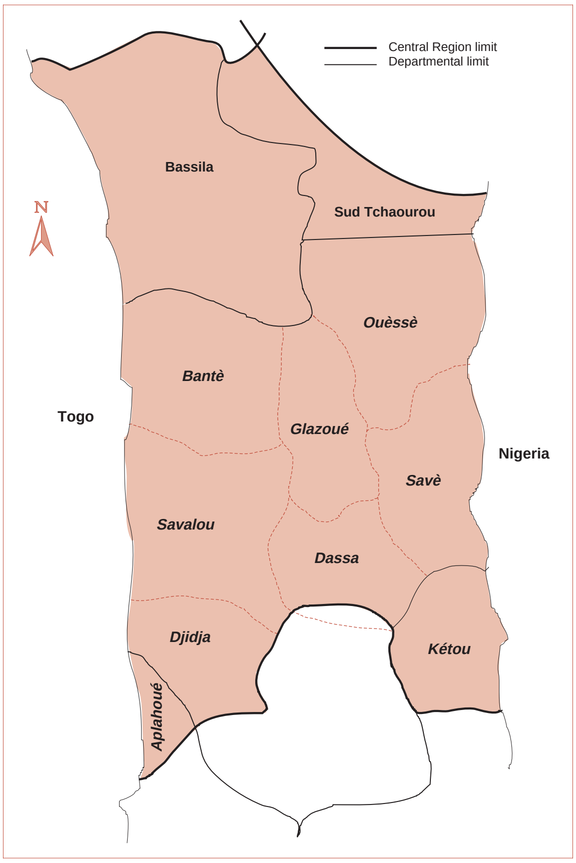
The Central Region has a population of 400,000, divided among three ethnic groups. Eighty-five percent is rural and almost all depend on agriculture for their livelihood. Rural population growth is minimal. Growth is concentrated in the urban centers, but also in the large cities of the adjacent Southern Region. In turn, the region receives migrants from the densely populated rural areas in the south of the country. The rural population is poor, with incomes less than half the national average.

The region's contribution to the national economy is basically through its agricultural production. Cotton production should be singled out because the crop accounts for the lion's share of international trade earnings. Within the agricultural and natural resource management sector, crops account for 72 percent, livestock for seven percent, and forestry products for 21 percent of total value. Maize and yam are the principal food crops.

Many of Benin's farmers are women. At three hectares per agricultural worker, there is ample land, but labor productivity is low. The principal issue is not where to find employment for people in agriculture but how to increase productivity. In the existing land-tenure situation, it is difficult and most probably irrelevant to distinguish individual farms and to calculate their size. Open-access land is still very important and is often a source of conflict between seminomadic cattle herders and farmers. Agricultural research has to consider the village as the focus for crop research and development activities, but livestock research should target nomadic groups as well as villages.

Until recently, agricultural support services were largely geared to cotton production. There is an unstructured market, but nevertheless, price arbitration is very efficient.

Several development projects are active in the region, initiated by the regional agricultural office or by NGOs and bilateral donors. The key objective expressed is to exploit the region's large agricultural potential in a sustainable manner. Industrial and urban development do not yet play a major role in the region. A more complete description of the region appears in the Plan Directeur de la Re-



ment and resource management. Much of this work is accomplished at a workshop. There, the participants construct a 'constraints tree', which takes the form of a flowchart. All participants are asked to write a statement of what they consider to be the central constraint or problem facing the region. The statements are then compared and synthesized into one central constraint. Here are three examples:

- limited capacity to generate income with the existing natural resource base
- absence of sustainable and profitable farming systems
- low incomes among agricultural producers

The participants' initial statements are used to structure the top branches of the constraints tree.

Working groups are then formed, each to develop one of the top "branches" further. Slowly a chain of causality is built. At each stage participants ask themselves what are the causes of a particular constraint, then, what is causing the causes of the constraint, and so on. Finally, they have broken down the central constraint into problems that are concrete enough to be translated into unambiguous objectives for a research or development project (e.g., inappropriate fertilization or absence of a road). Constraints identified may also be completely exogenous (e.g., falling world market prices). Once the working groups have finalized their branches the whole constraints tree is assembled and checked for internal logic and consistency.

The same constraints often appear at different places in the overall tree or are associated with different causes and effects. By checking the consistency of the tree, some of the duplicates can be removed, though some will remain simply because one problem may have many effects. This is a reflection of the highly complex and integrated nature of agriculture and natural resource management.

The use of a constraints tree promotes an integrated perspective on the region's problems. However, analysis using such a flowchart is not a full substitute for systems analysis because it concentrates only on constraints and not on other interactions. But because it maps out cause-and-effect relationships, the tree serves as a "constraint cross section" of the region's agricultural and natural resource management system.

For further details on how to develop a constraints tree, see Collion and Kissi (1994) or GTZ (1988).

The first constraints tree in box 6 shows the highest levels of constraints identified for Benin's Central Region. Below, the branch on 'poor management of production systems' is further developed. The constraints at the lowest level of the constraints tree are shaded.

Categories of constraints

Constraints on the sustainable development of a region's agriculture and on the management of its natural resources generally fall into six categories:

Degradation of natural resources. That is, water, soil, vegetative cover, plant genetic base, and wildlife due to production practices and the sociocultural milieu.

Land management. As it relates to type of exploitation, land-tenure policy, water control, cropping, livestock rearing, fishing, forestry practices, empowerment of local people, and the influence of cultural traditions on people's behavior.

Production systems. In relation to species, varieties, and breeds; crop pests; contagious animal diseases; cropping, herding, fishing, and forestry practices; and processing and marketing of products.

Integration of production systems. Specifically, poor integration of crops and livestock either within a single farming operation or among different types of farms, the lack of interaction between perennial and annual crops and among annual crops, poor links between components of the regional agricultural system.

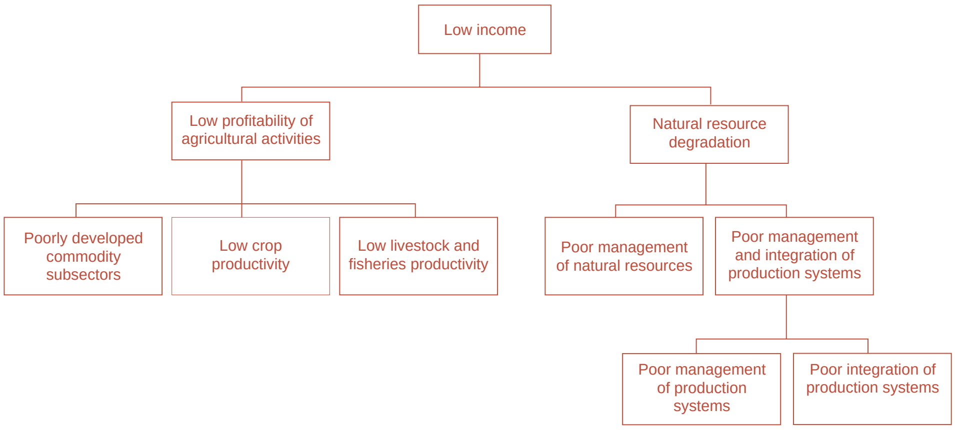
Organization of commodity subsectors. Related to the problems of poorly developed markets and insufficient information on market conditions, storage facilities, and the availability of quality seed.

Integration of agriculture within regional socioeconomic institutions. This constraint category includes problems related to credit, farmer organizations, coordination of various development agents, input supply, and the role of women in regional agricultural development.

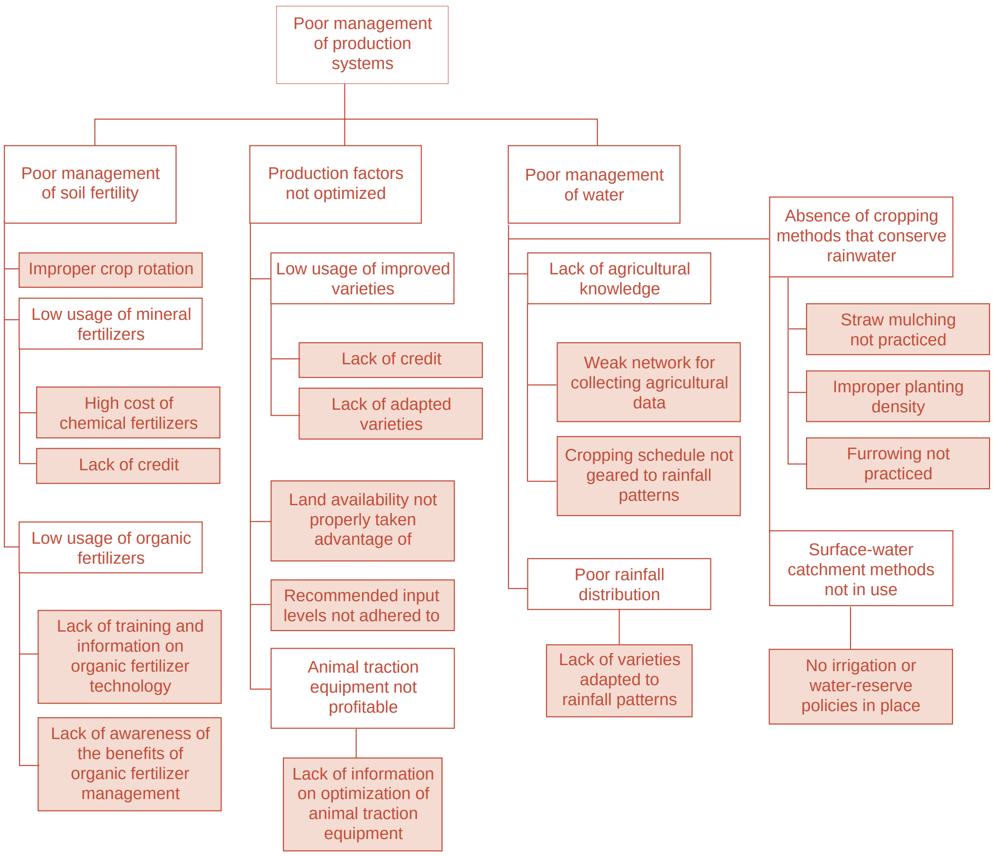
Many of the problems within these categories can't be solved through agricultural research. They depend on other development initiatives, such as creating infrastructure or improving credit, input supplies, education, and health services. There may actually be more nonresearchable constraints than researchable ones, which underlines the close connections between research and development at the regional level. Box 7 lists the nonresearchable constraints for livestock production and subsector development identified in the research plan for Benin's Central Region.

It is important to share such information with all parties able to address the constraints. Many such

Box 6: Portions of the constraints tree developed for Benin's Central Region research program



In the analysis of Benin's Central Region, two principal constraints were identified as underlying the central constraint of *low income.* These are *low profitability of agricultural activities* and *natural resource degradation.* The low profitability problem was, in turn, attributed to *poorly developed commodity subsectors, low crop productivity,* and *low livestock and fisheries productivity.* Similarly, natural resource degradation was attributed to *poor management of natural resources* and *poor management and integration of production systems.* The underlying causes of *poor management of production systems* are developed below. Lowest level constraints are those in the shaded boxes below.



people will be among the invited participants in program planning exercise. For nonresearchable constraints that concern the work of institutions not represented in the exercise, the program leader should take the initiative to communicate the information to them afterwards. This will help them to improve their own development plans and, by extension, will improve the prospects for a successful research program.

Box 7: A selection of nonresearchable constraints for Benin's Central Region

Constraints related to low livestock productivity

- inadequacy of watering stations during the dry season
- lack of demarcation of natural pasture land zones
- animal health not monitored by farmers
- distribution and use of pharmaceutical and veterinary products that are fake, expired, or ineffective
- veterinary products inappropriately packaged for village conditions
- livestock producers' lack of information
- low investment by livestock producers in their operations
- low availability of immediately useful technologies

Constraints related to the underdevelopment of commodity subsectors

- lack of confidence in formal credit institutions
- production based on usury
- use of loan money to cover religious expenses or for purchases that enhance prestige
- vagaries of the weather
- lack of credit to grow crops other than cotton and lack of means for ensuring regular supply of maize seed
- no competition among agricultural credit institutions
- lack of information on the use of maize seed
- improved technology not available locally for postharvest storage of crops
- lack of access to marketing information

Exploiting regional potential

Research programs should not only aim to remove constraints, even though this is a safe way to ensure impact. They should also exploit opportunities that arise from specific advantages or underutilized potential enjoyed by the region. These advantages fall into several categories:

Geographic location. Proximity to seaports, airports, road networks, or navigable waterways that can be used for trade.

Physical environment. Sufficient and regular rainfall, warm temperatures, moderate humidity, good weather, even terrain (flat or not too hilly).

Natural resources. Fertile, deep, and homogenous soil; abundant and diverse vegetative cover; water resources such as rivers, streams, a shallow water table or a good quality of water; the presence of useful ecotypes.

Human resources. Young population, satisfactory employment rate, good level of technical expertise among farmers, large and qualified workforce.

Organization and administration. A high degree of organization among professions, strong integration of the region's various economic activities, and good production support services such as credit, research, and extension.

Opportunities may be included in the constraints tree by expressing them in negative form. If, for instance, the presence of an international airport would allow for the export of vegetables and this is not done at present, the constraint may be formulated as "limited recognition of export possibilities."

2.3 Evaluation of Existing Research Results

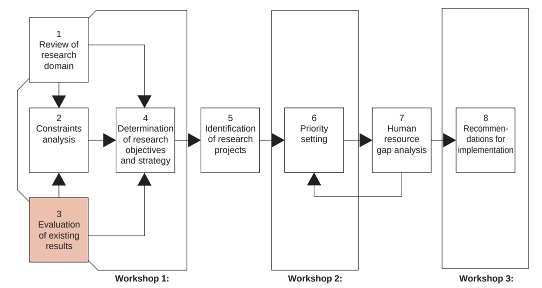
Detail of Step 3 of the Program Formulation Process, 'Evaluation of Existing Results '

Rationale
Efficient research programs do not inadvertently repeat research already done within the country or elsewhere

Output
Documents that help the program committee properly define the scope of research projects and avoid duplication of past work

Responsibility
Program committee member with background in agronomy

Participants
Researchers who belong to regional program or collaborate with it



Source: Collion and Kissi, 1994, with modifications by the authors

Information needs
Annual reports and research publications concerning the region or comparable regions

Methods
Bibliographic review, interviews with extension staff and farmers and data from research management information systems (e.g., INFORM)

Time and resources
Review should be started roughly three months before the first planning workshop. It will occupy most of assigned persons' time

The evaluation of existing research results, step 3 of program formulation, builds an inventory of technological progress already achieved and applicable to the region. It identifies research results already transferred or ready to be transferred, preliminary results in need of further testing, and partial results requiring further investigation. It also takes note of problems not yet researched. The review paves the way for new research projects to begin at the most advantageous point by taking account of previous knowledge. At the same time, it helps weed out projects which, in fact, are duplications of work already done.

