CIMMYT's Five-Year Budget Proposal

1990–1994

CENTRO INTERNACIONAL DE MEJORAMIENTO DE MAIZ Y TRIGO
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Preface

This document describes CIMMYT's needs for financial support from 1990 through 1994. This is our first five-year budget; we found its preparation a challenging task and we have taken a great deal of care in its development.

Our point of departure for preparing the budget was our strategic plan. In 1988 a draft version of the plan was endorsed by CIMMYT's Board of Trustees and by the CGIAR-commissioned External Program and External Management Review panels. The CG's Technical Advisory Committee commented briefly on aspects of the plan in a session focused on the results of the two reviews; the TAC commented more fully in March 1989. The themes discussed in the presentation of the budget, in particular those found in Chapters 3 and 4, rest heavily on the plan. With each review we have refined our strategic plan and, congruently, the budget.

In framing our budget, we gave careful consideration to likely funding. One option was to plan as if the strength of our arguments would itself ensure the required financial support. A second was to plan in terms of the straitened conditions of the CGIAR today. We decided on the latter course leading, we think, to quite reasonable proposals.

It will not surprise the reader to discover that we believe the CGIAR gets very good value from its investment in CIMMYT. It is a well established fact that investment in the global maize and wheat germplasm networks has yielded immense direct returns in added production. As well, but frequently overlooked, these networks provide assurance of the continued delivery of effective materials even in the face of declining fortunes for individual national programs. These returns are not just a consequence of the excellence of our scientific and support staffs, nor the ethic of service that powers our efforts, nor the prudence with which we use our funds. They rest as well on the fact that, however measured, maize and wheat are two of the principal food crops of the developing world. That single fact gives our work tremendous leverage. I add that, as we see it, the pressure for increased production for these crops will not abate during the next decade.

We were extra careful in framing our analysis, especially in our classification of activities into those "essential" and those "desirable." We took that care in the hope that we might improve the quality of the dialogue on CGIAR allocations to the centers. There was, I confess, a strong temptation to label everything "essential." After all, developing country maize and wheat production is valued at some 40 billion dollars (US) per year and our track record is good. Why should it

not all be considered essential? Strong as the temptation was, we opted to develop an argument which rests on concepts with broad appeal and with obvious connections to CGIAR goals. Doing so, we believe, has appreciably improved the analytical content of our proposal.

Many have contributed to the presentation which follows. I especially want to acknowledge contributions from the Board of Trustees and from the TAC. Those have made it a better proposal. We think the presentation is clear, we think the reasoning is transparent, we think the results follow easily from the analysis. We encourage communication from those who might find it otherwise. Meanwhile, we look forward to continuing the program of work the proposal describes, secure in the belief that it will do much to open options for the poor.

Donald L. Winkelmann
Director General

Chapter 1

Introduction

The International Maize and Wheat Improvement Center (CIMMYT) is an autonomous, international, nonprofit scientific research and training institution. It is one of 13 research centers supported by the Consultative Group on International Agricultural Research (CGIAR).

From its headquarters in Mexico and offices at 18 other locations around the Third World, CIMMYT operates a global program of maize, wheat, and triticale improvement, conducts research on special concerns in crop management, investigates economics issues related to its mandated crops, and provides training and other forms of support to about 100 national agricultural research programs responsible for maize and wheat in developing countries. Developing countries produce some 170 million tons of maize and 205 million tons of wheat annually, making these two of the three cereal crops which far surpass other food sources in importance in the Third World.

On April 12, 1966, the Center was established as a nonprofit "civil association" (CIMMYT A.C.) under Mexican law, but responsible to an internationally elected board of trustees. The Ford and the Rockefeller Foundations joined Mexico as the Center's initial principal supporters. Their support and that of subsequent donors has enabled the Center to make substantial contributions toward improving the well-being of the poor in developing countries. In early 1989, CIMMYT A.C. became CIMMYT International, licensed to operate as a true international institution in Mexico.

CIMMYT is best known for its germplasm products. The Center's role in facilitating the development and spread of high-yielding wheat varieties in developing countries is well-documented. Some 60 million hectares of Third World wheat land are now sown to varieties containing CIMMYT germplasm, and the value of the extra production gained by using improved varieties far exceeds the investments in research necessary to produce them. The spread of improved maize varieties in developing countries is less obvious, hence less well documented. Still, over 9 million hectares are now seeded to CIMMYT-related varieties, and there is solid evidence of increasing utilization of these materials.

Beyond our germplasm and other products and services (see below), we have also made significant contributions to agricultural science. A partial list includes: identification of the yield determinants in wheat as well as the factors influencing broad adaptation; identification of factors affecting yield, adaptation, and

development of tropical maize; path-breaking research related to the accumulation of genetic modifiers in quality protein maize; and the development of innovative on-farm research methods that help ensure the creation of new technologies appropriate to farmers' circumstances.

All these contributions have occurred within the context of an evolving purpose. At its inception, the Center was given a broad, multifaceted mandate:

> *To promote and carry out, nationally and internationally, programs to improve in all its aspects maize and wheat production and, if advisable, the production of sorghum, rice, and other food crops, in order to obtain greater unit yields and better production and quality of these crops, through research, the distribution of germplasm, training, scientific and technical meetings, and information.*

This broad mandate was soon narrowed to maize and wheat (triticale research began a little later) and the Center's purpose was more succinctly expressed in a forceful mission statement:

> *To increase the quantity and quality of maize and wheat produced in the developing countries of the world.*

Explicit in this statement was a focus on maize and wheat production, i.e., the output from farmers' fields, as the primary measure of the new Center's success.

While the Center's mandate has remained the same, of late it has come to be interpreted differently. During the 1980s, the Center began to view its mission as one of improving the productivity of agricultural resources, rather than increasing the production of maize and wheat, *per se*. Strategic planning has produced additional refinements, as reflected in our current mission:

> *To help the poor of developing countries by increasing the productivity of resources committed to maize and wheat, whether in research or on the farm; improved germplasm, new knowledge and information, research procedures, training, and consulting services are our principal means to this end.*

The difference between this mission statement and the previous one is far from semantic. In shifting our emphasis from increased maize and wheat production to enhanced productivity of resources committed to these crops, we have begun to focus our attention on the input side of the production equation rather than the output side. By emphasizing the productivity of agricultural resources, we and our colleagues in national programs can become more sensitive to a wider range of

options for increasing incomes in agriculture. A related concern worth special mention is our commitment to germplasm conservation--a charge we undertake through the maintenance of both active seed banks and base collections. In the former, we manage a continuing source of gene combinations for resolving current and emerging crop production problems. In the latter, we are the custodians of gene combinations which might be critical in the future.

In addition to suggesting a shift in the emphasis of CIMMYT's work, the current mission statement, unlike its predecessor, lists means of accomplishing the mission. These take the form of five primary products and services, which are intended to assist national systems in their efforts to develop improved maize and wheat technologies:

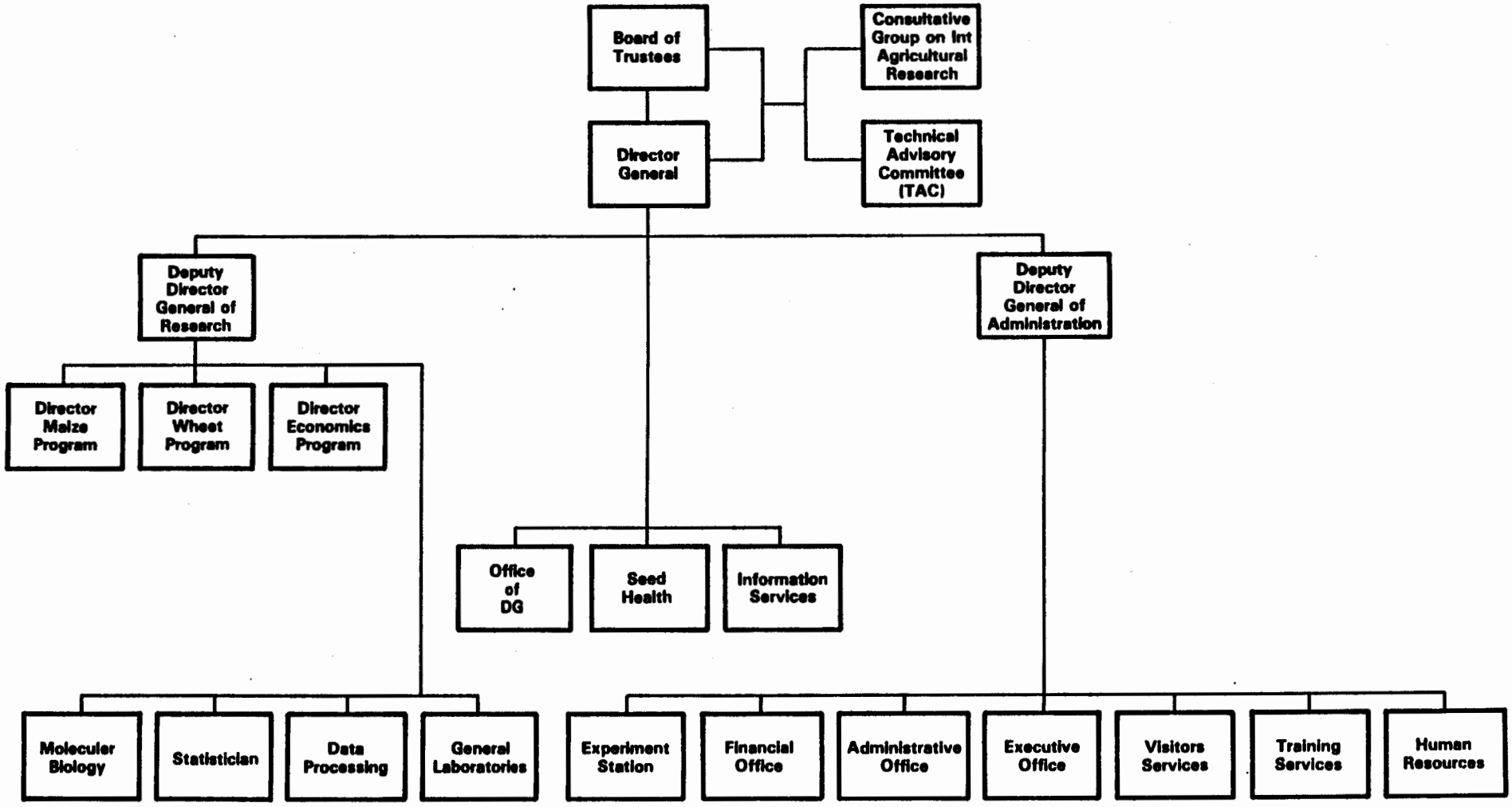
- Improved maize and wheat germplasm for major production environments in the Third World
- Efficient methods for plant breeding, crop management research, and agricultural decision making, especially in research
- Training of various types
- Scientific information stemming from the Center's own research and from the work of others
- Consulting services (technical consultation and assistance)

These products and services are provided by staff working the Center's three main programs--Maize, Wheat, and Economics--assisted by several research support units and general administrative services (see Figure 1.1).

In developing its products and services, CIMMYT draws upon information and procedures currently available in the agricultural disciplines. But the Center also devotes a certain proportion of its resources to generating new scientific information that improves the quality of its offerings, enhances the efficiency with which they are developed, and adds to the general body of scientific knowledge, thereby assisting other researchers in their work.

CIMMYT thus engages in a number of activities, all of which are guided by and consistent with its mission. These constitute the focus of the following chapter.

Figure 1.1. General organization of CIMMYT.



Chapter 2

Enterprises, Activities, and Projects

In this brief chapter we focus on defining a few key terms that appear throughout this document. This vocabulary serves two purposes: 1) it connects this five year plan and budget to the TAC's conceptual framework for classifying work in the CGIAR System and 2) it connects this document to our strategic plan. The TAC developed a set of definitions applicable to efforts that absorb resources and produce products. It calls these efforts "activities." Except for minor modifications we use TAC's definitions in describing our work.

We have added to the conceptual terminology, as well. We find it useful for planning purposes to aggregate activities, and we call these aggregates "enterprises." We also find it useful to subdivide activities into components we call "projects."

Enterprises--CIMMYT has two major enterprises: research and direct support to national programs. The Center's mission is to help the poor of developing countries by increasing the productivity of resources committed to maize, wheat and triticale. Said differently, we strive to open options to the poor. We do that through national agricultural research programs, by providing them with the products and services described in Chapter 1. They then develop improved technologies for farmers. Our support to national programs flows from our research endeavors and through various forms of direct support. These two enterprises thus serve to strengthen national programs, and each is effective to the extent that more options are opened to the poor.

Activities--CIMMYT's activities are shown in Table 2.1. Nine are listed, most of which conform with the TAC definitions. We have made modifications in germplasm improvement, where we aggregated several TAC categories into one, and in economics where some of our work does not fall nicely into the TAC categories. Of these nine activities germplasm improvement, genetic resources, crop protection, crop management and physiology, and economics make up our research enterprise. Training, information, and consulting comprise our direct support enterprise.

Projects--Table 2.1 also lists the projects undertaken by each program. Much of our budgeting and planning is done at the project level. For germplasm improvement, however, planning and internal budgeting actually occur at the next level of specificity. For example, within the spring bread wheat project we plan and budget internally for spring bread wheat for irrigated areas.

These levels of effort--enterprise, activities, and projects, along with subprojects for germplasm improvement--are the basic terms we use in describing our budgeting process and its results.

It should be noted that the activities and projects listed in Table 2.1 reflect CIMMYT's current research and training agenda. The level of resources which will be committed to various projects reflects a number of explicit decision criteria developed in conjunction with our strategic plan. These criteria, which comprise an important dimension of our planning framework, are summarized in the next chapter. Following that, we outline the role of mega-environments in our planning, establish the conceptual basis for distinguishing among "essential" and "desirable" activities in CIMMYT and the scale of each, and go on to discuss factors influencing priority setting.

Table 2.1. CIMMYT activities and projects, by program, 1989.

Activities	Projects		
	Maize	Wheat	Economics
Germplasm Improvement	Lowland tropical Subtropical Highland Hybrid International testing	Spring bread wheat Winter bread wheat Durum wheat Triticale International testing Industrial quality	Information and analysis
Genetic Resources	Germplasm bank Wide crosses Biotechnology	Germplasm bank Wide crosses Biotechnology Germplasm enhancement	
Crop Protection	Entomology Pathology	Pathology Entomology	
Crop Management and Physiology	Physiology Adaptive CMR* Strategic CMR	Physiology Adaptive CMR Strategic CMR	Adaptive CMR Strategic CMR
Economic Analysis			Policy issues in technology utilization Research resource allocations and impacts Commodity analysis
Training	Improvement Production Specialized courses Visiting scientists	Improvement Production Specialized courses Visiting scientists	Production Specialized courses Visiting scientists
Consultation	Yes	Yes	Yes
Information	Yes	Yes	Yes
Management/ Administration	Yes	Yes	Yes

*CMR = crop management research

Chapter 3

Planning and Priority Setting

This chapter deals with CIMMYT's criteria for planning, with the concept of mega-environments and their role in the planning process, with our approach to distinguishing between essential and desirable activities, with the issue of scale, and with the way in which priorities are set. Some of the discussion emphasizes concepts while some concentrates on mechanisms.

Criteria for Planning

Planning aims to enhance the decision making process of an organization. Our planning framework, that of strategic planning, is anchored in the future and emphasizes the assumptions and criteria that affect decisions. We wanted a clear rationale for resource allocations and a framework for fostering congruency between plans and the unfolding future. The first steps were to relate CGIAR goals to specific decision criteria and to identify the dimensions of the future environment most relevant to CIMMYT resource allocations.

Each decision criterion identified relates to the primary concerns of the CGIAR: an emphasis on the poor, an efficient use of resources in meeting their needs, sustaining the productivity of resources used in agriculture, sub-Saharan Africa, marginal lands, and a growing emphasis on basic and strategic research. From these general concerns we formulated a tentative list of criteria and then went on to identify those most relevant to the Center's decision making. These are briefly discussed below; their application is treated later in this chapter under the heading "Priority Setting." Beyond the fact that all major decisions begin with an assessment of expected economic returns and a concern for the poor, the reader should not draw conclusions about the relative importance of the criteria from the order in which they are presented.

Expected economic returns--Our point of departure for assessing expected returns to CIMMYT's research and related activities is the estimated value of the production that will be affected. Subjective estimates by scientists of the gains we can expect from alternative investments in research strongly influence our assessments of expected returns. And in allocating research resources the possibility of significant spillover effects, with research in one area providing benefits in others, is also taken into account.

Impact on the poor--CIMMYT and the CGIAR place considerable weight on identifying research products and services that will benefit the poor. New maize and wheat technologies may have greater impacts on the poor if they:

- Address the needs of poor producers, especially those concentrated in particular agroclimatic environments
- Reduce the price of food to poor consumers
- Promote greater employment of rural labor in production
- Lead to significant growth in other sectors of the economy (especially labor-intensive sectors)

In allocating the Center's resources, we have included the probable effects on both poor producers and poor consumers. We also recognize that most poor producers of maize and wheat are also major consumers of those products.

Food versus feed--Related to the poverty issue, and of particular importance to maize, is the question of food use versus feed use. About half of all maize produced in developing countries is currently used for feed. By the year 2000, feed use is expected to grow to over 60 percent of total production. This increasing use of maize to produce animal products, which weigh more heavily in the diets of the relatively affluent, appears to have implications for how CIMMYT's resources should be allocated.

Some argue that the poor will benefit relatively more from added food grain production than from enhanced feed grain production. Our examination of the argument suggests that, while valid, its implications for weighting in our decision making process are small relative to, say, the weight given to poverty itself.

Stability of yield--Also related to our concern for the poor is the concept of yield stability. Resource-poor farmers tend to be highly averse to taking risks, hence stability is a consideration in much of CIMMYT's work--in judging germplasm, in formulating crop management strategies, and in orienting our direct work with national programs. Beyond that we are giving greater importance than in the past to work undertaken for those environments in which stability in yield is an especially important concern, such as areas affected by drought stress.

Nutrition--This criterion is closely related to concern for the poor, already accounted for directly. We recognize this concern by ensuring that our germplasm products meet conventional minimum levels of nutritive value.

Alternative sources of supply--CIMMYT is part of a worldwide research network that includes other international centers, development agencies, and the public- and private-sector entities that comprise national research systems in developing and developed countries. Careful attention must be given to the question of which institutions in this network have a special advantage in providing specific products and services. Hence, an important criterion for establishing our priorities is the extent to which the Center can be a low-cost supplier of a given product or service in relation to alternative suppliers.

As a corollary, there are complementary suppliers who can enhance our efforts. For example, the International Rice Research Institute (IRRI) has expressed interest in collaboration in research on sustaining the resource base of the rice/wheat systems of Asia. Their research on rice in that system complements our research on wheat, making our efforts more valuable.

Strengthening national programs--Relationships among CGIAR centers and national programs are complex. In some instances, national programs serve as alternative sources of supply for the products and services delivered by the centers. Indeed, the CGIAR is challenging its centers to decentralize, meaning that the centers should pass on to national programs those activities in which the latter can match center costs, quality, and certainty of delivery. This challenge is consistent with the concern for efficiency in resource use. Stronger national programs are most likely to play this role. On the other hand, stronger programs are also more likely to capitalize fully on CIMMYT's efforts than are weaker programs, thereby enhancing the returns to CIMMYT's investment. What results is some ambiguity in weighting the presence of stronger national programs.

Beyond this is the CGIAR's interest in providing direct support to national programs, particularly the less advanced ones, so that they might be more effective in working with farmers. As we see it, this interest rests on the CGIAR's concerns for efficiency in center resource use and relates to national programs' potential contributions to the poor. The matter is complicated, however, by the fact that returns to resources invested in direct support to national programs are heavily influenced by factors not amenable to CGIAR influences. This consideration suggests a certain conservatism in investing in direct support. Even so, potential payoffs to such investment can be notably high when circumstances are favorable.

Our strategy is to assess returns to direct support to national programs in terms of the likely contribution to the productivity of farmer-held resources and invest accordingly. In those cases where investment in direct support to national

programs seems to offer roughly the same returns to the poor as would investment in our own research, we opt for that which promises to strengthen national programs.

Operational scale--This criterion rests on the concern for efficiency. Current evidence suggests that there are a greater number of distinct mega-environments for maize than for wheat. We believe that total returns to increased scale level off rapidly in our work, especially in plant breeding. In other words, the extra benefits coming from additional breeders working on the same set of research problems (i.e., the same mega-environment) declines quickly. Taken together, these factors have implications for the relative resource allocations between maize and wheat. All things being equal, fewer plant breeders would be needed in wheat than in maize, even though allocations to wheat carry with them a higher potential total payoff.

Minimum critical mass--We recognize that, for our involvement in some research and other activities to be effective, a "minimum critical mass" is required. Actually, this simply reflects a concern for good management. No activity should be undertaken without resources sufficient to produce a product that has some current value. Having said that, it is also necessary to argue that an activity's expected future value must cover the "opportunity cost" of the resources committed to it, i.e., the potential but foregone return that could be earned if those resources were used in some other way.

"Upstream" research--The CGIAR advocates that the international centers move "upstream," away from applied/adaptive research and toward more strategic activities. This counsel appears to rest on concerns for efficiency. One argument hinges on the belief that applying new tools stemming from basic and strategic research will reduce the cost of delivering the current product mix. This justification is fully consistent with CIMMYT's other criteria, especially our concern for efficiency. The extent to which we should move upstream can thus be judged in terms of contributions to expected returns.