The review looks at the past work not only of the program and the institute, but also of other research programs covering similar areas and problems. Computerized searches help identify results both internal and external to the national research system.

For internal results, the research institute's management information system should be consulted where one exists. Systems like INFORM, developed by ISNAR, provide data on research objectives, approaches, and results. They are a powerful tool for avoiding duplication in research projects (Vernon, 1995).

External searches are also important. As computer access improves, searches of international information bases are becoming the norm for research. Since regional research programs usually face a wide range of constraints, the external review is particularly important. It may find that identified research issues have already been successfully addressed elsewhere.

But the research review poses a potential timing conflict. On the one hand—and this needs emphasizing—the review can only be completed once the constraints have been laid out. This is because the constraints analysis pinpoints those research themes for which previous research results need to be compiled. On the other hand, because the research review is a lengthy process, the interests of the overall program formulation are served if the review is conducted beforehand. In this case it must anticipate as many constraints as possible. The conflict can be resolved by doing a second research review, after the first programming workshop, to cover those constraints not anticipated in the review conducted prior to the workshop.

The pool of past research results and knowledge varies from country to country and, within a country, from one region to another. In most developing countries, it is small because little research has been done or because the results have not be archived. Available results are most often sectoral in nature and concerned more with cash crops than food crops. There are usually few results in the area of natural resource management as well. This reflects what has, in the past, been the fundamental aim of research in most developing countries: to increase crop productivity, especially for export crops, without much worrying about management of natural resources. Furthermore, the emphasis has been on varietal improvement and plant protection. There are exceptions, of course. Early on some countries built national research systems with the explicit goal of promoting sustainable agricultural development.

By way of example, Box 8 highlights some of Benin's past research results in the area of natural resource management.

It should be noted that, at this level of planning, such results are to be presented as a synthesis. They are examined in more detail later, during the formulation of research projects.

Sometimes research results that could eliminate a constraint have already been obtained in another region of the country or abroad in agroecological conditions similar to those of the region concerned. In such cases, regional research programs are called on to formulate projects to confirm or adapt these results. But identifying such results requires complete familiarity with the state of both national and international research. This points to the necessity of involving people fully informed of the latest innovations in the planning process, be they national or foreign resource persons.

Experience shows that analysis of the existing pool of research results, while it is a pivotal step in planning, doesn't always elicit the interest it deserves. It is wrongly neglected and, most often, incomplete and limited to the specialization of the person assigned to conduct it. For this reason we recommend entrusting this detailed work of collection and analysis to a multidisciplinary team of motivated, veteran researchers under the leadership of one of the members of the program committee. In any case, the first stage of the review should be ready for discussion and validation at the first planning workshop, in the presence of farmers and development authorities.

Box 8: An overview of results from past NRM research in Benin

Soil fertility

- Ferralitic and ferruginous soils: Progressive degradation of these soils' chemical fertility has been demonstrated—lowered pH, reduction of organic matter, low content of exchangeable bases, and N, P, and K deficiencies.
- A "sandwich" composting method that uses crop and fallow residues, as well as industrial wastes, has been developed. It yields sufficiently decomposed matter in 90 days.
- Anaerobic composting accompanied by biogas production has been largely mastered.
- Use of natural phosphates: At 50 percent acidification, yields on ferruginous soils are very close to those obtained with ordinary phosphate.

Soil conservation

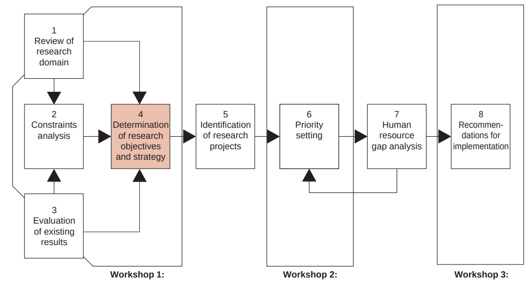
- On ferralitic soils, runoff reaches 60-80 percent and erosion causes soil losses of 20-30 tons per hectare per year. On the edges of plateaux with ferralitic soils where slope exceeds four percent, losses reach 70-80 tons per year.

Conservation and promotion of woody plant resources

- Fast-growing species have been selected for each soil type.
- The required periods of growth in bags in the tree nursery have been determined for the main species.

2.4 Defining Research Objectives and Strategy

Detail of Step 4 of the Program Formulation Process, 'Defining Research Objectives and Strategy '



Source: Collion and Kissi, 1994, with modifications by the authors

Rationale
The research program must focus on unambiguous objectives. Its projects, in turn, must respond to identified constraints

Output
Consensus on overall program direction and on objectives to be addressed to solve identified constraints

Responsibility
Program leader supported by facilitator

Participants
All workshop participants in close interaction with scientists and others to ensure relevant, feasible objectives

Information needs
Regional review, constraints analysis, and past research review

Methods
Discussion in plenary workshop and working groups

Time and resources
Between half and one day

Step 4 of program formulation, defining research objectives and strategies for the regional program, is a highly synthetic step. Information from steps 1, 2, and 3 is combined. Use of the results of the regional domain review and constraints analysis ensure that program objectives are relevant. Information from the review of past research helps guarantee feasibility of activities and prevent duplication of research effort.

In earlier days it was recommended that the researchers take exclusive responsibility for setting objectives. We find, though, that for a regional program, which is meant to involve users directly, research objectives are best defined jointly by researchers and users. While researchers assess approaches on their scientific merit, users and other stakeholders may assess them on their adoption potential.

Consider the example of research on bollworm, a pest that causes major damage to cotton. The research objective corresponding to this problem may be formulated in many ways: to develop resistant varieties, to identify an effective pesticide, to develop an integrated pest management (IPM) scheme, or to search for a biological enemy. Researchers may limit the range of research objectives by arguing that genetic resistance to the pest has never been found. Other stakeholders may similarly limit the range by pointing out the problems encountered in using IPM techniques on scattered plots. The group may thus agree that the objective should be to identify a chemical control agent (in the short run) and a biological enemy (in the long run).

Once a research objective is set, project titles can be formulated almost immediately. For example, if the objective is to identify a chemical control agent, the project may be called "evaluation of pesticides for controlling bollworm damage". Thus, defining research approaches and strategies follows directly and logically from setting research objectives.

As shown in this example, one constraint doesn't necessarily result in a single research objective.

Several objectives may be formulated, reflecting the complexity of the constraint or the uncertainty of finding a solution using a particular approach. By defining several objectives, the strategy on how to tackle a certain constraint is further refined.

Research objectives should be defined with particular care for the constraints at the bottom and top of the constraints tree (formulated during step 2). The highest level objective is the binding element of the program. It gives a sense of direction and strategy to program members, both in formulating the program and in executing it.

The research objectives formulated to correspond to constraints at the bottom of the tree are closely tied to possible research responses. They are the starting point for designing research projects, the building blocks of the research program.

Specific research objectives can be formulated only for researchable constraints. For nonresearchable constraints, complementary development measures may be formulated, but these are not addressed in the research program. Box 9 shows the link between researchable constraints, research objectives, and proposed research project titles for selected constraints in Benin's Central Region. Box 10 presents a selection of suggested complementary development measures.

Box 9: Selected researchable constraints, research objectives and proposed project titles for Benin's Central Region

Low crop productivity

Researchable constraint: Shifting cultivation of yam damages environment
Research objective: Develop yam production systems that preserve environment
Research projects: Develop a yam-based production system that preserves soil fertility and environment; develop manure mix for yam that doesn't affect tubers' eating characteristics; develop productive combination of yam and tree species

Low livestock productivity

Researchable constraint: Low productivity of natural pasture land during dry season
Research objective: Improve pasture land productivity during dry season
Research projects: Enhance natural pasture land through use of leguminous shrubs; develop natural pasture management techniques

Poorly developed commodity subsectors

Researchable constraint: Credit not matched to financing requirements
Research objective: Adapt credit to financing requirements
Research project: Study financing requirements and credit supply over time

Poor management of natural resources

Researchable constraint: Lack of knowledge about lumber species
Research objective: Achieve expertise in silviculture for most important local lumber species *(Isoberlinia, Afzelia, Anogeissus)*
Research projects: Develop seedling multiplication techniques for lumber species, study of planting methods and tree growth

Poor management of production systems

Researchable constraint: Absence of cropping methods that help conserve rainwater
Research objective: Develop cropping methods wherein plants make better use of soil moisture
Research project: Use agronomic measures to conserve soil moisture

Box 10: Selected complementary development measures, by constraint, for Benin's Central Region

Low livestock productivity

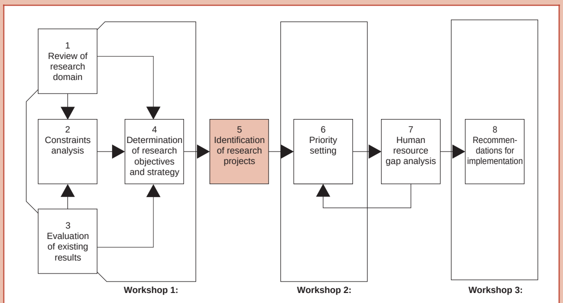
Nonresearchable constraint: Lack of demarcation of natural pasture zones
Complementary development measure: Improve land use regulation

Poorly developed commodity subsectors

Nonresearchable constraint: Lack of confidence in formal credit institutions
Complementary development measure: Improve targeting and sensitization of farmers. Improve structure of institutions to bring them closer to farmers

2.5 Identifying Research Projects

Detail of Step 5 of the Program Formulation Process, 'Identification of Research Projects '



Source: Collion and Kissi, 1994, with modifications by the authors

Rationale
To attain defined research objectives, research projects need to be specified

Output
List of research projects with their objective, corresponding constraint, project activities, and required human resources

Responsibility
Program leader supported by the program committee

Participants
Researchers associated with the program

Information needs
Research methodologies and, if possible, data on human resource requirements from earlier projects

Methods
Review of earlier projects, for example, through a management information system such as INFORM and consultation with possible collaborators

Time and resources
Up to two months

Identification of research projects is step 5 in the research program formulation process. Research projects follow from the constraints already identified. Each project consists of a coherent set of research activities. Every activity is required to attain the research objective; one cannot be removed without jeopardizing the project's success. At this stage, research projects don't need to be spelled out in great detail, but their overall shape should be determined. This takes the form of a title, the constraint to be addressed, the research objective, the component activities, the required human resources, and the location and duration of the project.

Research projects normally correspond to the constraints and objectives identified at the lowest level of the constraints tree. Occasionally a constraint at a higher level may be identified as the starting point for a research project. This occurs in cases where it is clear that all underlying constraints must be simultaneously removed if research is to successfully meet its objectives.

Research projects often involve various disciplines, but are made up of activities, each of which is normally undertaken by scientists from one discipline. Once the research project activities are defined, the time required of the different disciplines for each activity can be estimated. This is most easily done in terms of months of researcher time per year. In addition, the duration of the project (in number of years) has to be assessed.

When the time requirements per discipline change considerably during the course of the project, another approach can be followed. Then it is best to assess for each activity the number of years required and the number of months that need to be spent in each year. In this manner, a profile of time allocations across the length of the project can be established.

Time is most easily estimated in actual months of research time, but it should be recognized that a person will not spend 12 months per year on research. Even a person with a full-time research dedication spends time maintaining skills and knowledge, participates in conferences, has administrative duties, and takes vacation. Rarely will people spend more than eight months per year effectively on research projects.

Time is, of course, not the only cost of research projects, but on average it provides a high correlation with the actual total costs of a project for two reasons. First, the cost of human resources makes up the lion's share of most research institution budgets (Brush, 1996). Second, many of the operational costs (e.g., transport, fertilizers) are linked with the time commitment that researchers are making. For these reasons, at this stage of project identification, using approximations of human resource requirements to estimate total project costs is acceptable.

The program's research staff is normally responsible for formulating projects. In the first workshop, they may come up with preliminary project titles. But laying out project activities and estimating the required human resources are tasks best done after the workshop. Between the first and second workshops researchers may need up to two months to identify research projects in sufficient detail. The time is needed mainly to conclude bibliographic studies, reliably estimate the time frame of projects, and consult with potential collaborators.

Identifying research projects and their key parameters certainly isn't easy. Researchers tend to underestimate the time needed for successful completion of a project and overestimate the results that can be achieved. These weaknesses in judgment can be mitigated by consulting data on earlier projects as they become available in management information systems (Vernon, 1995). Projects documented in the data base will obviously be somewhat different from the ones being planned. But they may give a good idea of the time needed for various types of experiments and other activities.

Classifying research projects

Research projects can be usefully divided into two categories. Most fall under the heading of "technical", that is, they resolve a constraint to increased production or improved resource management. Once the results of such projects are disseminated, they should have a direct impact on the region. The second category is "support" projects. These eliminate scientific constraints to the progress of technical projects, thereby improving the overall effectiveness of the research effort. For example, without a proper assessment of the location and gravity of soil degradation, it may be impossible to make progress in other types of NRM research projects.

Another way to classify research projects is by their expected benefits. Some projects will have only one type of benefit. They may influence cropping, livestock, water management, forestry, or soil quality, but never more than one of those. These can be referred to as "focused" projects. Other projects may have an impact on several dimensions. Agroforestry work, for example, often affects cropping, forestry, and soil quality. Such research efforts can be referred to as "integrated" projects. These surpass traditional research boundaries and are a distinctive feature of regional programs. Integrated projects are the glue of regional programs, allowing them to handle the complex problems that arise in the context of resource use at the regional level. In Benin's regional research programs, integrated projects make up 36 percent of projects identified for the Central Region, 25 percent in the Southern Region, and 37 percent in the Northern Region. Box 11 lists a number of integrated projects identifies for Benin's Central Region.