Sustaining natural resources--In many areas of the world, population pressure and intensification of cropping have placed serious pressure on soil and water resources. Hence, an important objective for the Center's future research agenda is to maintain the productivity of agricultural resources over the long term. This clearly implies a preference for decisions that favor sustaining natural resources.

CIMMYT now focuses considerable attention on issues related to this theme. We have a substantial commitment to the conservation of germplasm; through crop improvement we seek to maintain the resistance of improved maize and wheat to mutating pathogens, thereby reducing the need for potentially hazardous

chemical control measures; and our training programs ensure that a resource maintenance perspective permeates presentations to trainees. We see, however, the possibility of an even greater commitment to this theme through innovative work in crop management research. We recognize that work in this arena carries with it considerable risk of low returns. Even so, the resource allocations of the next chapter reflect our interest in extending our role beyond current activities.

Sub-Saharan Africa--The CGIAR has a special concern for sub-Saharan Africa. Africa is so notably poor that, on the face of the matter, our emphasis on benefiting the poor in itself implies an emphasis on Africa. Yet there is a sense that the CGIAR has brought less to Africa's poor than to the poor of other continents. There is, then, a "catch-up" factor that we recognize in planning for the future by giving added weight to the poor of Africa over those of other continents.

In brief, then, 11 interrelated criteria are used by CIMMYT to help formulate resource allocations. Of these, five emerge from the CGIAR's interest in efficiency, four rest on a concern for the poor, one relates to sustaining natural resources, and one to the special needs of sub-Saharan Africa. In our analysis, we begin with an evaluation of the expected economic returns to a given investment, and then modify the outcome as we consider the remaining decision parameters.

As is evident in Appendix A, we assigned weights to selected decision criteria in order to reflect their relative importance in the decision-making process. Over time, we will refine the information upon which those weights are based. This growing precision may result in changes in the relative importance of individual activities in the Center. We will not, however, veer toward new allocations. Our shift toward ultimate allocations will be gradual and will accommodate the increasing precision of our data.

Not all of the criteria outlined above will apply to every decision, and the importance they assume when they do apply may, in some cases, vary. But they constitute the primary considerations that CIMMYT decision makers use as they allocate resources among competing activities and projects. Furthermore, they are used at several levels of decision making: first at the CIMMYT-wide level, such as in decisions about allocations between maize, wheat, and economics; then within the context of the Center's various programs, such as in the maize program's allocations among major activities; and ultimately within the context of individual projects, such as the spring bread wheat program's allocations among mega-environments.

Mega-environments as an Aid to Decision Making

Germplasm improvement research is by far the largest single activity in CIMMYT. To help ensure the efficient allocation of resources to this activity, we have devised a means of organizing and assigning different weights to our research projects such that the relative importance of each reflects national program needs and CGIAR priorities. Our approach rests on what we call the "mega-environment" concept. A description of the concept follows; its application is treated toward the end of this chapter under the heading "Priority Setting."

CIMMYT currently works with more than 100 national research programs, supplying the various products and services described in Chapter 1. These national programs serve the needs of maize and wheat farmers throughout the developing world by delivering improved germplasm adapted to local production circumstances. It would be an impossible task for CIMMYT to provide the diversity of germplasm required to meet all farmers' immediate needs. But we can provide materials that approximate farmers' needs, better in some cases than in others, and that can be improved upon with national resources and according to national priorities.

The task thus becomes one of determining the types or classes of germplasm CIMMYT should provide to national programs. While maize and wheat can be grown in a wide range of environments, the suitability of a specific genotype will vary as environmental circumstances change. In general, our work focuses on larger environments. We distinguish among three groupings of environments (mega, macro, and micro) largely on the basis of their global importance.

Before developing this concept further, one point of special relevance to wheat research needs to be made. Some of the improved wheat genotypes developed in favorable environments exhibit superior performance over a range of environmental circumstances. Even so, we believe that plant performance can be generally enhanced through the application of the mega-environment concept. Some materials will continue to be developed in well-endowed environments and these will serve to calibrate advances made through greater emphasis on genotype-by-mega-environment interaction.

Mega-environments--These are broad, not necessarily contiguous areas, usually international and frequently transcontinental. Mega-environments are defined by similar biotic and abiotic stresses, cropping system requirements, consumer preferences, and (for convenience) by the volume of production of the relevant crop. This last criterion ensures that we focus our efforts on the most important opportunities open to us. Germplasm products generated for a given mega-environment are adapted and applicable (i.e., suitable) throughout it.

By way of example, one of the more important maize mega-environments is characterized as requiring late-maturing, white dent germplasm with resistance to *H. maydis, P. polysora*, and fusarium ear and stalk rot. This mega-environment produces an estimated 6.8 million tons of maize on some 3.8 million hectares distributed across 18 countries. (See Appendix A for a current list of mega-environments.)

Macro- and micro-environments--We also define macro- and micro-environments. Again, the underlying considerations are plant performance, cropping system requirements, consumer preferences, and a measure of potential influence. These are smaller and more uniform environments. Virtually all macro-environments fall into one or another of the mega-environments. They are important enough to warrant the investment of germplasm improvement resources by a national program, and perhaps by a regional organization. Micro-environments are localized areas for which a high degree of specific adaptation is desirable. In this case, narrowly focused investment is usually not warranted and farmers must rely on materials that fit only some of their needs.

Other applications--In a similar manner, mega-environments may be defined for crop management research. Here common agronomic problems provide a common research theme uniting areas that may cross national boundaries. For example, the millions of hectares occupied by rice-wheat rotations distributed across five countries in Asia appear to constitute an agronomic mega-environment. Within this area there are macro- and micro-environments related to variation in land preparation practices, planting dates, etc. Even with this variation we believe we see a set of problems common across the whole area that are amenable to research and whose solution would be beneficial to farmers.

Environments defined for agronomy will rarely be congruent with those defined for crop improvement and are generally smaller and more numerous, reflecting the greater location specificity of crop management practices. Products of strategic agronomic research conducted at the mega-environment level will be response functions, or crop management principles with a specific cropping system perspective. These can then provide a basis for developing recommendations for farmers, and a starting point for developing more tailored, and ever more useful recommendations for macro-environments.

Classifying and Scaling Activities

The CGIAR asks that each center undertake only "appropriate" activities and to then classify these as either "essential" or "desirable." It asks that we do the

same for individual projects, as well. The rationale found in the following discussion applies equally to activities and projects in the CIMMYT context.

Appropriate activities--According to CGIAR strategies, to be *appropriate* an activity must follow logically from a center's mission, be international in scope, comprise research or research-related endeavors, and be important in the sense that benefits clearly exceed costs. However, in line with its emphasis on decentralization, the CGIAR favors transferring to others (e.g., national programs) even those activities deemed appropriate for its centers, whenever costs and other considerations are roughly comparable for either type of supplier.

Essential activities--TAC defines *essential* activities as those making up the minimum program necessary to carry out the most important tasks of a center's mission. This definition leaves both "minimum program" and a center's mission open to interpretation, but it does suggest that centers should concentrate on appropriate tasks that have a high payoff. Furthermore, because the definition relates to a planning period, it suggests concentrating on activities in which, because of costs and other considerations, the center has an advantage over the course of the planning horizon. CIMMYT has formed its definitions around this interpretation of TAC's statement.

In keeping with the CGIAR's concern for efficiency, our essential category includes only activities with high rates of return. In our framework, returns are equal to the likely economic gains of an activity adjusted for the CGIAR's concerns--e.g., for the poor, for sub-Saharan Africa, and for the strength of national programs.

Beyond returns, because of the CGIAR's emphasis on decentralization, our definition considers the characteristics of costs. As we consider costs, the quality, timeliness, and reliability of output are held constant. As we see it, the possibility for transfer of a given activity relates closely to costs, and three cases on the cost side limit the transfer of activities to other suppliers. The first, and the one with the longest lasting implications, relates to the structure of costs. When average costs decline over all reasonable ranges of output then, based on economic criteria, it is not advantageous to have more than one producer. Moreover, except through subsidies, it is unlikely that another producer will develop the capacities necessary to be cost competitive.

Are there declining cost curves for any of CIMMYT's current activities? We argue that there are. For example, in germplasm improvement and distribution, our place at the center of an international network that develops, shares, tests, and distributes germplasm gives us lower costs for a given level and quality of output than is likely to be achieved by others not at the hub. Duplicating the hub, which

is to say forming another entity like CIMMYT, would give rise to similar costs, but since they decline as the size of the operation increases, having two smaller entities would not be as efficient as having a single large one.

The second case occurs when human or natural resources make a lowest cost producer. This is a potentially long-lived advantage. For example, Mexico's diverse climate permits two or more crop cycles per year, reducing the time required to improve germplasm, and hence lowering CIMMYT's costs. The third case occurs when cost structures follow their more usual patterns, with average costs rising over the relevant range of production, but others are either unable or unwilling to take up production during the planning period.

In summary, then, we have classified as essential those high return activities which, because of any of the three cost considerations, are unlikely to be transferred to others, especially to national programs, during the next five years. Taking the argument a step further, we also classify as essential those activities that are themselves critical to essential activities. Examples are our experiment stations and portions of data processing.

Desirable activities--In our definition, *desirable* activities are like essential ones in that they entail research or are research related, are international, and are important. They differ, however, with respect to costs and, possibly, returns. Here cost curves rise over a significant portion of the relevant range. For this case, other entities have similar costs or could be established at similar costs within the planning period. As well, demand for the output of least-cost producers will be large relative to each producer's supply. In this case, costs and demand combine so that it makes good sense to have several producers.

And what of the returns side? First, activities that are considered desirable because of their cost structure might also have high returns, even as high as activities classified as essential. Certainly, to be characterized as desirable an activity should have expected returns greater than some minimum level established by the returns open to donors from alternative investments. The returns to some activities, however, will be acceptable (i.e., above some minimum), but not among the highest. These we classify as desirable because of returns.

Thus, activities are classified as desirable on the basis of cost curves or on the basis of net returns. One example on the cost side is training in crop management research. Total demand is well beyond our capacities given current budgets. CIMMYT does this quite well and is among the current low cost producers. We believe, however, that during the course of the next five years others could take on this work at costs approximately equal to or lower than ours.

One further point should be made here. Given that the CGIAR wants the centers to decentralize when circumstances are right, why would CIMMYT choose to engage in any desirable activities, i.e., why not place these activities with national programs straight away? Three exceptions immediately come to mind. The first is where demands exceed existing non-CIMMYT capacity; the second is when returns are not high enough to be classified as essential and our resources make us the low cost producer; and the third is where others have not yet had time to develop their capacities, but are expected to be on line after the planning period.

Many of our activities and projects can be easily classified as essential or desirable. Some, however, are less easily categorized. Consider, for example, work on sustaining natural resources in the rice/wheat rotation. Three of the countries most affected have strong research systems that could undertake such work. On that basis alone, we would classify the project as desirable. There are, however, critical aspects of such a research program that we believe international centers are uniquely qualified to handle. One entails facilitating effective communication among researchers of the various countries as well as among the various disciplines involved. Another is the "honest broker" role in seeking and apportioning funding. Both probably best fall to an international entity, at least initially. Because of these advantages and the high expected returns, we classify this project as essential.

A contrasting case relates to work on wheat for the tropical areas of South America. Here the cost curve considerations would make this an essential activity. There are, however, other sources of supply--the national programs of the region are quite advanced--and this limits the expected returns to CIMMYT's own energies. Because of these lower expected returns, we classify this work as desirable.

In summary, our distinction between essential and desirable rests on the CGIAR's wish to decentralize where circumstances permit, on expected returns, on costs, and on the availability of alternative suppliers. While some cases are difficult to classify, these considerations allow the bulk of our activities to be handled in seemingly reasonable ways.

The matter of scale--How much should we invest in a given activity or project? As we see it, a critical step in answering this question involves refining activities or projects until each is roughly homogeneous. It is not appropriate to solve the scale problem at the level of maize breeding, nor indeed at the level of breeding maize for the lowland tropics. Rather, a sense of the need for each of the several classes of lowland maize is required. (Recall the earlier discussion on mega-environments; each class of maize might be associated with a given mega-

environment.) Each of these classes of maize is a unique product. So are various classes of crop management research and economics. Once potential products are identified, the scale for each can be considered.

We argue that scale is largely dependent on three considerations. The first relates to returns, the second to "critical mass" and the third to the gains from specialization. As for the first, in general the larger the anticipated returns of a project the larger the likely scale of suitable operations. Having said this, we believe as well that returns to scale dimension rapidly as scale increases beyond a relatively small level. Relative to the second consideration, the smaller the resource commitment necessary to ensure that returns cover costs, the smaller the returns needed to ensure a viable project. And, as for the third, the greater the gains from specialization the smaller the scale for individual projects. The second and third points imply a larger number of viable individual projects, which in turn implies a larger commitment to the activity made up by aggregating the projects.

While there is little that can be quantified, we think these are the appropriate principles. We have set our scale levels by applying these principles in various ways, all the while recognizing the importance of opportunity costs. To give some sense of the differences that have emerged, our judgement is that the desired scale for developing improved germplasm for irrigated spring bread wheat areas is over four person years, while for well-watered durum areas it is less than one. (Note that this ratio is much smaller than that between production, 48:3. This is in keeping with the earlier observation on rapidly diminishing returns to scale.) For droughty spring bread wheat areas suffering from both cold and heat, we believe the appropriate scale of research to be zero person years, i.e., expected returns from investments in this research do not cover the costs of the required critical mass. Selections for such areas can be made from materials with, say, two of these characteristics and which also exhibit some tolerance to the third.

Setting Priorities

The elements discussed earlier in this chapter provided the framework for setting priorities for the next five years. The following sections briefly review the process through which this was done; more detail is available in our strategic plan.

Setting priorities among major activities--CIMMYT's decision criteria all emanated from CGIAR concerns, and primary among these is the desire that centers be efficient[1] in the utilization of resources. Our case for efficiency rests on judgements about the returns to investment in the activities in which we engage.

Looking first at allocations among major activities, we estimated potential economic returns for each and then modified these according to concerns motivating the CGIAR. We then compared, in a qualitative way, these potential returns with those in other areas. Through discussion and exchange with many sources we reached the following conclusions:

- That over the course of this budget period, we will give increased weight to the generation of new scientific information, less to consulting, and that these shifts in emphasis will hold throughout CIMMYT, both at headquarters and in regional programs

- That near-term payoffs are likely to be higher through crop management research than through germplasm improvement, but that the bulk of crop management research (CMR) should be undertaken by others, in particular by national programs

- That there are several sets of activities in the crop management area in which CIMMYT seems to have a clear advantage over others

- That new essential work should be added to training and that reductions should occur in work classified as desirable

- That in economics, some activities are of great importance to CIMMYT's own decision making and we should add other selected areas of potentially high payoff where CIMMYT seems to have clear advantage over other suppliers

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[1] Recall that our measures of efficiency are economic returns modified by other CGIAR concerns.

- And that work in information services and data processing will play a larger role within CIMMYT and will offer increasing value to national program clients

These discussions and the resulting conclusions gave us a sense of the appropriate magnitudes for resource assignments to various activities. We admit that our rationale is frequently more heuristic than analytical, but we have applied analysis where sufficient information was available. Through it all, the allocations rest on a sense of potential value added--giving most weight to value added for the poor, and taking into account the possibility of alternative sources of supply, whether from national programs or from others.

Setting priorities between maize and wheat--We then turned to the relative size of the maize and wheat programs. We concluded that more resources should go to maize than to wheat, especially in germplasm improvement. The most important consideration was the greater number of mega-environments in maize than in wheat. Also important were estimates on the relative expected gains from investment in the two, the significance attached to sub-Saharan Africa--where maize is notably important--and the considerable capacity in winter wheat breeding in China.

An important development in the recent past has been the growth in the System's investment in other research relative to that in wheat. This has already led to a greater relative reduction in wheat research than envisioned in the 1985 TAC Priority Paper. We confess to wondering if the relative reduction has not been overdone, especially given the opportunities now evident, but not earlier identified, in winter wheat. CIMMYT and ICARDA are now reviewing joint commitments in this area. At this time we expect to commit far fewer resources to winter wheat than our indicators (see Appendix A) suggest, with fewer resources going to wheat as a result.

That same 1985 TAC report pointed out possible efficiencies for the System through decentralization of certain activities now in the hands of the centers. CIMMYT is pursuing this idea, especially in training in crop management research. Two things stand out at this time. The demand for assistance in initiating such programs seems likely to lead first to an increase in professionals in specialized areas of training. The other is that advanced national programs are seeking more assistance from CIMMYT in new lines of work, for example in biotechnology and related themes in plant breeding. This all suggests that decentralization is not likely to lead to reductions in CIMMYT staff during the period of this proposal and that new lines of work could actually justify added staff.

As is shown in the following chapters, our expenditure on maize through the course of the immediate future is larger than that on wheat. We note, as well, that the person year budgets show maize at higher levels than wheat. We believe, however, that the importance of wheat, the implications of decentralization, and the demand for CGIAR involvement in winter wheat research require an open mind on this theme.

For now, and for the CGIAR as a whole, it appears that core-funded expenditures on wheat will be somewhat below those on maize, while all expenditures on wheat will be approximately the same as those on maize. This suggests that, on balance, donor contributions through special project funding favor wheat over maize.

Setting priorities within major activities--As for resource allocations within major activities, we can use germplasm improvement to illustrate the process we followed. The largest portion of CIMMYT's research, training, information, and consulting portfolio relates to the germplasm improvement activity. Fortunately, that is the activity for which the most information is available, thus permitting considerable specificity about the assumptions underlying the resource allocations described in Chapter 4.

To assign resources within germplasm improvement we first defined important mega-environments for maize and wheat, as described earlier in this chapter. Potential mega-environments that were eliminated fell back into similar environments. For example, the spring bread wheat environment requiring tolerance to drought, heat, and cold was folded back into the environment for drought and heat.

Production data from each of the regions making up a given mega-environment were then weighted by income level, by the partition between food and feed, by the strength of national programs, and by location in sub-Saharan Africa. The weighted data were then aggregated across each mega-environment. Each aggregate was then weighted by a measure of the progress expected through germplasm improvement from a given stock of research resources. These "weighted" aggregates were then compared to get a sense of their relative importance. The resulting outcomes, along with the weights assigned to each criterion, are found in Appendix A.

We expect to move the assignment of research resources toward greater congruency with the results of this process. At least four factors, however, will contribute to divergences from the measures in Appendix A:

- Some amount of research resources should be considered "venture capital," and applied to activities with relatively uncertain outcomes. This explains our apparent over-investment in triticale. This crop must soon begin to manifest its worth, however, or claim still fewer CGIAR resources.

- The measures in Appendix A reflect near-term contributions to productivity. Some investments have a payoff through additions to scientific information and, in the longer term, through production. To date, quality protein maize is an example. Thus, such pursuits will appear to be over funded.

- In some cases, the products we provide are also available from alternative suppliers, for example subtropical maize hybrids from the private sector. There will be an apparent under-investment on our part in such projects.

- Uncertainties about the data upon which resource allocations rest may also give rise to divergences.

Beyond these considerations, some may view the weighting results described in Appendix A as inappropriate, e.g., because of the criteria used. The results for marginal areas, for example, may strike some as being less than those desired by the CGIAR. This is a direct consequence of the weights given to various criteria, and especially to the expected rates of gain for germplasm improvement efforts aimed at such areas. Should the CGIAR, through TAC, decide that the present weighting scheme leads to too few resources for such areas, then they might ask that CIMMYT give special weight to marginal areas, *per se*, just as we are giving such added weight to sub-Saharan Africa.

In Summary

The considerations outlined in this chapter shaped the resource allocation conclusions drawn in our strategic plan. They are summarized here as background to the resource allocations presented in Chapter 4.

Allocations between maize and wheat--The plan calls for a greater allocation to maize than to wheat over the planning period, largely because of the greater number of mega-environments and scale considerations, of CGIAR concerns for sub-Saharan Africa, and of the TAC judgement that during the period covered by this budget there are relatively greater opportunities for new investment in maize than in wheat. Should a review of that judgement prove more favorable to wheat, there would be budgetary implications.

Allocations between enterprises--Among our major enterprises, there is a shift in emphasis toward research. The relative decline occurs in direct support to national systems. One implication of this shift is that core-funded regional activities will decline. At the same time, an expected increase in bilateral support for research will bring the total investment in CIMMYT's activities outside Mexico to roughly current levels.

Allocations among activities--A shift toward crop management research is anticipated relative to other research activities. Even so, germplasm improvement is also scheduled to increase, as is economics-related research. The major underlying assumptions are, first, that larger gains are attainable in the next dozen years through crop management research than through germplasm development or through economic research. The next is that national systems will continue to strengthen, implying less urgency for the Center's services and some opportunity to substitute national systems for CIMMYT in the supply of some products.

That assumption about the national systems has an especially strong impact on our commitments to training and consulting, and then on allocations between enterprises and among activities. Total allocations to training will decline, most notably in production agronomy. As well, there will be internal shifts toward training for mid-career professionals and toward developing training materials. Finally, allocations to information will be increased because of the increase in research and because of the expectation of greater facility in computation and in information delivery systems.

These conclusions gave direction to the changes developed in the individual budgets presented in Chapter 4.

Appendix A

Mega-environments, CGIAR Decision Criteria, and Apparent Relative Importance

We first developed weights to give us a point of departure for distribution of resources between maize and wheat. The weights utilized are shown below. In each case, comparisons were based on the sums over the mega-environments in Tables 3.A.1 and 3.A.2.