Project screening, transfer, and removal

As we saw in step 2 of program formulation, agricultural and NRM constraints in a region and their relationships can be highly complex. So it's understandable that the same constraint may be identified at two or more places in the constraints tree or that similar research projects may be identified by different researchers. "Screening" refers to the elimination of unnecessary project duplication within the program and other programs. Management information systems, which combine information on all projects in the institution, may be used as a source for checking for duplication across programs.

It may also happen that some of the proposed projects are more suited to research programs other than the regional one—whether they be commodity, disciplinary, or production-factor

Box 11: Integrated research projects for Benin's Central Region

Project title	Activity	Subsector	Human resource requirements in first three years
Development of method for **bush fire control**	Diagnose indigenous methods for bush fire control Screen species for use as "green" firebreaks Experiment with setting fire during different periods	Forestry Soil quality	Forester: 7 months Soil scientists: 4 months Socioeconomist: 3 months Total: 14 months
Development of improved **anti-erosion methods** adapted to different types of terrain	Take inventory of different types of erosion Diagnose traditional anti-erosion methods Screen shrubby and herbaceous species for use in erosion control Conduct comparative study of mechanical methods of erosion control	Forestry Soil quality	Soil scientists: 8 months Socioeconomist: 1 month Agroforester: 4 months Total: 13 months
Development of efficient methods of **fallow management**	Develope techniques for enhancing natural fallow land Develope different techniques for shrub-based fallow Develope ways to recycle animal manure and crop residues to fertilizer soil	Forestry Soil quality	Agroforester: 3 months Zootechnician: 3 months Agronomist: 7 months Total: 13 months
Development of agronomically feasible **crop rotation system**	Diagnose traditional crop rotation systems Identify best cropping practices Develop optimal rotation systems	Soil quality Crops	Socioeconomist: 1 month Agronomist: 7 months Total: 8 months
Development of methods for **soil moisture conservation**	Compare various soil cultivation practices that allow for better use of moisture Compare soil-cover practices that allow for better use of moisture	Soil quality Crops	Soil scientist: 3 months Agronomist: 7 months Total: 10 months
Development of **low-cost fertilization** methods	Characterize soils Establish nutrient budgets for specific crops Establish fertilizer formulas according to crop and zone Develope appropriate mixes of organic and mineral fertilizers	Soil quality Crops	Soil scientist: 9 months Agronomist: 9 months Total: 18 months
Development of productive **combinations of yam and tree species**	Screen tree species that can serve as living stakes for yam	Forestry Crops	Agronomist: 3 months Total: 3 months
Development of methods for **managing natural pasture land**	Study resistance of pasture forage species to trampling Study stocking potential of natural pastures Develop an appropriate schedule for pasture exploitation (periods for grazing, hay making and silaging)	Soil quality Livestock	Pasture scientist: 10 months Total: 10 months
Development of methods for using **agroindustrial by-products and crop residues in animal feed**	Compile an inventory of locally available agro-industrial and food processing by-products Develop methods for storage and preservation of by-products Develop methods for use of by-products in animal feed	Crops Livestock	Zootechnician: 6 months Nutritionist: 3 months Total: 9 months
Introduction of **forage species in crop rotations**	Test the performance of forage species in the region Develop pasture-establishment methods compatible with regional production systems	Soil quality Crops Livestock	Pasture scientist: 4 months Agronomist: 3 months Total: 7 months

programs. Passing such projects to those programs better suited to deal with them is referred to as "transfer."

Finally, in the creative atmosphere of research project identification, some researchers may propose projects that, in fact, don't require research at all, but only extension, credit, or input support. "Removal" is the identification and elimination of these types of projects.

The screening, transfer, and removal procedure differs from priority setting (step 6 in the program formulation process) in that it analyzes projects purely on their technical merit. If technical content does not justify the duplication of a project or its presence within the regional research program, the project is removed from the program or shifted to a more appropriate one. It can therefore be assumed that in step 6, all the proposed projects are appropriate for the regional program from a technical standpoint. They can then be analyzed on their expected benefits.

In Benin, the screening, transfer, and removal procedure resulted in a major streamlining of the projects identified for the regional research programs. In the Central Region's program the number of projects fell from 90 to 48, in the Southern Region from 110 to 53, and in the Northern Region program from 125 to 67. The procedure is the responsibility of the program committee, headed by the program leader. The representative of the planning unit should collaborate intensively with the program committee to ensure that projects to be transferred to another program are actually being considered there.

2.6 Choosing Priority Research Projects

Detail of Step 6 of the Program Formulation Process, 'Priority Setting '

Rationale

Finite resources available to the program usually means that only a limited number of the identified research projects can be implemented

Output

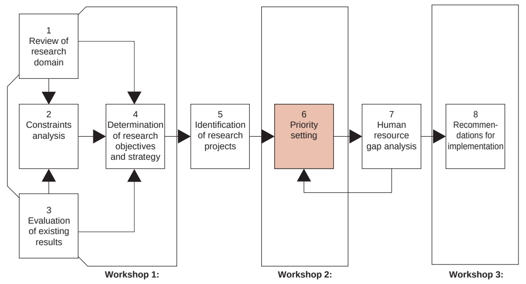
A list of projects ranked from highest to lowest priority

Responsibility

Socioeconomist supported by the program leader and a facilitator

Participants

All workshop participants



Source: Collion and Kissi, 1994, with modifications by the authors

Information needs

Economic data on agricultural production and resource values plus information on potential spread of technology and adoption behavior

Methods

Simplified cost-benefit analysis, trend analysis, and natural resource valuation

Time and resources

One month to prepare background information and one to one-and-a-half days during the second workshop

Invariably, more research projects are identified than can be implemented with the available resources. Hard decisions must therefore be made about the relative importance of projects.

Step 6 in the program formulation process is priority setting. Here, the analytical approach of steps 1, 2, and 3 and the creative approach of steps 4 and 5 are confronted with the managerial imperative to ground the overall programming process in reality. Projects can be ranked using a number of methodologies. In these guidelines, we use a scoring method to decide which projects to implement first and which to put off until later if additional resources are found.

Choosing priority projects for a regional program is complicated by the fact that the different research projects may provide different kinds of benefits. For example, it's not easy to compare a project for improving natural pastures with one for eliminating sorghum losses due to a pest, or with one for reducing erosion through agroforestry techniques.

In commodity research programs, all projects ultimately aim to increase commodity subsector profitability. Comparison of projects is straightforward because the relative benefit is a sufficient criterion for evaluation. If project "A" contributes more to maize productivity, and hence to profitability, than project "B", it's not important for the purpose of comparison to know the absolute values of the expected benefits.

In regional research programs, the situation is different. Projects may contribute to the profitability of the cereal subsector, or to the value of dairy production, or to the quality of soils. Therefore, as reasoned by Springer-Heinze (1994), comparing the likely benefits of different projects requires a more elaborate method. The priority-setting procedure presented here allows comparisons of the different types of benefits that could be attained through research projects. The procedure combines elements of a number of priority-setting approaches (multiple criteria, cost-benefit analysis, research production functions) with production and natural resource valuation techniques. For further description of priority-setting methods, readers are referred to Alston, Norton, and Pardey (1995) and Contant and Bottomly (1988).

Other procedures, of course, may be used than the one presented in this chapter. The choice depends largely on the time and data available and on the economics skills of the program committee. If time allows, a team of economists could theoretically develop analytical models for estimating the specific benefits of each and every research project proposed for the regional program. This might be to great advantage. But, in practice, such an all-encompassing procedure would be extremely data intensive and could take years given the number of projects normally considered in a program formulation exercise. Just as bad, such an approach would probably be so complex as to be unintelligible to outsiders, who would lose sight of why one research project might be chosen over another. Alternatively, a simple assessment on a few key criteria can be used. This approach is rather straightforward but often confirms rather than challenges the established thinking about the problems of the region. Readers who would want to set priorities by using a few key criteria without an economic evaluation framework should consult Tripp and Woolley (1989).

The priority-setting challenge, then, is to use an approach that effectively deals with the different types of benefits coming from a variety of regional research projects, but that can also be applied relatively quickly. The method presented here requires a modest amount of data collection, manipulation, and interpretation, and allows all projects to be evaluated using the same methodology. We first explain the methodological background of the approach and guide you through its application. Then, in the final section of this chapter, we discuss how the method can be feasibly applied in the context of a planning workshop.

A methodological framework for priority setting

The basic mathematics of the methodology for setting regional research priorities have been adapted from the approach developed by Collion and Kissi (1994) for commodity programs. In their approach, a project score is calculated as follows:

$$N_i = (V \times p_i \times s_i \times a_i) / C_i \qquad (1)$$

where

N_i = the score for project i.

V = the total potential impact of the research program on improving the value added to the subsector under consideration (e.g., cotton).

p_i = the contribution of research project i to realizing V. This can also be expressed as the relative severity of the constraint that the project addresses. The sum of p for all projects is one.

s_i = the chance of success of research project i (between zero and one).

a_i = the expected rate of adoption of the results forthcoming from project i if it is successfully completed (between zero and one).

C_i = the cost of project i (normally approximated by the required researcher time).

Projects that receive the highest scores have the highest priority for implementation. The equation admittedly suffers from several theoretical shortcomings, the main ones being that time lags in the generation and diffusion of new technologies are not sufficiently accounted for and cost estimates have been greatly simplified (see Collion and Kissi, 1994). However, the formula has been successfully applied in numerous planning exercises. The high level of stakeholder participation, mechanisms for fine-tuning participants' judgments and assumptions, and the transparency of the results compensate largely for the theoretical shortcomings.

The adaptation of this priority-setting approach to regional program planning is based on three considerations which bear repeating:

1. Research projects in a regional program may contribute to different types of benefits and objectives. To account for such differences between projects, the priority-setting approach has to distinguish between various benefit dimensions, such as the benefits of increased crop productivity, the benefits of increased livestock productivity, the benefits of improved soil quality, and so on.
2. Because one project may contribute to one benefit dimension and another project to a different dimension, it is not sufficient to know

the relative contributions of each project to the benefit dimensions on which they impact. The absolute sizes of each of the benefit dimensions need to be estimated in order to compare, for example, the benefit of a five percent increase in crop production with a 20 percent increase in livestock production.

3. Regional research programs take into account the integrated nature of agricultural production and resource management. Many projects will therefore contribute to more than one benefit dimension.

Based on these considerations, the score of project i can now be calculated by extending equation (1) into the following:

$$N_i = [\ (V_c \times p_{ci} + V_l \times p_{li} + V_f \times p_{fi} + V_q \times p_{qi} + V_w \times p_{wi}) \times s_i \times a_i\ ] \ /\ C_i \qquad (2)$$

where all previously used symbols have the same meaning as in equation (1), and V is the total impact of the regional research program on improving the value added or quality of the benefit dimension indicated by the subscript. The subscript letters have the following meanings:

c = cropping activities
l = livestock activities
f = forestry activities
q = soil quality
w = water management

Equation (2) states that the total potential benefit of project i is equal to the sum of its potential effects on improving the value added to crop production, livestock production, and forestry production, plus its effect on soil quality and water management. This sum is then corrected to take into account project i's chance of success (s_i), expected adoption rate (a_i), and project costs (C_i).

Many projects contribute to only one of these five benefit dimensions, which simplifies calculations. And not all the benefit dimensions may be relevant to the planning of every regional program. In Benin, for instance, only the first four were used. Other benefit dimensions may be added to the equation as well. In Senegal, for example, fisheries was included.

Finally, it is important not to double count project contributions, for example, in both the crop production and soil quality benefit dimensions. To avoid this, the types of benefits to be assigned to the different dimensions should be clearly defined. For crop production, to continue the example, one should estimate the short-term production effects on the assumption that soil quality doesn’t change. For soil quality, one should consider the long-term effects of soil improvement, as measured in land prices, production potential, or nutrient value.

Once the relevant benefit dimensions are specified, the identified research projects are assigned to the different dimensions and the potential benefits of each of the projects are calculated. Then the other project parameters are reviewed—chance of success, potential for adoption, and research cost—and a final project score is calculated. Finally, the resulting priority ranking is discussed and evaluated.

The sequence for priority setting in Benin’s Central Region research program is illustrated in the boxes throughout this chapter. Benin used simple estimation procedures and relied on the collective judgment of workshop participants to arrive at reasonable assessments. The estimation procedures were kept simple for three main reasons:

1. In many situations sophisticated procedures cannot be used because the necessary data are not available.

2. Simple procedures keep the priority-setting method transparent for the workshop participants. This promotes acceptance of the method, and allows the assumptions and outcomes to be improved on by all.

3. At the level of program planning, the information on the projects being prioritized is in outline form only. There is no reason to complement such sketchy project information with highly detailed benefit estimation procedures.

However, in cases where detailed data are available or where more precise methods can be easily implemented, their use is certainly recommended.

Defining benefit dimensions

In the area of agricultural productivity, there are two main benefit dimensions that will define project scores:

- **The benefits of increased crop productivity.** That is, the productivity of both annual and perennial crops. In regions where perennial crop production is especially important, this may be split off into a separate benefit dimension.
- **The benefits of increased livestock productivity.** This concerns large and small ruminants, pigs, poultry, and other animals. Where fisheries are of limited importance, they can be included in this benefit dimension. Otherwise a separate fisheries benefit dimension may be needed.

The benefits of improved pasture productivity should be treated with special care. To the extent that improved pastures lead to better animal nutrition, their benefits fall under the livestock benefit dimension. To the extent that they lead to more productive crop rotations, their benefits fall under the soil quality benefit dimension of improved natural resource management (see below).

For improved natural resource management, three benefit dimensions are most significant:

- **The benefits of increased sustainable forestry production.** By supplying wood, fruit, medicine, and other products, forests can make a major contribution to the regional economy (Franzel, Jaenicke, and Janssen, 1996). By improving forest management, the flow of such products may be maintained or increased.
- **The benefits of improved soil quality.** Soil degradation is a serious threat to long-term agricultural productivity and may, through erosion, have major off-site effects. Siltation of dams may undermine the potential for irrigation and energy generation. Siltation of rivers and reservoirs may reduce fish catch and increase the threat of flooding.
- **The benefits of improved water management.** Water, not land, may be the most limiting resource in a region. An example is the semiarid regions of Morocco. In such areas, improved use of water may have a high impact. This is especially true where competition exists among different uses of water—for human consumption, energy production, and irrigation, for example.

The benefit dimensions related to natural resource management have clear economic value to the region, though they tend to be long term rather than short term. Incorporating resource management concerns into project priority setting, therefore, does not move us away from maximizing the economic benefits of research. Rather, it implies an explicit effort to put a value on such long-term effects.