Our first step was to identify mega-environments. National program staff participated with headquarters and regional CIMMYT staff in characterizing the environments--based on biological and economic factors--and in estimating areas and production. With some exceptions, mega-environments with less than roughly one million tons of production were folded into other environments. For each crop we then applied weights for poverty, for food/feed, for the strength of national programs, for expected rates of progress, for location in sub-Saharan and West/Central Africa, and finally for relative prices (not shown in Tables 3.A.1 and 3.A.2).

Our poverty measures are based on estimated national income levels. They do not reflect incomes in agriculture nor the extent to which these might vary from region to region within a country. The food/feed and strength of national programs weights also assume that country proportions are applicable throughout each country. Rates of progress, however, are assumed to vary from region to region. It is assumed that progress in more difficult environments will be roughly half that in favored environments; that in intermediate environments will be between the two extremes. As well, maize is expected to make 50% more progress than wheat. To look at maize versus wheat, we applied the relative price ratio (1.00:1.30) characteristic of the last 20 years or so.

Adding up the weighted production over all mega-environments for each crop gives a measure of the relative importance of maize and wheat. The following table shows two different outcomes: column one refers to maize, exclusive of temperate maize, and all developing country wheat; column two shows maize as before but excludes facultative and winter wheats. Maize is used as the base. As it stands, we have worked with the estimates in column two.

	Column 1	Column 2
Maize	100	100
Wheat	154	112

Unhappily, these weights make quite a difference in the relative importance of maize and wheat. They make only a slight difference in the relative importance of mega-environments within maize and wheat.

In keeping with the generally conservative tone of our estimates, we have given strong national programs relatively little weight, i.e., a ton of maize in Bolivia has three times more weight than a ton from Mexico. Indeed, the difference in weight given to the weakest national programs as compared with the strongest is the same as the weight given to the poorest country as compared with the best off. Increasing the weight of strong national programs adds to the advantage of wheat.

Sensitivity analysis on the other weights did not much influence the maize versus wheat outcomes, nor did they much influence the relative results for the various mega-environments within maize and within wheat. In particular, we varied over a wide range the weights for location in Africa and reduced the weight given to the poorest. These led to minor changes in the proportions both for maize and for wheat mega-environments.

The aggregates can be improved. During the course of the immediate future we intend to delineate the environments and to refine the data reflecting the criteria, especially that relating to poverty. Over time, with added confidence in the data, we can feel comfortable making our resource allocation pattern more congruent with the results of such analysis. As noted in the text, we recognize that there will be other considerations beyond those on which the tables rest. Our challenge will be to make those explicit and palpable as elements shaping resource allocations. Meanwhile, without veering towards the allocations suggested by the tables, we will be moving in the directions indicated and, at the same time, will be adding precision and confidence to the analysis.

Table A.1. Indices of area, production, and weighted production for maize by mega-environment.

Mega-environment	Estimated area (%)	Estimated production (%)	Weighted production[a] (%)
Highland			
Tropical highlands	6.0	4.4	1.0
Tropical transition zone	4.1	6.4	12.0
Temperate highlands	1.0	0.9	0.7
Subtotal	**11.0**	**11.7**	**13.7**
Subtropical			
Early white flint/dent	1.2	0.9	1.6
Early yellow flint	1.8	1.1	1.2
Intermediate white dent	7.5	9.5	8.6
Intermediate yellow flint	1.9	1.3	1.5
Late white flint	3.9	3.3	11.2
Late white dent	5.1	6.1	12.4
Late yellow dent/flint	7.8	9.5	2.6
Other	0.8	1.0	1.3
Subtotal	**30.0**	**32.6**	**40.4**
Tropical lowland			
Early white flint	4.0	2.2	3.7
Early white dent	1.2	0.7	1.0
Early yellow flint	7.1	4.3	3.5
Early yellow dent	2.5	1.3	0.5
Intermediate white flint	2.1	1.5	3.2
Intermediate white dent	5.3	6.2	3.6
Intermediate yellow flint	9.6	9.7	6.1
Late white flint	4.4	3.6	4.4
Late white dent	6.9	7.3	5.0
Late yellow flint	8.4	9.7	9.4
Late yellow dent	1.7	2.3	2.6
Others	5.8	7.0	2.9
Subtotal	**59.0**	**55.7**	**45.9**
Total	**100.0**	**100.0**	**100.0**

[a]Weighted by: per capita income; uses of maize (food, feed, or others); research productivity potential; strength of the national programs in the mega-environment; and the added CGIAR emphasis on sub-Saharan Africa.

Table A.2. Indices of area, production, and weighted production for wheat by mega-environment.

Mega-environment (characteristics)		Estimated area (%)	Estimated production (%)	Weighted production[a] (%)
Bread Wheat		**89.5**	**92.4**	**92.1**
Spring Type				
ME1	(irrigated, low rainfall[b], temperate)	36.1	42.7	43.4
ME2	(high rainfall, temperate)	8.5	10.4	9.5
ME3	(acid soil, high rainfall, temperate)	1.9	1.3	0.4
ME4A	(low rainfall, temperate, winter rain)	6.1	2.3	2.1
B	(low rainfall, temperate, winter drought)	3.6	2.1	0.8
C	(low rainfall, temperate, mostly stored moisture)	4.9	2.5	2.1
ME5A	(high temperature, high relative humidity)	4.4	4.9	5.7
B	(high temperature, low relative humidity)	3.6	1.5	1.2
ME7	(severe winter, spring sown, high latitude)	6.2	6.8	5.8
	Subtotal	75.3	74.5	71.1
Facultative/winter type				
ME6A	(moderate cold, high rainfall)	5.1	9.8	10.9
B	(moderate cold, low rainfall)	7.4	2.0	2.4
C	(severe cold, high rainfall)	6.7	9.2	11.5
D	(severe cold, low rainfall)	5.5	4.6	4.2
	Subtotal	24.7	25.5	29.0
	Total	100.0	100.0	100.0
Durum Wheat		**10.5**	**7.6**	**7.9**
Spring type				
ME1	(irrigated, low rainfall, temperate)	3.6	7.9	6.9
ME2	(high rainfall, temperate)	23.0	33.6	46.5
ME4A	(low rainfall, temperate, winter rain)	45.6	32.0	23.5
C	(low rainfall, temperate, mostly stored moisture)	14.5	8.7	5.0
	Subtotal	86.7	82.1	81.9
Facultative/winter type				
ME6C	(severe cold, high rainfall)	1.6	5.6	6.7
D	(severe cold, low rainfall)	11.7	12.3	11.4
	Subtotal	13.3	17.9	18.1
	Total	100.0	100.0	100.0
Grand total		**100.0**	**100.0**	**100.0**

[a]Weighted by: per capita income; research productivity potential; and the strength of the national programs.
[b]rainfall just before and during the wheat crop cycle: high = >500mm; low = < 500mm.

Chapter 4

Five Year Resource Allocations in CIMMYT

We turn now to the resource assignments made to CIMMYT's various programs, activities, and projects. We show how person years are currently divided between essential and desirable activities, and show two kinds of changes in those assignments, one from reassignments in the existing staff and the other through modest growth in staff numbers. After treating some general considerations, we discuss the changes envisioned.

General Considerations

Five general themes, applicable across the whole of CIMMYT, are advantageously treated here. One relates to direct involvement with national programs, a second to the work of post-docs and associate scientists, a third to how we envision augmenting our work in biotechnology, the fourth to changes that have occurred since 1987 in the orientation of our work, and the last to classifying activities as either essential or desirable.

Direct support to national programs--Through bilateral programs and, to a lesser but still significant degree, through regional programs, Center staff have gained considerable experience in working directly with national systems. These experiences give us a sensitivity that helps us to focus our efforts in areas that national programs find complementary to their own work. We understand that the erosion of these connections could jeopardize the relevance of our agenda. We believe that this relevance can be maintained through a limited number of bilateral programs. We also believe that such work can be funded through bilateral arrangements with selected donors.

We are negotiating such arrangements. While their major emphasis will be on a single country, the research results will be applicable beyond national boundaries, i.e., in similar agroclimatic regions, and there will be cooperation among the scientists of countries with similar concerns, giving each project an international projection.

We have had some difficulty in classifying this work. On the basis of our definitions, it should be called desirable. Yet, because of its importance to the long run productivity of the Center, one could argue that it is essential. We have classified it as desirable. Nonetheless, we want to reflect its considerable importance to CIMMYT's broader efforts.

Post-docs and associate scientists--Post-docs come to CIMMYT for a period of two years. While most are from developed countries, in recent years the balance has swung toward those from developing countries. In the past, many post-docs have gone on to positions with CIMMYT or with other international centers. While this is less true today, it should be noted that the number of new post-docs each year, four in maize and four in wheat, is only about double our expected annual staff turnover. Hence, a significant number of these people can expect to have an opportunity to compete for a longer term position with the Center. More important, however, they will make critical contributions to our increasingly important efforts in research.

The work of associate scientists is usually focused on well-defined projects that can be finished in two years or less. At the end of the project, there is no necessary commitment for the future, either by the associate or by CIMMYT. We find this an attractive option for employing advanced scientific staff for specific projects.

In the tables that follow, these two groups are combined in one category (Other). Virtually all of their work is classified as essential.

Biotechnology--During the next five years, we expect to increase considerably the resources committed to biotechnology. We see most of the work during that period contributing to reducing the cost or the time needed for our efforts in plant breeding. We also see opportunities for training developing country specialists in this area. We regard this as a crucial shift in our research portfolio, and we expect to have first one and later two senior positions in the laboratory. We also anticipate dedicating some of a statistician's time to its support.

We expect to further augment this work with some five post-docs and associate scientists, supported through special grants and projects. As well, there will be work in maize and wheat germplasm improvement that interfaces with the work in biotechnology.

Even though we expect to fund the effort in various ways, all of the work in biotechnology is classified as essential.

Changes since 1987--In preparing CIMMYT's budgets we needed a point of departure. We chose the dollar figures for 1989 and the human resource figures for 1987, the last year for which TAC recommended human resource limits for the Center.

In 1987 the TAC authorized 87 positions for CIMMYT's core funded activities. The 1988 External Management Review Panel advocated two additional positions. We used the sum (89) to establish the base for staff budgeting. We then assessed the activities of the 106 current (1989) positions, the 89 "authorized" plus the 17 currently funded through special projects, and classified the activities being undertaken through those positions as either essential or desirable. Because this classification rests on new perceptions of how to partition between the two, the number of person years in essential activities in 1989 is less than the number of 1987 TAC-approved positions (Table 4.1).

In 1988 we began a shift toward essential activities and by mid-1989 we will have added about five person years to this category. By 1992 essential activities will absorb the 87 person years authorized in 1987 plus the two added in 1988.

Distinguishing among essential and desirable--In keeping with the discussion of the previous chapter, the following generalizations hold with respect to partitioning between essential and desirable activities:

- All germplasm work--banks, improvement, wide crosses-- is regarded as essential, except for Wheat Program work in germplasm enhancement (because returns are low) and in two regional breeding programs (because of strong national programs).

- The disciplinary work in crop protection is classified as essential, except for selected efforts focused on wheat diseases for which somewhat lower rates of returns are projected.

- In crop management, only strategic research is classified as essential, especially that related to sustaining the productivity of resources in agriculture; except for work aimed at improving research procedures, adaptive and applied CMR is classified as desirable.

- All work in physiology is classified as essential.

- As for training, that related to germplasm improvement and to experiment stations is classified as essential, as is that in CMR aimed at mid-career scientists; entry-level training in CMR is desirable. Work on training materials is seen as essential.

- Consulting related to germplasm improvement is essential and that related to CMR is desirable; economics consulting is classified as essential, except for that related to on-farm research.

Table 4.1. CIMMYT human resource allocations to activities, 1989-94.

	1989			Reallocations[a]			1994[b]		
	E	D	O	E	D	O	E	D	O
Germplasm improvement									
Total (person yrs)	24.8	2.7	10.8	29.0	1.1	11.0	29.6	2.3	12.8
% of total resources	32	9	31	33	6	31	31	10	27
Genetic resources									
Total (person yrs)	4.0	0.9	0.4	5.7	0.0	1.3	7.7	0.0	4.3
% of total resources	5	3	1	6	0	4	8	0	9
Crop protection									
Total (person yrs)	3.7	1.2	5.5	5.2	0.4	5.0	6.7	1.1	4.9
% of total resources	5	4	16	6	2	14	7	5	10
Crop management and physiology									
Total (person yrs)	4.9	6.4	3.1	7.9	5.2	3.4	9.4	6.7	4.3
% of total resources	6	22	9	9	31	10	10	29	9
Economic analysis									
Total (person yrs)	1.2	1.4	1.0	2.3	2.0	1.0	2.9	2.0	1.0
% of total resources	2	5	3	3	12	3	3	9	2
Training									
Total (person yrs)	6.4	8.3	2.7	6.4	4.0	2.1	6.4	5.9	2.5
% of total resources	8	28	8	7	24	6	7	26	5
Consulting									
Total (person yrs)	4.8	6.1	0.5	4.4	2.4	0.2	4.1	2.9	0.2
% of total resources	6	21	1	5	14	1	4	13	0
Research support									
Total (person yrs)	12.0	0.0	11.0	13.0	0.0	11.0	15.0	0.0	17.0
% of total resources	16	0	31	15	0	31	15	0	36
Management/Administration									
Total (person yrs)	15.0	2.2	0.0	15.1	1.9	0.0	15.2	2.1	0.0
% of total resources	20	8	0	17	11	0	16	9	0
Grand total (person yrs)	**76.8**	**29.2**	**35.0**	**89.0**	**17.0**	**35.0**	**97.0**	**23.0**	**47.0**

E = essential Senior Staff; D = desirable Senior Staff; and O = postdoctoral fellows, associate scientists, and associate staff.

[a]Reallocated total essential person years are equal to 1987 TAC-approved positions plus two positions recommended by the 1988 External Management Review (this column shows reallocations among activities and from desirable to essential activities, holding total human resources at present approved levels).

[b]Final human resource allocations, including additional essential positions.

Table 4.1 shows the changes in activities projected for CIMMYT over the next five years. These are portrayed in two stages--one reflecting reallocations of existing resources and the other bringing in several new positions.

The changes in essential and desirable activities between 1989 and 1994 accord with the findings of our strategic plan. Research in germplasm improvement increases. The large change in genetic resources emerges from the greater emphasis given to biotechnology. There is an increase proposed in the disciplinary research of crop protection. In crop management research and physiology, the increases and declines represent a shift from the adaptive and applied work currently underway toward work on strategic issues and, in particular, toward themes related to sustaining the productivity of agricultural resources.

The shifts in training are in the direction of fewer core-funded resources committed to that in crop management research, and more such resources to specialized courses and to supporting work with mid-career visiting scientists. Finally, consulting also declines as we move toward more interaction with national programs through research itself.

These shifts affect some 20% of our staff over the course of the next five years, and rest on our interpretations of the criteria identified as important to the CGIAR and of the evolving circumstances in which the Center works. It is important to note that changes in our activities during the next five years will come more from the shifting of existing resources than from growth.

Funding strategy--We will support essential activities with both core and extra-core funds. In particular, the associate scientists, post docs, and visiting scientists engaged in biotechnology work, all of which is classified as essential, will be extra core funded.

Maize Program Resource Allocations

As shown in Tables 4.2 and 4.3, Maize Program research and training in CIMMYT are currently conducted by a multidisciplinary team of 48 international staff (senior staff, associate scientists, and post docs). Twenty-nine are located at headquarters and 19 are deployed outside Mexico among six regional maize programs, one bilateral project (serving Ghana), and one cooperative research venture (with the International Institute of Tropical Agriculture, IITA, concentrating on the improvement of tropical lowland germplasm for West and Central Africa under terms of an agreement reached in 1988).

Most headquarters-based staff are involved in germplasm improvement activities, while those in the regions now focus relatively more on direct support to national programs in germplasm improvement and CMR (Table 4.4). Some regional staff also engage directly in germplasm improvement research, in those instances where the research is not readily practicable at headquarters (such as for downy mildew or corn stunt resistance). Regional maize staff are found in the Andean zone, Central America and the Caribbean, Asia, the Middle East/North Africa, eastern Africa, and southern Africa.

On January 1, 1989 the Maize Program implemented notable changes in its organization, adding decision points so as to enhance management efficiency. Changes were made in three areas. At the Program management level, the associate director now focuses on the management of Maize Program activities outside Mexico, while the director concentrates on all headquarters-based activities. The Program was divided into nine subprograms, which together constitute a second organizational tier. Four of these subprograms focus on germplasm improvement: lowland tropical, subtropical, highland, and hybrids. The remaining subprograms are: crop management and physiology, germplasm distribution, crop protection, genetic resources, and training. Each subprogram has a coordinator. Finally, team leaders responsible for on-site management of Maize Program resources were designated for each regional and bilateral location.

Current resource allocations--Current allocations reflect the central role of germplasm improvement in the Maize Program's work (Table 4.2). This activity receives just over half of total resources. All breeding activities are considered essential, as are those disciplinary activities related to germplasm improvement.

Germplasm improvement--Our germplasm improvement research is largely governed by concerns embodied in the mega-environment concept (see Chapter 3). Among the various projects that comprise this activity and based on the weighting criteria described in Chapter 3 (i.e., the extent of lowland tropical maize production in developing countries, the number and diversity of the mega-environments in which it is grown, its broad disease- and pest-resistance requirements, and the lack of alternative suppliers), lowland tropical maize receives the largest share of resources, with 7.3 person-years (Table 4.3). The allocation to subtropical maize (3.0 person years) is also more or less in line with the relative importance of this category of materials in developing country production, given alternative suppliers, especially from the private sector. Highland maize receives slightly more than is dictated by its production levels, but to allocate less than the current 1.5 person years would not give us the minimum critical mass that we consider necessary to supply superior germplasm for this quite distinct and challenging set of environments. The allocation to

Table 4.2. Maize Program human resource allocations to activities, 1989-94.

	1989			Reallocations[a]			1994[b]		
	E	D	O	E	D	O	E	D	O
Germplasm improvement									
Total (person yrs)	14.3	0.0	5.0	15.2	0.0	5.0	15.2	0.0	5.0
% of Program resources	51	0	50	48	0	50	45	0	42
Genetic resources									
Total (person yrs)	1.8	0.0	0.0	2.6	0.0	0.0	3.6	0.0	2.0
% of Program resources	6	0	0	8	0	0	11	0	17
Crop protection									
Total (person yrs)	1.8	0.0	2.0	2.0	0.0	2.0	3.0	0.0	2.0
% of Program resources	6	0	20	6	0	20	9	0	17
Crop management and physiology									
Total (person yrs)	2.6	3.5	2.0	4.4	3.5	2.0	4.4	4.0	2.0
% of Program resources	9	39	20	14	70	20	13	57	17
Training									
Total (person yrs)	2.5	2.7	1.0	3.2	0.8	1.0	3.2	2.3	1.0
% of Program resources	9	30	10	10	16	10	9	33	8
Consulting									
Total (person yrs)	2.0	2.1	0.0	1.6	0.0	0.0	1.6	0.0	0.0
% of Program resources	7	23	0	5	0	0	5	0	0
Management/Administration									
Total (person yrs)	3.0	0.7	0.0	3.0	0.7	0.0	3.0	0.7	0.0
% of Program resources	11	8	0	9	14	0	9	10	0
Grand total (person yrs)	28.0	9.0	10.0	32.0	5.0	10.0	34.0	7.0	12.0

E = essential Senior Staff; D = desirable Senior Staff; and O = postdoctoral fellows, associate scientists, and associate staff.

[a]Reallocated total essential person years are equal to 1987 TAC-approved positions (this column shows reallocations among activities and from desirable to essential activities, holding total human resources at present approved levels).

[b]Final human resource allocations, including additional essential positions.

Table 4.3. Maize Program, breakdown by year of shifts in human resource allocations to activities and projects, 1989-94.