Some benefit dimensions are difficult to assess because the major share of the benefit will fall to other regions and, possibly, other countries. Also, the effect of research within the region may not be clearly traced. This may be the case, for example, of research to maintain genetic diversity. The priority of such research to a (strictly) regional program may be low because the users within the region obtain only a small part of total benefits, and because for maintaining genetic diversity globally, it may not be clear how important work in the specific region is. This is not a reflection on the importance of genetic diversity, but on the geographic boundaries used to delimit research benefits. The importance of genetic diversity work is better assessed at a national, or possibly international level. If from such assessments the conclusion follows that work in a certain region is key to maintaining diversity, resources should be made available and genetic diversity work should be integrated into the regional program.

As we shall see, the next task in applying this priority-setting approach is to estimate the potential impact of the regional research program on each of the selected benefit dimensions. This requires substantial work. Indeed, including additional benefit dimensions makes the exercise more complex. The caution here is that benefit dimensions should not be added without good reason. In the case of Benin, it was decided not to include an explicit water management benefit dimension, because it would complicate the calculations unduly.

Finally, it should be noted that benefit dimensions don't directly correspond to the principal branches of the constraints tree. This is simply because identified constraints often have repercussions in several dimensions. So research aimed at eliminating a constraint such as "poor integration of farming system components" may bring benefits to crop and livestock production as well as to soil quality.

Estimating the size of benefit dimensions

The "size of a benefit dimension" is defined as the difference between, on the one hand, the expected value of a region's agricultural production and natural resources and, on the other hand, their potential value if all constraints that are researchable for that benefit dimension are removed.

Estimation principles

What are the potential benefits of removing all regional research constraints to, say, livestock production or soil quality? For livestock production, it's a matter of estimating what portion of production growth is attributable to removing these constraints. This is a rather straightforward exercise, as we will see below. The same goes for crop production (see also Collion and Kissi, 1994).

It is less obvious how soil quality relates to agricultural supply (Norse and Saigal, 1993; Mendelsohn et al., 1994). Here it may be easiest to turn the question around and ask what is the value of soil quality losses and what share of those losses could be prevented through regional research. We also know that soil degradation often causes traceable problems downstream (off-site effects). So we should try to estimate the extent of downstream problems and the potential of the regional research program to solve them.

For forestry, both the quality and supply approaches can be attempted. The supply approach follows the livestock example, estimating the added increase in the supply of forest products achieved by removing constraints. The quality approach is similar to the soil example in that it estimates the value of the forest cover that disappears annually because of poor management and then assesses the extent to which this could be stopped.

For water management, an efficiency improvement approach may be used for valuation purposes. Current water use in the region is compared with likely use following the introduction of water-saving measures. The value of such savings can be calculated by multiplying the amount by the price of water. The price of water can be obtained by estimating the cost of supplying water (production and transport costs) (Arntzen, 1995). This approach will not be elaborated further here.

Estimation assumptions

To estimate the size of the benefit dimensions three steps are taken:

1. Initially a crude estimation is made of the expected benefits of research. This estimation may be that research contributes one percent additional production growth (or value), or that it stops all soil quality losses. The preliminary nature of these assumptions allows the program planning team to prepare initial estimates of the size of the benefit dimensions before the second workshop.

2. Second, the initial, crude assumptions are reviewed. Is it probable that research could increase both crop and livestock production by one percent? Is it realistic to presume that research can stop all soil quality losses? If not, what share of the initial assumption can be realized? This review is done by the participants in the second workshop.

3. Finally, the share of the regional program in the total benefits derived from the whole research effort is estimated. The regional research program may be more important for one benefit dimension than for another. For example, this may be because of significant research efforts in other programs. The estimation of the share of the regional program of total research benefit is also made during the second workshop.

Initial estimates of the size of the benefit dimensions

Initial, crude estimates of the size of the benefit dimensions are based on the supply impact of research, the on-site impact of agricultural research, and the off-site impact of research. As we have seen, for crops, livestock, or forestry, crude estimates of potential research impact can be based on the supply impact of research. For the soil quality dimension, the initial estimation is based on an assessment of the on-site and the off-site effects of research.

Supply impact of research. For production benefit dimensions, the first step is to assess the additional growth in supply resulting from successful research. Consider an agricultural sector at subsistence level, with a static policy framework (it doesn't get better or worse) and with no efforts to improve the technological base of production.

Under these conditions, one may assume that supply growth will be strongly defined by the demand induced by population increases. Existing production constraints would cause supply growth to lag somewhat behind population growth, but the lag would be shortened by the dissemination of technologies from other parts of the world. With population growth in Africa at two to three percent per year, we can assume that without any domestic efforts to make new technologies available, the rate of supply growth in agriculture would be two percent. Probably such growth would occur largely through increased input use and area expansion (where possible).

Technological progress, including agricultural research, helps increase supply growth. The initial question is by how much. Aggregate data on this question are sparse. Research by Block (1995) showed that roughly one-third of production growth in African agriculture could be attributed to technological change. With this estimate in mind we make the initial assumption that a successful research program could increase production growth by one percent—that is, raise it from the reference level of two percent to a total of three percent.

The impact of research started today will be felt only after the several years needed for technology development and dissemination. But impact will build rapidly once research results are adopted. Rather than trying to construct benefit profiles over time, we propose to estimate the research-induced benefits by using the projected difference in supply in 10 years' time. The projected supply value in 10 years assuming two percent growth is subtracted from the value obtained assuming a three percent growth rate. This estimation method is a compromise between two observations. First, the expected benefits in 10 years' time will probably still be below the projected difference, because of the lag between technology development and diffusion. Second, benefits may build rapidly in the years afterward, in which case their absolute value will be higher than the projected difference for year 10.

Box 12 shows the estimates made in Benin for three benefit dimensions: crop production, livestock production, and forestry production.

Research impact on on-site resource quality. The impact of research on soil quality can be assessed in various ways. Norse and Saigal (1993) propose four alternative approaches:

1. The difference between the market value of quality land and that of degraded land is measured. The feasibility of this approach depends on the presence of a functioning land market and a sufficient number of transactions to allow analysts to isolate the quality effects from other price-shifting variables (population pressure, accessibility, urbanization, and so on). To operationalize this approach, reference qualities must first be defined for different plots.

2. The difference between the productivity of quality land and that of degraded land is measured. To apply this approach, the interaction between land quality and productivity must be clear. As with the method above, it is important to define standard reference qualities, which may be quite difficult.

3. Expenditures to prevent soil degradation—for example on anti-erosion windbreaks—are measured.

4. Costs for replacing the elements that embody the fundamental quality of the resource are measured. In the case of soil degradation, these are the nutrients being lost, as well as soil texture and structure. Van der Pol (1992) elaborated this approach for Mali.

For practical purposes, the choice of approach is determined largely by the availability of data. Let us look at each of the four approaches in that light.

First, in many developing countries, land markets do not function well enough to observe differences that can be interpreted. Second, the quality-productivity relationship is not disputed, but a factual estimation is very difficult, to say the least. Third, expenditures to prevent soil degradation are difficult to measure, because of their nonlinearity. To prevent 80 percent of soil degradation, a certain investment may be sufficient. But to prevent the next 10 percent may cost just as much. Last, the replacement approach is highly sensitive to the nutrient prices that are imputed and the effect of nutrient losses is not yet fully understood (Smaling, Fresco, and de Jager, 1996). The replacement approach gives equal value to each cubic meter of soil lost, whereas it is well known that the initial losses do not have as large an impact as later losses.

In the case of Benin, market data, data on the quality-productivity interaction, and prevention data were not available. However, there were data on nutrient losses from an Africa-wide study. Fur-

Box 12: Calculation of potential research impact on crop, livestock, and forestry production

The figures in the table at the right show 1992-94 values for crops, livestock, and forestry in Benin's Central Region (expressed as millions of dollars). We see, for example, that cropping is clearly more important than livestock production. It is also worth noting that the value of the region's forest products is more than three times that of its livestock production. To a more modest extent this can also be seen at the national level: forestry production is more valuable than livestock production, and crops are most important. The numbers reflect low income levels in the country. Animal protein is too expensive for many people and firewood is the primary source of energy.

To estimate of the potential value of research, the difference is calculated between a two percent and three percent increase in the value of production in the region (in the table below).

Here we see that if research resulted in a one percent supply growth (in addition to the two percent growth expected to result from population increases), the expected benefits of research in the region would be close to $30 million for the year 2005. Benefits would obviously be skewed towards cropping, and away from livestock.

Commodity	National Production Value	Region's Share of Value (percent)	Regional Production Value
Crops			
Maize	99.6	16	15.9
Cassava	71.1	32	22.8
Yam	115.4	37	42.7
Groundnut	24.9	53	13.2
Sorghum	29.1	14	4.1
Cowpea	29.6	43	12.7
Cotton	64.6	32	20.7
Rice	4.9	25	1.2
Tomato	18.6	7	1.3
Pepper	6.7	18	1.2
Sweet Potato	1.9	15	0.3
Cashew nut	1.5	40	0.6
Oil palm	78.1	0	0.0
Coconut	9.1	0	0.0
Pineapple	1.2	0	0.0
Total crops	*556.3*	*25*	*136.7*
Livestock			
Beef	35.2	5	1.8
Small ruminants	7.9	12	0.9
Milk	34.4	5	1.7
Pork	8.9	17	1.5
Poultry	15.6	10	1.6
Eggs	5.0	10	0.5
Fish	70.0	5	3.5
Total livestock	*177.0*	*6*	*11.5*
Forestry			
Forest products	*227.6*	*17*	*38.7*

Category	Value 1992-94	Value in 2005		Difference
		2 Percent Growth *(a)*	3 Percent Growth *(b)*	*(b) - (a)*
Crops	136.7	173.4	194.9	21.5
Livestock	11.5	14.6	16.4	1.8
Forestry	38.7	49.1	55.2	6.1

All values in millions of dollars.

thermore, the replacement approach (under 4 above) had been applied before in the region (van der Pol, 1992). The replacement approach was therefore used to estimate the size of the soil-quality dimension. Box 13 illustrates this for the on-site benefits and costs.

Off-site impact of agricultural research. In the first, second, and fourth approach above, different methods are applied to measure the on-site effect of soil degradation. However, soil degradation may also have off-site effects, when sedimentation causes losses in fish catch, increased risks of flooding, or the shortening of the economic life of hydroelectric plants. These losses should be measured as well. For the approach under three above, the prevention of soil degradation stops the off-site damage as well, and there is no further need to measure off-site effects.

Estimating the off-site impact of research in agriculture is certainly difficult. Soil quality research, for example, may produce technologies to reduce sedimentation, which in turn, benefits the fish catch, reduces the chance of flooding, and improves the life span of dams. If soil quality research leads to improved water retention, flooding risks may be further reduced—a benefit to which forestry research and cropping technology development may simultaneously contribute. Similarly, agricultural research to increase water use efficiency may have the off-site effect of improving the quality of drinking water in urban areas.

The off-site impact of soil degradation by erosion is considerable. Pimentel et al. (1995) estimate such impact to be on the order of 60 percent of on-site effects for the USA, but they do not draw conclusions for other countries. Ashby et al. (1994) estimate the off-site effects of erosion of Colombian hillsides to be greater than erosion's on-site impact on soil quality.

Box 13: Estimating the on-site benefits of soil quality research

The research program for Benin's Central Region used a replacement approach to estimate the direct benefits of soil-quality improvement research. Stoorvogel and Smaling (1990) estimated nutrient balances for different land use systems in Benin for the year 2000. They distinguished six principal land categories according to moisture availability: low rainfall, uncertain rainfall, good rainfall, problem area, naturally flooded, and irrigated. A seventh land category was added for permanent pasture land. By overlaying the map of the land categories with the map of the regional divisions, the share of the Central Region in the different land categories was defined.

Element	Total Nutrient Losses (tons per year)				Losses in Central Region
	Good Rainfall Areas	Natural Pastures	Irrigated Areas	Flooded Areas	
N	33,749	5,304	141	—	12,838
P_2O_5	10,876	1,326	100	—	4,072
K_2O	29,662	1,874	274	—	10,773
Central Region's share of areas	35%	19%	13%	28%	

The Central Region has 35 percent of the area in Benin with good rainfall and 19 percent of the permanent pasture land. The region also has part of the irrigated and the flooded areas—13 percent and 28 percent respectively of Benin's total. The other categories are not present in the Central Region. By multiplying the total nutrient losses in each land category by the share of the Central Region, the total nutrient losses in Central Region can be calculated (see table above).

Valuing nutrient losses for the year 2005. To attach a value to these losses, nutrient prices have to be known. Nutrient prices were obtained from IFDC statistics on fertilizer prices in West Africa (IFDC, 1995). Prices were available for various fertilizer sources, and the cheapest source for each element was chosen. In this example, these were urea for N, TSP for P2O5, and KCl for K_2O. Before multiplying nutrient losses by fertilizer prices, a correction was made for the availability of the element in the fertilizer (Agricultural Compendium, 1981) (see table below).

Element	Nutrient Loss (tons per year)	Fertilizer Price (dollars per ton)	Nutrient Availability (correction factor)	Value of Nutrient Loss (millions of dollars)
N	12,838	230	42% (2.38)	7.0
P_2O_5	4,072	170	49% (2.04)	1.4
K_2O	10,773	112	55% (1.82)	2.2
Total value				*10.6*

In the year 2005, expected losses would be larger because the agricultural area is expected to grow. At a growth rate of two percent per year, the total value of nutrient losses in the year 2005 would be: $1.02^5 \times$ \$10.6 million = \$11.7 million.

The annual value of nutrient losses should be interpreted carefully. On the one hand, minor elements are not included in the calculations. Neither are losses of organic matter. This suggests that the present value underestimates nutrient losses. On the other hand, not all nutrients that are lost need to be replaced and fertilizers may be a costly way to replace nutrients. This suggests that the present value overestimates losses.

Identifying the principal off-site processes that agricultural research may affect is the first step to valuing such potential benefits. Off-site effects may be estimated following the same principles as those presented for estimating the on-site impact of research on soil quality. That is, the value of assets affected may be estimated, the production loss of the assets may be estimated, or the cost of compensating for the damage may be calculated. Box 14 provides an example from Benin's Central Region.