				Changes														
	1989			1990			1991			1992			1993			1994		
Activity/Project	E	D	O	E	D	O	E	D	O	E	D	O	E	D	O	E	D	O
Germplasm improvement																		
Lowland tropical	7.3	–	1.0	0.1	–	–	0.3	–	–	0.3	–	–	–	–	–	8.0	0.0	1.0
Subtropical	3.0	–	1.0	–	–	–	–	–	–	–	–	–	–	–	–	3.0	0.0	1.0
Highland	1.5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.5	0.0	0.0
Hybrids	0.8	–	2.0	0.1	–	–	0.1	–	–	–	–	–	–	–	–	1.0	0.0	2.0
International testing	1.7	–	1.0	–	–	–	–	–	–	–	–	–	–	–	–	1.7	0.0	1.0
Total (person yrs)	14.3	0.0	5.0	14.5	0.0	5.0	14.9	0.0	5.0	15.2	0.0	5.0	15.2	0.0	5.0	15.2	0.0	5.0
% of Program resources	51	0	50	48	0	45	47	0	45	45	0	42	45	0	42	45	0	42
Genetic resources																		
Germplasm bank	0.9	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.9	0.0	0.0
Wide crosses	0.9	–	–	-0.2	–	–	-0.2	–	–	–	–	–	–	–	–	0.5	0.0	0.0
Biotechnology	–	–	–	0.6	–	1.0	1.5	–	–	0.1	–	1.0	–	–	–	2.2	0.0	2.0
Total (person yrs)	1.8	0.0	0.0	2.2	0.0	1.0	3.5	0.0	1.0	3.6	0.0	2.0	3.6	0.0	2.0	3.6	0.0	2.0
% of Program resources	6	0	0	7	0	9	11	0	9	11	0	17	11	0	17	11	0	17
Crop protection																		
Entomology	0.9	–	1.0	0.1	–	–	–	–	–	1.0	–	–	–	–	–	2.0	0.0	1.0
Pathology	0.9	–	1.0	0.1	–	–	–	–	–	–	–	–	–	–	–	1.0	0.0	1.0
Total (person yrs)	1.8	0.0	2.0	2.0	0.0	2.0	2.0	0.0	2.0	3.0	0.0	2.0	3.0	0.0	2.0	3.0	0.0	2.0
% of Program resources	6	0	20	7	0	18	6	0	18	9	0	17	9	0	17	9	0	17
Crop management and physiology																		
Physiology	1.2	1.0	–	–	–	–	–	–	–	–	–	–	–	–	1.2	0.0	1.0	–
Adaptive CMR	–	3.5	1.0	–	–	–	–	–	–	–	0.3	–	–	–	–	0.0	4.0	1.0
Strategic CMR	1.4	–	–	1.0	–	–	0.3	–	–	0.5	–	–	–	–	–	3.2	0.0	0.0
Total (person yrs)	2.6	3.5	2.0	3.6	3.5	2.0	3.9	3.5	2.0	4.4	3.8	2.0	4.4	3.8	2.0	4.4	4.0	2.0
% of Program resources	9	39	20	12	39	18	12	45	18	13	56	17	13	56	17	13	57	17

Training																		
Improvement	1.4	0.9	–	–	–	–	–	-0.3	–	0.2	-0.6	–	–	–	–	1.6	0.0	0.0
Production	1.1	1.8	1.0	–	1.3	–	–	-0.3	–	–	-0.7	–	–	–	–	1.1	2.1	1.0
Specialized courses	–	–	–	0.2	0.2	–	–	–	–	0.3	–	–	–	–	–	0.5	0.2	0.0
Total (person yrs)	2.5	2.7	1.0	2.7	4.2	1.0	2.7	3.6	1.0	3.2	2.3	1.0	3.2	2.3	1.0	3.2	2.3	1.0
% of Program resources	9	30	10	9	47	9	8	46	9	9	34	8	9	34	8	9	33	8
Consulting	2.0	2.1	0.0	–	-1.5	0.0	–	-0.6	0.0	-0.4	0.0	0.0	0.0	0.0	0.0	1.6	0.0	0.0
Total (person yrs)	2.0	2.1	0.0	2.0	0.6	0.0	2.0	0.0	0.0	1.6	0.0	0.0	1.6	0.0	0.0	1.6	0.0	0.0
% of Program resources	7	23	0	7	7	0	6	0	0	5	0	0	5	0	0	5	0	0
Management/ Administration	3.0	0.7	–	–	–	–	–	–	–	–	–	–	–	–	–	3.0	0.7	0.0
Total (person yrs)	3.0	0.7	0.0	3.0	0.7	0.0	3.0	0.7	0.0	3.0	0.7	0.0	3.0	0.7	0.0	3.0	0.7	0.0
% of Program resources	11	8	0	10	8	0	9	9	0	9	10	0	9	10	0	9	10	0
Grand Total	28.0	9.0	10.0	30.0	9.0	11.0	32.0	7.8	11.0	34.0	6.8	12.0	34.0	6.8	12.0	34.0	7.0	12.0

E = essential Senior Staff; D = desirable Senior Staff; and O = postdoctoral fellows, associate scientists, and associate staff.

Table 4.4. Maize Program human resource allocations between headquarters and outreach, by activity (Essential + Desirable)

	1989		1994	
	Headquarters PY*	Outreach PY*	Headquarters PY*	Outreach PY*
Germplasm improvement	7.2	7.1	8.0	7.2
Genetic resources	1.8	0.0	3.6	0.0
Crop protection	1.8	0.0	3.0	0.0
Crop management and physiology	1.5	4.6	2.6	5.8
Training	2.5	2.7	1.8	3.7
Consulting	0.6	3.5	0.4	1.2
Management/Administration	2.6	1.1	2.6	1.1
Total	**18.0**	**19.0**	**22.0**	**19.0**

*PY=Senior staff person years.

international testing (1.7 person years) is what we have gauged to be sufficient for testing and distributing products of the various breeding projects.

CIMMYT's hybrid maize program is very limited, since open-pollinated varieties still predominate in developing country production and most of the relatively small area planted to hybrids is concentrated in favored environments in a few countries, e.g., Argentina, Brazil, and China, that have strong national maize programs. Our decision to allocate a modest amount of resources (0.8 person year) to this work was based on the changing priorities of breeders, even in the smaller countries of Africa, Latin America, and Southeast Asia, to expand the share of production contributed by hybrids. A few countries are well on their way to fulfilling this aim, as is the case for El Salvador, which has about 70% of its maize planted to hybrids. There and in a number of other countries, breeders have used CIMMYT's germplasm in their hybrid development efforts, and much of our own hybrid program's work is designed to enhance the utility of our materials for this purpose. The products of our research in this area include early generation inbreds, source materials, and parents for non-conventional hybrids.

Related activities--Our investments in activities related to germplasm improvement--genetic resources, crop protection, and physiology--are motivated both by their importance in support of germplasm improvement and by our interest in the disciplinary work, per se. Each of the projects in these subprograms--germplasm bank, wide crosses, entomology, pathology, and physiology (which in subsequent discussion is grouped with crop management)--receives approximately one person year.

Although we recognize that CMR is critical to the successful utilization of improved maize germplasm by developing countries, we have made a smaller investment in this activity than in germplasm improvement, and we regard much of our involvement to date in adaptive CMR as desirable (3.5 person years) rather than essential. The basis for this position is that as an international center we have a stronger comparative advantage in germplasm improvement than in adaptive agronomy research, which tends to be more site specific and therefore less amenable to a global approach. We have, however, identified some opportunities for strategic CMR that could yield benefits across a much wider swath of developing country maize area and have made a modest investment of 1.4 person years, all classified as essential, in this work.

Allocations to training and consulting also have essential and desirable components. The essential allocations to these activities (2.5 person years to training and 2.0 to consulting) represent what we judge to be the minimum required for contributing to steady growth in the capacity of national programs to effectively use our germplasm and other products. We have, in addition,

channeled resources into production agronomy training (1.8 person years) and general consultation (2.1 person years), which we consider desirable activities.

Maize staff are engaged in a complex and wide ranging program of work that requires administrative attention, both at headquarters and outside Mexico (3.7 person-years in total).

Planned growth and changes to 1994--Changes during the period covered by this budget include reallocations of resources from desirable to essential activities and growth. Four person years currently assigned to desirable training and consulting activities will be reallocated to essential germplasm improvement and genetic resources activities. These shifts bring the total person years allocated to essential activities up to the 1987 authorized level of 32 (Table 4.2). In addition, we have included four senior staff person years, one each devoted to genetic resources and crop protection activities and two assigned to desirable training activities. Two associate scientist and postdoctoral person years will be added in genetic resources.

Overall, the proportion of Program resources assigned to genetic resources and crop management activities will increase, while those assigned to germplasm improvement decline. Allocations to other activities will remain relatively constant.

Germplasm improvement--The primary objective of maize breeding at CIMMYT is to provide national programs with elite germplasm for nearly all of the major production environments in developing countries (with the exception of temperate areas) and with source germplasm for key traits (chiefly stress resistances) that contribute to yield stability. The majority of these products are open-pollinated materials: the broadly adapted products with good stress tolerance are mostly experimental varieties, and the highly resistant source materials generally take the form of populations. To these we have added an increasing number of inbred materials, and for all products we are generating new information about their stress resistance levels and other key traits.

The only germplasm improvement projects in which we plan growth are lowland tropical and hybrid maize. Although we already have an extensive array of lowland tropical open-pollinated products, there is considerable demand from our clients for product expansion and improvement. Other factors pointing toward increased resources for lowland tropical maize are that it is by far the largest class of germplasm grown in developing countries, encompasses more numerous and diverse mega-environments than all other classes of materials, and requires resistance to a far greater number of diseases and pests. It is arguable, in fact, that our current allocation of 7.3 person years has been slightly below that required to fully satisfy the demand for lowland tropical maize. The

necessity of correcting this shortfall (by increasing the allocation to 8.0 person years) is made all the more urgent by the absence of strong alternative international suppliers of lowland tropical germplasm.

A somewhat different situation prevails with respect to subtropical germplasm. We expect that a sizeable share of this material will be supplied by the private sector, though almost entirely in the form of hybrids. To meet the continuing need for open-pollinated materials of subtropical adaptation, CIMMYT will maintain its allocation to this project at the current level. We are planning modest growth in our own hybrid project (from 0.8 to 1.0 person year) to keep pace with the growing interest in hybrids among national programs that serve the lowland tropics.

Genetic resources--All of the Program's work in genetic resources is regarded as essential. Its purposes are to conserve genetic variation (primarily in the form of seed of maize landraces and wild relatives), distribute this germplasm and information about it to researchers worldwide, and apply techniques for utilizing the germplasm in maize improvement. Recent developments in biotechnology have increased the likelihood of high returns from this activity. Techniques are already available that promise to be extremely useful for identifying desired traits in germplasm bank accessions and for facilitating selection for these traits in germplasm improvement, with significant increases in speed and cost-effectiveness.

This work will be expanded and we will shift 1.2 person years into biotechnology, partly at the expense of wide crosses, whose allocation will drop from 0.9 to 0.5 person years. We also seek new funds for an additional person in biotechnology to bring its allocation to 2.2 person years by 1994, plus two new positions for associate scientists or postdoctoral fellows. Maize biotechnology staff will initially focus on the utility of RFLPs and other molecular markers in breeding for insect resistance. Should this approach noticeably improve our efficiency in the development of resistant germplasm, it will be applied in other areas of the breeding program as well.

Resources committed to the germplasm bank will remain the same, since it has been adequately staffed in recent years and has received special attention through a visiting scientist consultancy and substantial capital expenditures. Some essential expansions in bank facilities are anticipated, however (see Chapter 5).

Crop protection--The use of insect and disease resistant cultivars is an environmentally safe approach to crop protection and the only practicable one for poor farmers, who can seldom afford chemical controls. For those reasons crop

protection research in the Maize Program focuses almost exclusively on facilitating the development of insect and disease resistant maize. Entomologists and pathologists work toward this goal by providing insects and inoculum to create artificial insect and disease pressure for selection, identifying new sources of resistance, and by developing more efficient techniques employed in resistance development.