Valuing natural resources, both on-site and off-site effects, has become an important field of study. Advanced methodologies, requiring sophisticated data are available, and wherever possible, these methodologies should replace the crude calculations made here. We refer the reader to Munasinghe (1993), Pearce (1994), Serageldin and Steer (1994), Bartelmus et al. (1994), and Willis and Corkindale (1995) for further theory and examples.

Estimating the feasibility of research for the different benefit dimensions

Thus far, we have assumed that, on average, a successful research program could increase agricultural production growth rates by one percent. But the feasibility of achieving one percent production growth through research is not necessarily the same for cropping, livestock, and forestry. Whereas for one subsector, the total growth rate as a result of successful technology development may be sizably higher than one percent, for other subsectors it may be equal or lower. Moreover,

Box 14: Estimating off-site impact of soil quality research

Two principal off-site effects of soil degradation were identified in Benin:

1. River and reservoir sedimentation reduces fish habitat and therefore the catch principally in the south of the country. Since fish are the principal source of animal protein, this effect is strongly felt.

2. Sedimentation causes frequent flooding in the southern departments.

Between 1989 and 1994, the average fish catch in the south of Benin dropped by 2680 tons per year. At a price of $1.8 per kilogram (the local fish price), this works out to a loss of $4.8 million per year. Half the annual loss ($2.4 million) was attributed to sedimentation, the other half to overfishing.

The expected costs of increased flooding could not be estimated as easily. It was decided to double the costs of sedimentation to account for the losses due to flooding. The total costs of sedimentation were therefore estimated at $4.8 million per year. Sedimentation is expected to increase with the area under agriculture. The growth rate of the agricultural area was estimated at two percent. For the year 2005 the expected losses were thus calculated as $1.02^{10} \times$ \$4.8 million = \$5.8 million.

Losses to fishery and losses due to flooding are indirectly caused by agricultural activities on all land that drains to the south of the country. This includes all of the southern and central regions and 30 percent of the land in the Northern Region. Taking into account the surface areas of the respective regions, it was estimated that 38 percent of sedimentation losses should be attributed to agricultural activities in the south, 28 percent to the center, and 34 percent to the north.

The cost of sedimentation in the year 2005 attributed to agricultural activities in the Central Region was thus estimated as \$5.8 million $\times$ 0.28 = \$1.6 million.

Using the replacement approach, the total size of the soil quality benefit dimension (*BD*) is then estimated at $1.6 million per year (off-site impact) plus $11.7 million per year (on-site benefits), for a total value of $13.3 million per year.

the chance of resolving, for example, all soil degradation problems through research is certainly not similar to that of achieving one percent growth in crop yield.

The share of benefits that can be realistically achieved through research may be larger than, equal to, or smaller than the one percent reference estimate, depending on the amenability of the benefit dimension to solution by research. This depends on two factors:

1. **The extent to which the constraints related to a benefit dimension are researchable in nature.** Constraints to increased production or improved resource management may be caused by factors outside the research domain, for example, by poor infrastructure, deficient legislation, inadequate institutional development, or a poor education system. If development is principally constrained by such issues, agricultural research will not have major impact. In most circumstances, researchable constraints affect crop production strongly. For livestock, the institutional environment (credit, extension) appears to be very significant. For forestry, research solutions are important, but legal elements and education strategies may also play a large role. For soil quality and water management, nonresearchable constraints such as poor infrastructure, absent legislation, and poor education and institutional arrangements tend to dominate. By reviewing the relative importance of the researchable and nonresearchable constraints identified in step 3, the planning group may assess this factor.

2. **The ability to deliver new technologies to users**. Knowledge-intensive technologies are normally difficult to transfer, whereas physically embodied technologies (seeds for example) can be transferred more easily. Capital intensive technologies (e.g., new livestock, erosion control investments, or irrigation schemes) can often only be offered on a limited scale and require extensive organization. If there is a strong extension system, it increases the probability of obtaining high benefits through such research solutions. Table 3 summarizes the degree to which these factors will normally affect the feasibility of research.

Ranking these factors, one would expect that the impact of research would be, on average, greatest in cropping activities, followed by livestock, forestry, water management, and soil quality. These differences suggest the need to weight the calculated values of the size of the different benefit dimensions. For example, the value for the livestock benefit dimension (based on the one percent reference value) could be multiplied by 1.5 because of the strong amenability to technological progress. For the soil quality dimension, the value might be multiplied by a much smaller correction factor, say 0.5, because of lower research feasibility.

Table 3. Factors influencing the feasibility of research solutions for different benefit dimensions

Factor	Benefit Dimension				
	Cropping	Livestock	Forestry	Soil Quality	Water Management
1. The extent to which constraints are researchable in nature	high	medium	medium	low	low
2. The ability to deliver new technologies to users	high	medium	medium	low	low

Amenability of benefit dimensions to solution through research is classified as low, medium, and high.

Estimating the share of the regional program in total research benefits

Once we know the feasibility of research for each benefit dimension, we still need to define the regional program's share in overall research benefits. As explained in Part 1, commodity and discipline-based research programs may also play a role in the region, and they may be more or less important than the regional program. Therefore, only part of the total future research benefits that will accrue to the region can be attributed to the regional program.

The relative importance of the regional program depends strongly on the strategic considerations discussed earlier. If, at the national level, a decision was taken to share research between a regional research program and a commodity research program, then the regional program's role is obviously smaller than if the work had been concentrated only in it. It is difficult to provide generic guidelines on the role of a regional program. In box 15, we show, by benefit dimension, the relative importance of different kinds of programs in the overall research effort for Benin's Central Region.

To sum up, the share of a regional program in the total research effort is always between zero and one. For Benin's Central Region research program, as implied in box 15, one would expect the figure for soil quality and livestock research to be higher than that for crops.

Assigning values to the feasibility of research and the share of the regional program in total research-derived benefits is done in plenary by the participants of the second workshop. It is a highly subjective exercise based on their collective wisdom. At the same time, it is truly a very important activity, since it defines the relative importance that the program will attach to the different types of benefits that it can pursue. Alertness of the workshop participants is critical, since the data base assembled to estimate the benefit dimensions often contains gaps. At this stage, workshop participants should consider how to correct these deficiencies.

Box 15: Importance of various types of research programs for the Central Region

Various types of research programs play a role in Benin's Central Region. A commodity research program focuses on the genetic improvement of staple foods, cotton and oil palm. There are no separate commodity programs for livestock and forestry. Some research on soil quality (characterization and mapping) is done by a central laboratory, and irrigation research is undertaken by the technology program. A discipline-based program does postharvest research in both the crops and livestock sectors. Some policy research is done across the agricultural and NRM sector. The international agricultural research centers contribute to some extent to crops and livestock research. Finally, NGOs do some adaptive research in forestry, livestock, and water management. The share of the regional research program in the total research effort for the Central Region is smaller for crops than for the other benefit dimensions.

Importance of Research Program Type for Benefit Dimensions

Research Program Types	Benefit Dimensions				
	Cropping	Livestock	Forestry	Soil Quality	Water Management[1]
Regional program	medium	high	high	high	high
Commodity programs	medium	—	—	—	—
Postharvest programs	low	low	low	—	—
Policy research program	low	low	low	low	low
International centers	low	low	—	—	—
NGOs	low	—	low	low	low

[1]Water management was not distinguished as a separate benefit dimension in Benin. The column has been added for purposes of illustration.

Final estimates of the size of each benefit dimension

Once estimations have been made for the three variables—initial estimates of the size of each benefit dimension, the feasibility of research, and the share of the regional program in total research benefits—a final estimate of the size of each benefit dimension can be calculated. This is done by multiplying the initial estimate of the size of the benefit dimension by the feasibility of research and the share of the regional research program in total research benefits. Thus:

$$V = BD \times fr \times rp \qquad (3)$$

where:

V = size of the benefit dimension

BD = initial estimate of the benefit dimension

fr = correction factor for the feasibility of research

rp = correction factor for the share of the regional program in the total research effort that will benefit the region

Box 16 shows the sequence for Benin's Central Region.

In equation (3), subscripts have been omitted. Nonetheless, the formula has to be applied to each benefit dimension selected (c for cropping, l for livestock, f for forestry, q for soil quality, and w for water management). Care should be taken to include both on-site and off-site benefits in estimating the size of BD.

Assigning projects to benefit dimensions and calculating their expected impact

Research projects may contribute to one or more benefit dimensions. For example, an agroforestry project may improve crop production, forestry production, and soil quality. In principle, all projects could be evaluated for each benefit dimension, but this would require more time than is available to workshop participants. It is more efficient for the program committee to identify, be-

Box 16: Estimating the size of the benefit dimensions

In Benin's Central Region, initial estimates of the benefit dimensions were made for cropping, livestock, forestry, and soil quality (on-site and off-site benefits). Dollar figures (expressed in millions) are given in the accompanying table. In the second workshop the participants discuss the feasibility of research and the share of the regional program in total research benefits.

Probability of research success *(fr)*. For cropping, workshop participants agreed that the benefit dimension was quite amenable to research solutions. An additional 0.8 percent growth would be feasible. Since the reference value for benefit dimensions measured in terms of supply was one percent, the calibration factor was set at 0.8. For livestock, they found this to be overly ambitious, and agreed on a factor value of 0.6. For forestry, the participants thought the amenability was much lower. The factor value was set at 0.3. Also for soil-quality matters, participants agreed it would never be possible to solve all degradation problems with research results. They agreed on 0.3 as a reasonable correction factor.

Share of the regional program *(rp)*. For crop production it was recognized that a sizable amount of research would be undertaken by commodity programs and international centers. The contribution of the regional research program was therefore set at a modest 0.4. For livestock, some university research, some postharvest research, and some research efforts by international centers were taken into account (*rp* = 0.7). For forestry research, the participants concluded that, apart from the regional program, there were no major contributors. The forestry value was therefore closest to one (*rp* = 0.9). For soil quality, the strength of the national soil laboratory was recognized (*rp* = 0.75). The resulting potential benefits by benefit dimension are shown in the table. The values shown in the last column were then used to estimate the potential contribution of identified research projects.

Benefit Dimension	Initial Estimate of Benefit Dimension[1]	Correction Factor *fr*	Correction Factor *rp*	Final Estimate of Benefit Dimension[1]
Crop production	21.5	0.8	0.4	6.9
Livestock production	1.8	0.6	0.7	0.8
Forestry production	6.1	0.3	0.9	1.7
Soil quality	13.3	0.3	0.75	3.0

[1]Millions of dollars.

fore the priority-setting workshop begins, the benefit dimensions to which research projects contribute.

Then, in the workshop, working groups are formed — one for each benefit dimension — to assess the likely impact of each project. Those projects that contribute to more than one benefit domain are assigned to more than one working group for analysis. Following the approach used by Collion and Kissi (1994), each working group distributes 100 points among the various projects that impact their assigned benefit dimension. In this way, each project's share of total projected benefits for that dimension is expressed as a percentage.

In its preliminary work, if the program committee has doubts about a project's impact on a particular benefit dimension, it is best for it to go ahead and assign it to that dimension anyway, as well as to those dimensions which the project clearly impacts. After all, the responsible working group can always decide to set the value of the project's impact at zero if its members agree the project really does not affect that particular dimension.

Once each project's impact on one or more benefit dimension has been estimated as a percentage or percentages, their total impact in dollars can be calculated. Percentages are simply multiplied by the potential benefit (*V* expressed in dollars) for each benefit dimension and the products are added. Box 17 shows the calculations for a set of projects in the regional program for Benin's Central Region. The projects are the same as those highlighted in Box 11.

Estimating other project parameters

Once the value of each project's potential contribution is known, we can continue the priority-setting exercise following the Collion and Kissi approach. Now each project's chance of success and the expected rate of adoption of the results have to be defined. (See equation 2, page 36.) To get the final project score, the overall product is divided by the expected cost of the project.

Chance of success "s"

For any project, the value of *s*, the chance of success, lays between zero and one. Many factors influence the determination of the value:

Complexity of the research project. If a project requires the collaboration of many disciplines, and the sequencing of many steps, it is more complex and this reduces its chance of success.

Potential for building on research results from other regions. If similar problems have been resolved elsewhere, the chance of success increases.

Progress on the project. If certain elements required to solve the problem have already been identified, the chance of success increases.

Available human resources. Competence and motivation of the researchers involved increases the project's chance of success.

Techniques and methodologies required. If a project is to utilize advanced techniques not yet routinely used, the chance of success declines.

Project duration. The longer the project's duration, the greater the chance that it will be discontinued before its successful completion.

Rate of adoption "a"

The value of *a*, the rate of adoption, also varies between zero and one. Factors influencing adoption rates for different technologies are as follows:

Profitability of a technology. If users have to make only a small investment for a large return, they will be inclined to adopt the technology.

Risk. If the payoff of a technology varies widely from year to year, and if users run a big risk of taking a loss in the year of adoption, then the chance of adoption declines substantially.

Complexity of a technology. If users have to make a major effort to master the technology, the chance of adoption drops.

Capacity to deliver. If the extension service can easily deliver the technology or customize it for the user group the adoptablity increases. Especially for complex technologies, the presence of a capable extension service helps improve the adoption rate.

Box 17: Calculating the impact of identified research projects in Benin's Central Region

To arrive at the expected value of an identified research project's impact (expressed in dollars), the project's impact on each benefit dimension (expressed as a percentage) is multiplied by the contribution of that dimension to the total potential benefits. The results are then added. For example, the contribution of the project on bush fire control to the various benefit dimensions is 0.05 x 1.7 (for forestry) plus 07 x 3.0 (for soil quality), for a (rounded) total of 0.30. Expressed in dollars, this project has an expected annual value of $300,000.

Because the potential benefits *(V)* in the crops and soil quality dimensions are highest, projects that contribute to these are more apt to have high values of total expected impact.

Project	Benefit Dimension				Expected Value of Project's Impact (millions of dollars per year)
	Cropping	Livestock	Forestry	Soil Quality	
	Potential Benefits (millions of dollars per year)				
	V_c	V_l	V_f	V_q	
	6.9	**0.8**	**1.7**	***3.0***	
	Project Contribution (percent)				
	p_c	p_l	p_f	p_q	
Bush fire control	—	—	5	7	0.30
Anti-erosion methods	—	—	10	7	0.37
Fallow management	—	—	8	8	0.37
Crop rotation systems	6	—	—	9	0.68
Soil mositure conservation	7	—	—	6	0.66
Low-cost fertilization	8	—	—	7	0.76
Combining yam and tree species	4	—	6	—	0.37
Managing natural pasture lands	—	6	—	5	0.19
Agroindustrial by-products and crop residues in animal feeds	3	4	—	—	0.24
Forage species in crop rotation	4	4	—	4	0.42
Subtotal	32	14	29	53	4.4
Other projects	68	86	71	47	7.9
Total	100	100	100	100	12.2

Symbols are defined in equation 1, page XX. More detail on projects in Box 11, page XX.

Availability of accompanying inputs. If, for a certain technology, required inputs are not easily found, the rate of adoption declines.

Infrastructure. In areas with poor roads and other problems of infrastructure, new technologies tend to diffuse more slowly.

Estimates of the chance of research success and the potential rate of adoption of research-derived technologies are made during the second workshop, by the working groups, based on the above criteria. If a project is being evaluated by two groups (because it contributes to two benefit dimensions), both groups give estimates of chance of success and the potential rate of adoption, based on the factors discussed above. If the results are similar, the average can be taken. If not, the estimates can be discussed and compared in a plenary session to confirm the accuracy of the final value.

Obtaining good estimates of chance of success and rate of adoption is very important. Both factors are included in a multiplicative fashion in the equation to measure benefits. Their estimates therefore, strongly affect the final outcome. Two tools may be applied to obtain estimates that are as reliable as possible:

1. Rather than making estimates as a group, working groups may split up in couples. Couples discuss the projects and provide initial estimates. The results of the different couples are compared afterwards, and for those projects where major differences are found, a discussion is held and new estimates are supplied that satisfy all people present. For the projects where the differences are small, the average is taken.

2. Once all projects are assessed, estimates for a subsample of projects (e.g., five projects) are

compared. The group now assesses whether the rank order of the estimates (from lowest to highest) is correct. If not, the estimates for the under- or overrated projects are redone. After consensus is reached for the subsample of five, the place of each other project in comparison with the first five is evaluated, and adapted when necessary. In this manner, estimates are made consistent across the total pool of possible projects.

Cost of the project

Research costs normally consist of personnel, equipment, transport, inputs, land, and infrastructure. At the level of program planning, projects are not sufficiently detailed to make precise estimates of the different cost components. It is assumed, therefore, that total costs are proportional to personnel costs (which are normally the biggest cost component). Personnel costs were already estimated during step 5 of program formulation, project identification.

Once the chance of success, potential rate of adoption, and cost of research projects are estimated, the score for each project can be finalized using equation (2).

$$N = [\,(V_c \times p_c + V_l \times p_l + V_f \times p_f + V_q \times p_q + V_w \times p_w\,) \times s \times a\,] \;/\; C \qquad (2)$$

The part within parentheses was calculated in the previous sections and was defined as the expected value of the project's impact. Box 18 pursues the example from Benin's Central Region.

Box 18: Calculating final project scores for Benin's Central Region

The final project scores vary widely, the range being 1.3 to 32.1. Among the projects for Benin's Central Region, a few ranked higher, close to 600, and some ranked lower, as low as 0.35. The variability shows how important it is to calculate the scores, rather than rely on only scientists' spur of the moment judgment. The program would be making a grave error if it adopted the project scoring 354 instead of one with a score 100 times larger, simply because of the personal interest of one of the people concerned.

Project	Expected Value of Project's Impact $(V_c \cdots p_w)$[1]	Chance of Research Success *(s)*	Rate of Adoption *(a)*	Researcher Requirements (months) *(C)*	Final Project Score[2] *(N)*
Bush fire control	290	0.28	0.22	14	1.3
Anti-erosion methods	370	0.81	0.46	13	10.6
Fallow management	370	0.69	0.54	13	10.6
Crop rotation systems	680	0.74	0.51	8	32.1
Soil moisture conservation	660	0.62	0.60	10	24.6
Low-cost fertilization	760	0.42	0.89	18	15.8
Combining yam and tree species	370	0.20	0.31	3	7.6
Managing natural pasture lands	190	0.30	0.30	10	1.7
Agroindustrial by-products and crop residues in animal feeds	240	0.47	0.53	9	6.6
Forage species in crop rotation	420	0.50	0.25	7	7.5

[1]Values in thousands of dollars per year.
[2]Expected benefits per year for each month of researcher time invested in thousands of dollars.

Defining and interpreting the final project scores

Once project scores have been calculated, they need to be put in perspective—that is, interpreted. The final score indicates the expected benefit per year that would be produced for each month of researcher time invested. In the present approach we have not made any explicit assumptions about how long project benefits will continue to be generated. However, let us assume that projects produce a benefit stream over 20 years, which would only begin in 10 years' time. Let us also assume that the real interest rate is seven percent and that all research costs are concentrated at project startup. Under these conditions, to be profitable a project should have an annual benefit above 18 percent of the project cost.

Based on the project scores, a priority ranking can now be established. The higher the score, the higher the priority for implementation. Certainly, however, the ranking has to be reviewed by workshop participants for its internal consistency and overall logic in a coherence test.

For this purpose, rather than focusing on minute differences in project scores, the programming team divides the projects into large clusters of first, second, third, and fourth priority according to their relative scores. Dividing lines between clusters can be set using two criteria. The first is the presence of large differences in scores between two projects next to each other in the ranking. Where these differences exist, they may form an easy criterion to distinguish first from second priority projects, and so on.

The second criteria considers the resources available to the program. A natural distinction is between those projects that can be implemented with the available resources, and those that cannot be implemented. Projects of first priority will be implemented under any conditions. These are the core of the program, the bare minimum needed for program viability. Second-priority projects are ones that program managers will want to implement if additional resources are made available. Third-priority projects are ones that will be implemented only if financed from outside sources. If fourth-priority projects have been identified, they will, alas, probably never be implemented!

The ranking is then checked for internal consistency. Perhaps workshop participants erred in their initial judgments. Or maybe certain special considerations were not taken into account by the scoring method and analysis. To correct for such flaws, the ranking and clusters resulting from the initial analysis are presented in the workshop and discussed among the participants. If good arguments are presented, acceptable to all workshop participants, a project may be moved up or down in the ranking or from one cluster to another. However, if the ranking is completely overhauled, this raises the issue of whether the method has been applied carefully enough or even whether it was appropriate for the program concerned. Box 19 shows the ranking for 10 projects in Benin's Central Region and explains why some projects were afterwards moved up in the ranking.

Box 19: Defining and interpreting the final priority ranking

The group consensus was that livestock projects were undervalued because the scoring approach didn't sufficiently take into account the potential for fast growth of the livestock subsector in the region due to urbanization pressures in the south. Within the ranking for the 10 projects listed here, therefore, two livestock projects—introduction of forage species in crop rotations and techniques for using agroindustrial by-products in animal feed (ranked 4 and 5 at right)—were moved above the project on improved anti-erosion methods.

Priority Ranking	Score	Project Title
1	32.1	Agronomically feasible **crop rotation systems**
2	24.6	Methods for **soil moisture conservation**
3	15.8	**Low-cost fertilization** methods
4	7.5	Introduction of **forage species in crop rotations**
5	6.6	Techniques for using **agroindustrial by-products and crop residues in animal feed**
6	10.6	Improved **anti-erosion methods** for different types of terrain
7	10.6	Efficient **fallow management** methods
8	7.6	Productive **combinations of yam and tree species**
9	1.7	**Natural pasture management** techniques
10	1.3	Methods for **bush fire control**

In Benin, costs per researcher (including salary and overheads) were estimated at $60,000 per year, or $5000 per month. At these cost levels, a project should have a score above 900 (18 percent of 5000) to be considered for implementation. Since working groups' estimates of the chance of success, the rate of adoption, and the costs in research time, tend to be rather optimistic, the limit may be doubled to 1800. In this case, projects ranked as 9 and 10 should never be implemented as they represent poor investment opportunities. The other eight projects appear to be good investment opportunities.

Organizing the priority-setting workshop

The procedure for setting priorities among projects has now been fully presented. In this final section we make some practical recommendations on how to make the exercise go smoothly. We also invite you to consult ISNAR's Research Management Guidelines No. 2, titled *Guide to Program Planning and Priority Setting*. Chapter 5, Approach to Priority Setting, describes techniques for tapping the combined experience of planning group members.

As we have shown, project scoring hinges on three main factors:

1. Assigning values to various factors that affect the potential impact of regional research on production and resource quality (crops, live-

stock, fisheries, forestry, soil, and so on). The factors are

- initial estimate of the benefit dimension (*BD*)
- feasibility of research solutions (*fr*)
- regional program's share of total research effort (*rp*).

2. For each project, determining the contribution it will make to each benefit dimension (*p*). (The contribution of any given project will vary from one benefit dimension to another.)

3. For each project, determining the expected adoption rate *(a)*, the expected chance of success *(s)*, and the cost *(C)*.

To make the workshop run smoothly and to take maximum advantage of the participants' knowledge and skills, we propose the procedure and division of work shown in table 4. Activities are divided into two stages: those before the workshop and those during it.

The pre-workshop stage is devoted to estimating, with the participation of development organizations, the size of the benefit dimension *(BD)* for each component (crops, forestry, etc.). This stage is also used to make an initial estimate of the cost of research *(C)*, in terms of months of researcher time required. The exercise is coordinated, of course, by the program leader. If for some reason these tasks have not been carried out before the workshop begins, researchers should be called out of the workshop for the time needed to complete them.

In the second stage—the actual workshop—participants work together to validate the *BD* values that have already been calculated, to quantify the correction parameters *(fr* and *rp)*, and to estimate the chance of success *(s)*, the expected rate of adoption *(a)*, and the contribution of each project to the applicable benefit domains *(p)*.

The validation exercise and determination of values for parameters *fr* and *rp* take place in plenary. Estimating the value of parameter *a* and *s* is best done in working groups, and afterwards discussed and reconciled in plenary. As for quantifying the contribution that the project makes to the different benefit dimensions (the *p* for crops, livestock, fisheries, forestry, and soils), this task is also done in the working groups formed to analyze the contributions of projects to the benefit dimensions.

Before setting up and assigning the groups their tasks, there is good reason to classify the projects according to the benefit dimensions that they will likely affect. This may be done by the program leader or by the program committee.

Once the projects have been divided up, the groups are formed. One group is assigned to each benefit dimension. For Benin's Central Region, four groups were formed: crops, livestock, forestry, and soils.

It's important to ensure that development authorities and farmers are well represented in these groups. Their participation is indispensable in setting the value of the parameters that come into play in the project scoring.

Table 4. Organization of the priority-setting exercise

Pre-workshop
1. A multidiscliplinary group of researchers and development officers estimate the size of the benefit dimension *(BD)* for each of the components or benefit domains, for example, crops, livestock, fisheries, forestry, and soil quality. 2. The same group estimates the cost *(C)* of each project.
During the workshop
3. In plenary, workshop participants validate *BD* values and estimate, by consensus, the values of *fr* and *rp*. 4. Working groups estimate the expected value of project impact *(p)*, of *(a)* and *(s)*. Groups are formed by dividing participants along the lines of their knowledge and interest. 5. In plenary, participants validate the values of *a* and *s* estimated in the groups. 6. Program committee calculates project scores using equation (2). 7. In plenary, workshop participants conduct the coherence test.

Support projects are dealt with in the same way as technical projects, with one exception: the value of the contribution of support projects to a given benefit component will be the sum of the values assigned to the technical projects they support. Sometimes participants may decide that all support projects are high priority. In such cases, these projects are not subjected to the priority-setting procedure.

Finally, the values of all the parameters are combined to produce the final project scores and to develop the project ranking. The ranking is then submitted, in a plenary session, to a coherence test.

2.7 Human Resource Gap Analysis

In step 7, the human resource gap analysis, the program committee defines, by discipline, the number of researchers needed to implement the priority projects. By subtracting the number of researchers available in each discipline from the number needed, the gap can be determined. The gap should be filled by recruitment, by transferring researchers from other programs, or by contracting research out to other organizations. Box 20 provides estimates of the human resource requirements and gaps for top-priority projects in the program for Benin's Central Region.

The spectrum of scientific specializations needed in a regional program is wide. This reflects the integrated nature of such programs. Specialists from the agricultural sciences, animal sciences, and forestry and fisheries are needed, as well as economists and sociologists. On the one hand, certain disciplines can be anticipated to have special importance within a regional program—for example, crop management, soil science, engineering, and ecology. On the other hand, the role of plant breeding, plant protection, and postharvest technology is relatively less. These differences are more marked when regional programs run side by side with commodity programs, which take care of breeding and plant protection research. The range of specializations within the regional program must, of course, be kept within

Detail of Step 7 of the Program Formulation Process, 'Human Resource Gap Analysis'

Rationale

The program should be equipped to implement priority projects and human resources are central to this

Output

Required number of researchers by discipline and staff requirements per year for priority projects, identification of gaps between requirements and availability

Responsibility

Program committee led by the program leader

Participants

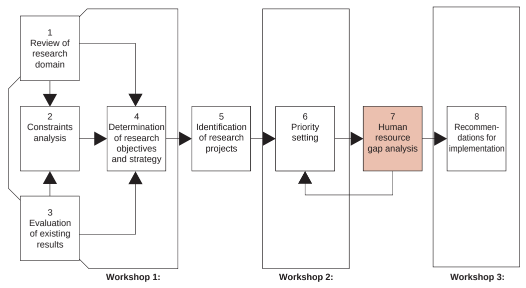
Program committee, human resources department

Methods

Matrix of priority projects by disciplinary requirements and sensitivity analysis

Time and resources

One to two weeks after the second workshop



Source: Collion and Kissi, 1994, with modifications by the authors

Box 20: Estimating human resource requirements for first-priority projects

Benin's Central Region research program currently employs an agronomist and a soil scientist. Scientists can be expected to dedicate 70 percent of their time to research (eight months). The remainder will be spent on training, administration, organizational duties, leave, etc. Using these estimates, the program will have to recruit an economist and the soil scientist's time should be shared with another program, possibly in exchange for part of a forestry scientist's or a livestock scientist's time. The pasture scientist and engineer could be brought in through special contracts.

Project Title	Agronomy	Economics	Soil Science	Engineering	(Agro) Forestry	Pasture Science	Animal Science
Bush fire control	2.3						
Rural credit needs and availability		1.3					
Improved use of in-land valley areas	2.0	1.0	1.0	1.0			
Sustainable cropping systems	2.3	1.0					
Plant multiplication techniques					1.0		
Yam-based production systems	2.5						
Sociological study of land use		1.0	1.0		1.0	1.0	
Animal husbandry							2.5
Commodity system analysis		2.0					
Factors affecting technology adoption		2.0					
Animal traction technology use		1.0					
Total requirement	8.8	9.3	2.0	1.0	2.0	1.0	2.5
Availability	8.0		8.0				
Gap	0.8	9.3	-6.0	1.0	2.0	1.0	2.5
Gap in person-years per annum	0.1	1.16	-0.75	0.13	0.25	0.13	0.31

reasonable limits. Otherwise, it becomes impossible to recruit the necessary personnel. For example, when a pasture production specialist, a pasture ecologist, a pasture botanist, and a pasture taxonomist are "required", serious consideration should be given to having the assigned tasks done by a single pasture scientist.

2.8 Preparing for Implementation

Once projects are identified and prioritized, and human resource implications have been assessed, the regional program is ready to be put in place. Implementation may occur under one of two scenarios:

First, if the program focuses on a new area of research, the activities to be carried out under the priority projects are implemented gradually as researchers are recruited or reassigned to the new program and as financial resources are mobilized.

Second, if the program already exists and the planning exercise has served principally to reorient research activities, the priorities established by consensus during the planning exercise must be reconciled with activities already in progress. If research in progress matches an established priority, it must continue within the framework of the reoriented program and receive the necessary support. However, if projects in progress do not match an established priority, but have been going on for quite some time and are close to completion, it is best to complete the work—espe-

Detail of Step 8 of the Program Formulation Process, 'Recommendations for Implementation'

Rationale
Conditions for program implementation need to be created. All stakeholders should have access to program planning outcomes

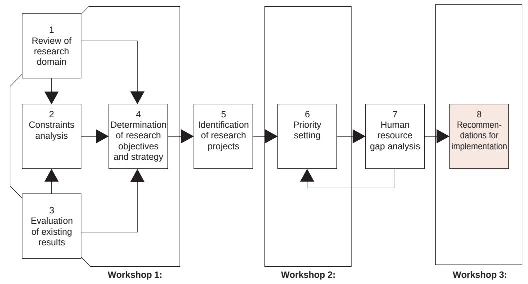
Output
A program document and validation of program by stakeholders and research managers

Responsibility
Program leader, program committee, and possibly, program members

Participants
All those involved in the previous steps

Methods
Consultation and report writing

Time and resources
Four to six weeks after second workshop



Source: Collion and Kissi, 1994, with modifications by the authors

cially if the project has already consumed a large part of the resources set aside for its implementation. The same holds true for activities that a researcher is doing as part of a thesis in preparation for an academic degree.

With the exception of these two cases, it's preferable to stop on-going research and assign new priority project activities to the affected researchers.

Major shifts in the direction of research don't occur without difficulties of course. Some scientists who have experienced such a reorientation have expressed frustration because they considered their research work important to the country's agricultural development. Managers must explain to them that, yes, the activity may be important but it is not an immediate priority given more pressing needs of users and the extent of available resources. Sometimes training is needed to prepare researchers to carry out their new duties under the best possible conditions.

To ensure successful implementation, it is crucial to have both internal and external support for the program. This will already be largely achieved through the participation of various stakeholders in the planning process. But it needs to be reinforced once the program has been finalized. The availability and communication of clear and transparent information on the program are key to obtaining this support. The program leader should therefore take the following steps:

- Write a program document explaining how the program came about. Its outline can roughly follow the eight steps of the planning process. In the preface, it may be useful to acknowledge the participants since they give the plan a good measure of its credibility. The document should also provide specific recommendations on filling the human resource gap, pay special attention to the nonresearchable constraints identified, and suggest development measures. Box 21 suggests an outline for a program document with 10 chapters.
- Stage an internal validation workshop within the research institute. This identifies potential collaborators and possible overlaps with other programs and may also serve to assess the program's scientific merit. The internal validation shouldn't be too concerned with the program's relevance, as the different stakeholders present in the planning workshops will have already established this.
- Present the program to the various stakeholders (external validation). In this presentation, encourage questions on the program's relevance. If the program has been prepared with care, the validation workshop will only help to strengthen it, in part by building commitment among possible research partners in the stakeholder community. Highlight the nonresearchable constraints since these demonstrate the importance of integrating research with other development activities. An extensive discussion on the complementary development measures needed and on their feasibility will greatly enhance the viability of a regional program. Are the legal arrangements or the policy guidelines suggested by the research

planning team feasible? Should the research team anticipate other changes in the environment? If the complementary measures are feasible, try to obtain a commitment from other organizations to try to implement such measures. Similarly, discuss the usefulness of regular contact between research and development organizations and whether certain activities could be undertaken together. A discussion of the role of development will lead many stakeholders to appreciate that the program's architects recognize the limits of research; and they will leave the meeting with new ideas for their own development work.

- Finally, once the program has been validated internally and externally, the program leader should ask program staff members to start developing the research projects in more detail. This means identifying research methodologies, resource requirements beyond scientific staff, budgets, and monitoring and evaluation mechanisms. Once available, data on the projects should be entered in the institute's management information system to avoid duplication in future planning exercises.

Box 21: Suggested outline for a program formulation document

Table of Contents

Preface

Executive summary

1. Introduction (1-2 pages)
- purpose of document
- institutional context
- planning context (long term, medium term, annual plan)
- participants
- acknowledgments

2. Sector review (7-10 pages)
- production and consumption information, resource use, production and marketing structure, etc.
- regional development objectives

3. Evaluation of past research (5-7 pages)
- within the institute
- within the country
- in other countries

4. Constraints analysis (10 pages with constraints tree, 4 pages of text)
- presentation of constraints tree
- explanation of constraints tree (concise)
- identification of constraints that are amenable to research solution

5. Determination of research objectives (3-5 pages)
- description of principal objectives for research program as derived from the constraints tree
- description of derived objectives (principal research fields that need to be addressed)

6. Identification of research projects (10 pages)
- description of research projects to address the constraints, expected research results, activities to execute these projects
- classification of research projects into technical projects and support projects
- estimation of project duration (in years)
- estimates of human resources needed by discipline for each project

7. Priority setting among research projects (10 pages)
- explanation of method used in priority setting
- estimates of parameters required in priority-setting exercise
- showing and explaining the results of priority-setting exercise (ranking)
- description and explanation of changes made to initial ranking
- judgments on support projects

8. Resource gap analysis (4-6 pages)
- on the basis of the list of priority projects and indications by management on the size of the program, identify:
  - – human resource requirements
  - – physical resource requirements
  - – location
  - – comparison of resource requirements with resource availability and identifications of gaps
  - – proposals for filling resource gaps (recruitment, training, building, purchasing, etc.)

9. Policy recommendations (4 pages)
- review nonresearchable constraints and make recommendations
- suggest institutions best placed to pursue recommendations

10. Conclusion (1-2 pages)
- highlights of principal outcomes

References

PART 3

Concluding Remarks on Regional Research Planning

3.1 Nature and Time Requirements of the Planning Process

Regional research programs can be an effective tool for responding to the growing demand for better integration of NRM concerns in the agricultural research agenda. By developing a shared perspective on the characteristics, constraints, and potential of a region, regional planning combines a holistic diagnostic perspective with a focused research plan.

The regional planning approach examined in this document combines subjective and objective information from different sources. It uses a quantitative, economics-based procedure to prioritize research projects. But it does not pursue very detailed and precise information on the different projects. Neither does it apply advanced and detailed project evaluation methods. Rather, it assumes that the confrontation of these rough results with the subjective judgments of the members of the planning group is the best way to improve relevancy and orientation of the program. Thus the type of estimation procedures proposed and the extent of participation required are strongly intertwined. Without participation, the estimation procedures do not hold sufficient guarantee for reliable results. But with well managed participation, further sophistication of the procedures would not necessarily do justice to the combined expertise of the planning group. The final procedure is a mix between analysis, expert knowledge, economic estimations, creativity, and teamwork.

Whether the amount of detail provided in these guidelines is sufficient under all conditions is difficult to assess. When regional research programs deal with larger mandates (bigger regions, more production), one might expect that the level of investment in the exercise might be higher than that suggested in this document, both in terms of the number of people that participate, and in terms of the amount of data collection and processing. In the suggested form, the time requirements are roughly as follows: the planning group of some 20 people would be involved for roughly five days, for a total of 100 days. The program committee of three members would be involved for 12 weeks each (60 days), for a total of 180 days. Researchers would spend two days to provide information for each project, or approximately 100 days. And a stakeholder group of about 25 persons would assess the plan during one day, totaling approximately 25 days. The time consumption would then be 405 days, or 81 weeks, roughly comparable to two person years. If the exercise is used to plan a program of, let us say, 10 full-time researchers for a period of eight years, the total costs of planning the program would be roughly 2.5 percent of the resources that the program will spend.

3.2 Future Problems and Opportunities

Regional programs may start absorbing traditional farming systems units (or on-farm research units). They will have a mix of on-station and on-farm research components, depending on the specific constraints addressed by each research project, but not depending on the organizational unit in which the research is done. Regional programs tend to soften the rigid linear sequence of basic, strategic, applied, and adaptive research, especially in the applied and adaptive stages. The feedback loop between farmers and research is shortened. Most researchers in a regional program will likely have experience with on-farm participatory methods, though not all to the same degree.

Regional research programs must be accountable to more than farmers. They should pay attention to the needs of other resource users as well. Some of these are water management authorities and nonagricultural households. They should also be aware that their support will have to come from regional authorities and other representatives of regional interests. The program may feel pressures from many sides but should be well placed to address them.

Decentralization

Regional programs normally require a measure of decentralization and often they will be based outside the capital city. This is justified because in many countries the concentration of research in just a few central locations results in scientists being unaware of the wide variety of conditions faced by farmers elsewhere in the country. This undermines their effectiveness as problem solvers. Nevertheless, decentralization must not be taken to extremes. For researchers to maintain their skills and qualifications, they need to belong to a peer group. Decentralization can also reduce living standards for researchers and their families. The difference between daily life in the capital city and daily life in the countryside can be enormous, especially in developing countries. If decentralization is pushed beyond, say, the second tier of cities (e.g., provincial or departmental capitals), researchers may start looking for alternative employment. Of course, the best researchers will be the ones to find it most easily.

Effective implementation of regional programs demands adequate resources. Transportation is a key factor. It may be as important as having a well-equipped research station—perhaps even more important.

Human resources are the heart of any research program. Regional programs demand a mix of many disciplines. This, in turn, means paying special attention to people management, especially taking measures to focus different kinds of scientists on shared objectives and outputs (Janssen and Goldsworthy, 1995).

What about program management? The regional approach to research affects it in two very different ways. On the one hand, the wide spectrum of scientific subjects and issues to be dealt with complicates management. On the other hand, the proximity to users of research results facilitates it. If researchers can't clearly explain to farmers and program leaders why certain problems are approached in certain ways, it's probably because they have not defined them properly. The variety of issues that come to play in a regional program provides another argument for developing such programs in a systematic fashion.

Questions for further development

The procedure described in these guidelines is still open to improvement. We would therefore like to end with some of the questions that confronted us while we were developing and testing the approach.

Is it possible to make the program planning process more participatory? Rapid rural appraisals could be used in the regional analysis (step 1) and in the identification of researchable constraints (step 2). The challenge in strengthening participation is to maintain a representative overview of the region and not be biased toward the needs of small pockets of farmers.

Is workshop participants' knowledge adequate for effective regional program planning? We found that even in carefully selected groups only a few people could speak with some depth of knowledge about the range of issues in a particular region. If such people are absent, participatory regional planning may be biased toward the interests of over-represented groups or it may be difficult to achieve consensus. Our solution was to emphasize a rigorous regional review by means of secondary data and the development of a regional profile. But the extent to which participants are able to absorb this information at the beginning of the planning process should not be exaggerated.

How can the results of the planning exercise be exploited for purposes other than research? The planning method does make provision for formulating development (i.e., nonresearch) measures to deal with nonresearchable constraints (part of step 4). However, it may be useful to go beyond this step by organizing a workshop for the main development organizations working in the region. For the sake of credibility, such an initiative would have to be supported by the regional government.

What is the value of exploiting GIS beyond its role as an aid in setting the overall boundaries of a region? The program formulation method assumes that regions are relatively homogenous. On this assumption, one could argue that further zonation through GIS may not have much to offer. Nevertheless, we are aware that the impact of identified constraints on agricultural development varies among different groups within a region. GIS could be used to differentiate in more detail the likely beneficiaries of research. This might improve the quality of priority setting among projects.

Should the priority-setting framework (step 6) not be more concerned with questions of timing, especially since NRM is often concerned with long-term effects? Developing procedures that do a better job of incorporating discounting principles is not really a problem, especially when spreadsheets are used. In fact, we first developed a priority-setting approach that accounted for benefit streams over 50 years. To streamline the process, we went back to the present nondiscounted method. But we do encourage users of this manual to pursue more sophisticated discounting procedures if they believe that such a refinement would be welcomed by their program formulation group.

Is there a way to improve experience-based assessments of the research project's chance for success (part of step 6)? Under the current planning method, many assessments reflect the educated guesses of working-group members simply because information on the feasibility of future technology development is so scant. ISNAR is looking into ways to fill part of this gap. But our expectation is that project feasibility assessments will remain largely subjective, even if they are fed with better background information. For the moment, we believe the best way to improve assessments is by identifying unambiguous research projects and specific research activities. Validating judgments on these activities is easier than on overall projects and this improves the quality of the resulting program.

Is it realistic to expect regional programs to be fully implemented? This depends largely on how flexible the programs are and on the availability of resources. New or revised research programs are constrained by previous commitments and by staffing patterns that cannot be changed immediately. However, if a solid program is presented, the chances of finding the necessary resources increase markedly. It should be obvious that the expected success and vigor of a program increase if it has been properly planned.

We hope the planning approach presented in these guidelines will be useful to you. If you have the occasion to apply them in whole or in part, please share your experience with us. This will contribute significantly to future refinements of the method.

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Glossary

Glossary

Formulating a research program involves a variety of partners, usually from different institutions. These program architects need to speak the same language. That is, they must agree on the meaning of the words they use. This isn't always easy. Experience has shown that terminology differs greatly from one country to another, between institutions, and even within a single institution. It doesn't really matter what terms are used. The important thing is for members of a single programming group to have a common vocabulary. So at the start of a programming exercise they should pay attention to standardizing the terminology.

To help with this, some definitions are suggested below. They are organized alphabetically. The 12 terms bearing an asterisk (*) comprise the minimum vocabulary for which group members should have a shared understanding of meanings. Italicized terms within definitions are ones that are themselves defined elsewhere in the glossary.

Agroecological zone: Contiguous geographical area that is homogenous in climate and soils. Agroecological zones can be useful for identifying target areas for technology generation.

Benefit dimension: The main economic activities or resources that are affected by the regional research program. Cropping, livestock, forestry, soil quality, water management, and fishery are examples of possible research benefit dimensions. The "size of a benefit dimension" is defined as the difference between, on the one hand, the expected value of a region's agricultural production and resources and, on the other hand, their total potential value if all research constraints are removed. Signified by the variable "*BD*."

Central constraint on a subsector: From a development perspective, this *constraint* embodies all the problems blocking the development of an agricultural domain, region or subsector's potential. Poor income-generating capacity is an example of a central constraint.

Coherence test: The final step in setting priorities among projects. The test consists of examining the ranking of *research projects* based on their scores to ensure it is logical and coherent. It serves to identify differences between the ranking that results from applying the priority-setting equation and the subjective or intuitive ranking by *planning group* members. Any divergence is discussed. This can lead to a change in the weighting of the criteria used to evaluate the project whose score is being questioned. On the other hand, the discussion may simply demonstrate deficiencies in group members' intuitive evaluation.

The coherence test, then, allows the group to fine-tune the results of the priority-setting exercise and to correct for weaknesses in the method being used and in its application. It often stimulates fruitful debate and improves the degree of consensus.

Complementary development measure*: A recommended action, aimed at policymakers, that is likely to promote the adoption of new technologies. Such a measure can be institutional or economic.

Institutional measures include organizing professions, creating associations, or restructuring public services.

Economic measures include building infrastructure, importing inputs or equipment, supporting export incentives, price interventions, and tax reform.

In Morocco, for example, three complementary development measures were advocated to promote the adoption of technologies coming out of the country's olive research program:

- the creation of "tree centers" for distributing plant material
- organization of the tree nursery profession
- a public information campaign to avoid "selling on the tree."

Constraint*: A situation or factor that prevents production potential from being fully achieved. This potential may be based on extending the area under cultivation, increasing yields, cutting production costs and losses, or raising value added by processing and packaging.

There are four main types of constraints:

- *physical*, that is related to climate (rainfall, temperature, wind, air humidity), terrain, soil (depth, texture, composition, etc.)
- *socioeconomic*, that is related to the land tenure system, market structure, and pricing and credit policies
- *institutional*, that is related to marketing practices and input distribution
- *technical*, that is related to production, processing, packaging, or storage

Constraints tree: A hierarchy of research and development (R&D) problems originating from the *central constraint*. It is a tool for systematically analyzing such problems, allowing for a participatory approach to formulating *research projects and programs*.

The starting point in building a constraints tree for a particular subsector is to identify the central constraint. The causes and effects of all factors underlying the constraint are then analyzed, along with their interdependency. The constraints tree takes the form of a flow chart composed of various boxes at different levels. Each box represents a separate constraint that is further broken down into subconstraints at the levels below it.

Development objectives*: Economic and social aims that a government seeks to achieve for a production sector, production system, or agroecological zone. Realistic objectives are defined in light of comparative strengths and weaknesses, existing constraints, and potential technological breakthroughs.

Here are some examples of development objectives:

- increasing the level of self-sufficiency in a certain commodity
- developing a marginal area
- maintaining or increasing production
- increasing the value added to production in the postharvest stage
- boosting exports
- increasing income or employment.

Duration of an activity or project: The period from the beginning of the research to achieving the final results. For a *research activity*, it is the interval between the starting date of the first *specific action* and completion of the last. For a *research project*, it is the interval between the date on which the first activity begins and the completion date of the last.

Institutional or interinstitutional program: A research program can be conducted by a single institution or by several bodies within the national research system. In the first instance, the program is institutional; in the second, it is inter-institutional.

Location of a research activity: Where the main activities are carried out. This can be an experiment site, an institute's or teaching establishment's laboratory, a private farm, a unit in an agrifood industry. A research activity may have several locations if its *specific actions* are spatially duplicated. This is often the case when the same *research objective* is being pursued in several agroecological zones.

Nonresearchable constraint*: In most cases, such constraints have to do with the physical environment. Agricultural research doesn't provide direct solutions to these problems but it can suggest ways to eliminate or reduce their effects. It isn't possible to change the climate, the slope of the land, or soil depth. However, research needs to describe such factors and study their interactions with those factors that are under the producer's control, such as choice of varieties, technical calendar, management.

Socioeconomic and institutional constraints can often be removed by development work or by social science research. Some of these are beyond the scope of the *research program* under formulation and, for its purposes, are therefore considered nonresearchable.

Planning by objective: A systematic method for planning research activities for a given domain or subsector. Specific intermediate research objectives are determined as a means of achieving a defined overall objective. Intermediate objectives are then translated into *research projects* composed of *research activities*, the results of which contribute to the achievement of the research project's specific objective.

Planning committee: The committee responsible for organizing meetings and preparing the necessary background information. It is normally headed by the research program leader. Two other research program members should be on the committee, one with a background in socioeconomics, the other trained in agronomy. The fourth committee member should be a representative from the unit responsible for research planning. This person contributes knowledge of program formulation procedures and ensures that the program under formulation is consistent with the overall direction of the national agricultural research system.

Planning group: An analytical, coordinating, and advisory body whose job is to plan, monitor, evaluate, and adjust research activities for a given domain or subsector. It is a structure within which a dialogue is established among researchers and the users of research results for the purposes of program formulation. The researchers come from various disciplines and belong to different research bodies. The users are selected according to the type of *research program* to be formulated.

Priority projects within a program: The minimum set of *research projects* needed for a program to have the intended impact on the development of the domain or subsector concerned. Setting priorities among projects is done in light of their relevance and the resources (particularly human resources) expected to be available to the *research program* over the medium term.

Program as structural unit: The word program can refer either to the actual set of *research projects* for a particular domain or to the organizational unit that brings together researchers from various disciplines to carry out the projects. When several research organizations are involved, the program constitutes a national research network for the domain or subsector in question.

The composition of a program makes it a flexible unit. The participation of individual researchers isn't indefinite. They cease to be members of the program once the intended results of their research have been achieved—unless, of course, they initiate other research activities that are also part of the program.

Program planning workshop: A working meeting in which a group of researchers and users of research results—here called the *program planning group*—formulates or adjusts a *research program* for a given domain or subsector.

Project research results: Results expected from a *research project* can take the form of new information, the development of a new technology, or the improvement of an existing technology.

Technologies may have to do with

- selecting a variety or clone resistant to a disease or insect pest adapted to specific agroecological conditions or having well-defined quality characteristics
- developing new practices for cropping, seed multiplication, plant care, harvesting, soil management, storage, or adding value through processing and packaging
- designing a crop rotation scheme
- developing a method for crossbreeding animals
- determining feed levels for livestock
- designing new agricultural or agro-industrial equipment
- developing or improving a laboratory instrument or experimental methodology.

Research results in the form of information can be agroecological or socioeconomic studies and projections.

Researchable constraint*: A constraint likely to be removed by agricultural research (including social science research). Adoption of the results allows the causes of the constraint to be eliminated or at least their effects to be reduced.

Research activity*: A component of a *research project*. A research activity is a coherent set of *specific actions* to be carried out in a given period, all of which are necessary to attain the desired result of the activity. It is generally monodisciplinary and carried out by one researcher, sometimes with the assistance of technicians, according to an experiment protocol. It has an objective, location, schedule, and cost. A research activity can have several locations if the desired objective applies to several agroecological zones. The number of activities varies from project to project.

Research objective*: An innovation that scientists hope to make through research in order to remove a *researchable constraint*. This can be in any of several areas:

- plant and animal materials
- farming techniques

- crop rotation
- herd management
- natural resource management
- product storage, processing, and packaging
- understanding the physical or socioeconomic environment
- research methods in the agricultural sciences

Research objectives tree: A hierarchy of *research objectives* that must be achieved to eliminate the *central constraint* or problem faced by a particular area or subsector of agriculture.

The objectives tree is constructed using the *constraints tree*. First, an overall objective is assigned to the central constraint. Next, the specific research objectives required to achieve the overall objective are determined. Each specific objective corresponds to a research opportunity and serves as the basis for identifying a *research project*.

The cause and effect relationships set out in the constraints tree thus become the links between the intermediate objectives and the overall objective. Development objectives do not come into play in this tree.

Building an objectives tree is not as mechanical as it may seem. It isn't simply a matter of replacing a negative phrase describing a constraint by a positive one defining the objective. Rather, the process first requires an analysis of the constraint. It's important to ask, for example, whether the constraint is researchable. There is no point in assigning research objectives to constraints such as "poor rainfall distribution" or "uneven terrain". But these factors should be taken into account in the analysis that leads to program formulation. Similarly, results from earlier research should be reviewed since a solution or partial solution to the constraint may already exist.

Like the constraints tree, the research objectives tree takes the form of a flow chart with various boxes organized at several levels.

Research program*: A set of *research projects* carried out to address *development objectives* and users' needs in a particular domain or subsector. The domain or subsector covered by the program can be a commodity (such as olives), a group of commodities (such as food legumes), an agroecological zone (such as Central Benin), or a production factor (such as farm mechanization).

Research project*: A component of a *research program*. The combined results of a program's constituent research projects allow the program objectives to be met. A project is a coherent set of *research activities* all of which are necessary to meet the project's research objective and which are to be completed in a given time frame. A research project generally produces a technology.

A project is carried out by several researchers and often provides a framework within which several disciplines can interact to achieve the common research objective. A research project can involve several disciplines of the agricultural sciences; this is called a multidisciplinary project. A research project limited to one discipline is called monodisciplinary.

In Benin, a research initiative titled "Development of Millet Varieties Adapted to Northern Benin" is an example of a multidisciplinary project. It brings together agronomists, weed scientists, plant pathologists, and agricultural economists. An example of a monodisciplinary project, in Morocco, is "Improved Extraction of Olive Oil in Artisanal Pressing Operations." In this research project, only technologists are involved.

The number of projects varies from program to program. In Morocco, for example, the Date Palm Program has 17 projects, the Oilseeds Program has 26, the Dryland Crops Program has 48, and the Food Legume Program has 52.

A project has several defining characteristics: an objective, component research activities, a project leader, a timetable, a budget, expected results, and target indicators for the purposes of monitoring and evaluation.

Research-year*: Twelve months of *research activities*. The time a researcher devotes to "research" over the course of a calendar year is, in the strict sense of the word, less than 12 months. This is because of other duties such as supervising students or junior researchers, teaching, and participating in technology transfer and scientific events. And, of course, there is time off for annual leave. A research year therefore covers more than one calendar year of a researcher's time.

In Morocco, for example, INRA estimates that researchers devote an average of eight months of the calendar year to actual research.

Specific action*: A basic component of a *research activity*. Specific actions, when combined, make it possible to achieve the intended result of the activity. The specific actions of a research activity can be

- manipulation of plant or animal materials—such as hybridization, crossing, castration, grafting, or isotopic marking
- agricultural interventions such as plowing, sowing, maintenance work, spraying, or harvesting
- testing, analyses, observations, measurements or weighings in the field, on station, in a food processing plant, or in the laboratory
- censuses, canvassing, surveys, data collection, etc.

In principle, all specific actions of a research activity are carried out by the researcher in charge of the activity. However, in practice one or more specific actions may be handled by a technician under the researcher's supervision or by another researcher.

Subprogram: A *research program* is sometimes divided into subprograms. When a program covers several products or commodities, there is often a subprogram for each. For example, a cereals program may have subprograms for wheat and barley. Alternatively, subprograms may correspond to agroecological zones if there is sufficient diversity to justify the pursuit of separate research strategies.

Support project*: During program formulation, the *planning group* may identify certain projects to be carried out in addition to those *research projects* that are supposed to lead directly to new or improved technologies. A support project is one that generates information useful to researchers or development authorities. For example, the information may improve researchers' understanding of the physical or socioeconomic environment, allowing for better targeting of technologies. Or it may increase the probability of success of another research project by enhancing control of intervening factors.

In the case of development authorities, information from a support project may help them to improve the chances of new technologies being adopted.

Here are examples of support projects identified during the formulation of a food legume program:

- study of the socioeconomic impact of mechanization on small farms
- study of food legume supply and demand
- taxonomy and mapping of diseases and pests
- study of parasitism mechanisms and host-parasite relationships.

Users of research results: Target groups for the technologies developed by research. Direct users include the various types of crop and livestock producers, agro-industries, traders, and scientists. Indirect users are those whose activities should take research results into account: decision makers, development authorities, extension managers, and so on.

Identifying future users allows for better targeting of research. The nature of the technologies to be developed should be determined in light of the needs of the user groups for whom they are intended. For example, in the area of farm mechanization, tools for cultivation, crop maintenance, and harvesting need to be adapted to the type of farm where they are to be used.

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About these Guidelines

These guidelines present a method for formulating regional research programs with a mixed perspective - one that combines productivity and natural resource management issues within a regional, decentralized context. Based on earlier work by Collion and Kissi (1994), it has been substantially modified to account for the peculiarities of regional research planning. The method was pilot tested in Benin. It has also been applied in Senegal and Morocco.

Part 1 presents the rationale and background of regional research planning. This section is particularly relevant for institute directors, policymakers reviewing research options, and, of course, for research program leaders. The method for regional research planning is treated in Part 2. In the first five steps of the planning approach, research constraints, objectives, and projects are identified in a structured, logical, and participatory fashion. Step 6 of the research planning approach examines how priorities are established among the research projects. This presentation is aimed specifically at economists involved in research planning and research program leaders. In steps 7 and 8 of the program planning process, the results of the planning exercise are translated into implementable recommendations. Part 2 is focused specifically for program leaders and research institute directors. Part 3 reviews the overall procedures and poses some questions and issues that should be resolved in the future. It may be of interest to all persons involved in regional research planning.

Throughout the document, a series of boxes illustrates the experience of Benin with regional research planning. These boxes aim to provide a clear example of the sequence, organization, and execution of the regional research planning process.

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