All crop protection work is classified as essential. In view of the increases described above in selected germplasm improvement projects, we will be reallocating some existing resources to crop protection (from 1.8 to 2.0 person years). This internal shift will be evenly distributed between entomology and pathology. In addition, we seek new funds for another person year in entomology. Historically, progress with insect resistance has been slower than with diseases, both at CIMMYT and in developed country breeding programs. But recent breakthroughs in multiple-insect resistance using conventional breeding techniques suggest that an increased investment in entomology would yield greater returns than it could have only a few years ago. Progress might be further increased, as suggested in the discussion of genetic resources, through the application of RFLPs and other molecular markers. In fact, biotechnology staff will focus initially on insect resistance, precisely because it promises greater gains in cost-effectiveness than other aspects of the Maize Program's work. Achieving these gains, however, presupposes increased expertise in entomology, which we thus view as a necessary corollary to our new investments in biotechnology.

Crop management and physiology--Most agronomists in the Maize Program are engaged in CMR under cooperative arrangements with national programs. Some of their time is committed to essential strategic CMR, such as investigations on striga, a parasitic weed that occurs across much of sub-Saharan Africa. But more of their time is absorbed by desirable adaptive CMR, in which our staff help crop management specialists examine soil, plant, and atmosphere relationships in fashioning crop production technologies that enable farmers to achieve more efficient, sustained crop production.

Through reallocations the Maize Program will shift additional resources to CMR, mostly for strategic research, bringing its allocation to 3.2 person years. Even though CIMMYT's general orientation is shifting toward strategic research, the Program will maintain and even slightly increase (from 3.5 to 4.0 person years) its investment in adaptive CMR, classified as desirable. Most of this work will be in bilateral programs.

Training--Courses offered at Center headquarters and in regional and bilateral programs are designed to equip national program cooperators with the practical

skills and knowledge they require to conduct effective germplasm development and CMR.

Over the plan period, the total allocation to training will increase slightly (0.3 person year). Considerable changes, however, are planned for the components of this activity. In improvement training, the Program will increase its emphasis on advanced courses while reducing entry level training, especially that done outside of Mexico, which is currently classified as desirable. The decline in entry level training is in response to what we perceive as the increased capacity of national programs to provide such a service. There will be an overall decrease in resources assigned to improvement training.

In CMR training the emphasis will also shift from entry level to advanced courses, with a decline in training at headquarters. To promote the decentralization of CMR training over the long term, 2.1 desirable person years are included to strengthen national program capacity for this service and to aid in course and materials design. Finally, the Program will increasingly include specialized short courses among its offerings.

Consulting--Maize Program staff periodically visit researchers in developing countries to consult with them about specific details of the planning and execution of national research. Major aims of consultation are to improve priority setting and decision making capabilities in national programs and to obtain information about the requirements of national maize research and production, which can guide CIMMYT staff in their own priority setting.

A decline in this activity is planned: consultation for specific purposes will drop from 2.0 to 1.6 person years, and the 2.1 person years currently allocated to general consultation will be dropped altogether. As in the case of training, these changes are necessary to free resources for increases in other activities that are deemed essential. The reductions are also a logical response to the progress we perceive in national programs.

Management/administration--In spite of anticipated overall growth in the Maize Program, we do not expect to exceed our current allocation of 3.7 person years to management and administration. We expect that gains in management efficiency from our new structure will offset the additional management/administrative burden that will accompany an overall increase in staff.

Wheat Program Resource Allocations

Wheat research and training are currently conducted by 47 international staff (senior staff, associate scientists, and post docs), 32 at headquarters and 15 located outside Mexico in five regional programs, one bilateral project (serving Bangladesh), and two collaborative research programs (one with Turkey, focusing on winter and facultative wheats, the other with ICARDA, focusing on spring bread wheat and durums for dry environments). The Wheat Program also collaborates with ICARDA in research on barley by providing material support for their staff stationed at CIMMYT headquarters, and ICARDA provides similar support for CIMMYT staff in Syria. Relationships with ICARDA have been clarified and strengthened. Tables 4.5 and 4.6 show the allocation of wheat human resources to activities.

Most Wheat staff located at headquarters engage in germplasm improvement activities, though crop management research at base figures more prominently than in Maize (Table 4.7). Regional wheat staff spend much of their time in direct support of national programs and contribute significantly to the development of improved germplasm by providing information on the performance of CIMMYT nursery materials in their regions. Staff working in Turkey and Syria (ICARDA) have some regional responsibilities, but the bulk of their time is devoted to research. Regional staff are located in the Andean zone, the Southern Cone of South America, Eastern and Southern Africa, South Asia, and Southeast Asia.

The Wheat Program made significant changes in its organizational structure in early 1989. The purpose of the reorganization was to decentralize management by adding decision points to the structure and to foster additional disciplinary research. Four subprograms were created along disciplinary lines: germplasm improvement, genetic resources, crop protection, and crop management/physiology. Each has a leader responsible for research management at headquarters and, to a lesser extent, in regional and bilateral programs. The subprograms are composed of sections--for example, genetic resources contains the germplasm bank, wide crosses/biotechnology, and germplasm enhancement--and each section has a head who coordinates the work.

As the wheat program looks to the next five years and beyond, thinking is dominated by the anticipated growth in demand for wheat in developing countries of 3% per annum. Much of this demand must be met by productivity increases in these countries. Another strong perception is that crop management is becoming a greater constraint to productivity growth than germplasm improvement. However, CIMMYT's comparative advantage still lies clearly in the area of germplasm improvement.

Table 4.5. Wheat Program human resource allocations to activities, 1989-94.

	1989			Reallocations[a]			1994[b]		
	E	D	O	E	D	O	E	D	O
Germplasm improvement									
Total (person yrs)	9.8	2.7	5.8	11.5	1.1	5.5	12.1	2.3	7.3
% of Program resources	41	25	48	40	18	46	38	23	45
Genetic resources									
Total (person yrs)	2.2	0.9	0.4	3.1	0.0	1.3	4.1	0.0	2.3
% of Program resources	9	8	3	11	0	11	13	0	14
Crop protection									
Total (person yrs)	1.9	1.2	3.5	3.2	0.4	3.0	3.7	1.1	2.9
% of Program resources	8	11	29	11	7	25	12	11	18
Crop management and physiology									
Total (person yrs)	1.4	1.4	0.9	2.4	1.4	0.9	3.5	2.4	1.8
% of Program resources	6	13	8	8	23	8	11	24	11
Training									
Total (person yrs)	2.7	2.2	1.2	2.7	1.5	1.1	2.7	1.9	1.5
% of Program resources	11	20	10	9	25	9	8	19	9
Consulting									
Total (person yrs)	2.8	1.6	0.2	2.8	0.9	0.2	2.5	1.4	0.2
% of Program resources	12	15	2	10	15	2	8	14	1
Management/Administration									
Total (person yrs)	3.2	1.0	0.0	3.3	0.7	0.0	3.4	0.9	0.0
% of Program resources	13	9	0	11	12	0	11	9	0
Grand total (person yrs)	24.0	11.0	12.0	29.0	6.0	12.0	32.0	10.0	16.0

E = essential Senior Staff; D = desirable Senior Staff; and O = postdoctoral fellows, associate scientists, and associate staff.

[a]Reallocated total essential person years are equal to 1987 TAC-approved positions (this column shows reallocations among activities and from desirable to essential activities, holding total human resources at present approved levels).

[b]Final human resource allocations, including additional essential positions.

Table 4.6. Wheat Program, breakdown by year of shifts in human resource allocations to activities and projects, 1989-94.

				Changes														
	1989			1990			1991			1992			1993			1994		
Activity/Project	E	D	O	E	D	O	E	D	O	E	D	O	E	D	O	E	D	O
Germplasm improvement																		
Spring bread wheat	4.0	1.6	2.7	1.0	-0.3	-0.3	0.6	–	–	0.5	–	0.1	–	–	–	6.1	1.3	2.5
Winter bread wheat	1.4	0.3	0.2	0.2	–	–	–	–	–	–	–	0.8	–	–	–	1.6	0.3	1.0
Durum wheat	1.5	0.4	0.6	–	–	–	–	–	–	–	–	–	–	–	–	1.5	0.4	0.6
Triticale	0.8	0.4	1.1	–	-0.1	–	–	–	–	–	–	–	–	–	–	0.8	0.3	1.1
International testing	1.7	0.0	0.0	–	–	–	–	–	–	–	–	–	–	–	0.9	1.7	0.0	0.9
Industrial quality	0.4	0.0	1.2	–	–	–	–	–	–	–	–	–	–	–	–	0.4	0.0	1.2
Total (person yrs)	9.8	2.7	5.8	11.0	2.3	5.5	11.6	2.3	5.5	12.1	2.3	6.4	12.1	2.3	7.3	12.1	2.3	7.3
% of Program resources	41	25	48	41	21	42	39	21	39	39	21	42	38	23	45	38	23	45
Genetic resources																		
Germplasm bank	0.8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.8	0.0	0.0
Wide crosses	1.2	–	0.4	–	–	0.5	–	–	–	–	–	–	–	–	–	1.2	0.0	0.9
Biotechnology	0.0	–	–	0.8	–	0.5	–	–	–	–	–	–	–	–	–	0.8	0.0	0.5
Germplasm enhancement	0.2	0.9	0.0	0.2	–	0.9	–	–	–	–	–	–	0.9	-0.9	–	1.3	0.0	0.9
Total (person yrs)	2.2	0.9	0.4	3.2	0.9	2.3	3.2	0.9	2.3	3.2	0.9	2.3	4.1	0.0	2.3	4.1	0.0	2.3
% of Program resources	9	8	3	12	8	18	11	8	16	10	8	15	13	0	14	13	0	14
Crop protection																		
Pathology	1.9	1.2	3.5	0.6	-0.1	-0.5	0.7	–	–	0.5	–	-0.1	–	–	–	3.7	1.1	2.9
Entomology	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.0	0.0	0.0
Total (person yrs)	1.9	1.2	3.5	2.5	1.1	3.0	3.2	1.1	3.0	3.7	1.1	2.9	3.7	1.1	2.9	3.7	1.1	2.9
% of Program resources	8	11	29	9	10	23	11	10	22	12	10	19	12	11	18	12	11	18
Crop management and physiology																		
Physiology	–	–	–	–	–	–	0.8	–	–	–	–	–	–	–	–	0.8	0.0	0.0
Adaptive CMR	–	1.0	–	–	1.0	–	–	–	–	–	-0.3	–	–	–	–	0.0	1.7	0.0
Strategic CMR	1.4	0.4	0.9	–	–	–	0.9	–	0.9	0.3	0.3	–	0.1	–	–	2.7	0.7	1.8
Total (person yrs)	1.4	1.4	0.9	1.4	2.4	0.9	3.1	2.4	1.8	3.4	2.4	1.8	3.5	2.4	1.8	3.5	2.4	1.8
% of Program resources	6	13	8	5	22	7	10	22	13	11	22	12	11	24	11	11	24	11

Training																		
Improvement	2.2	1.0	0.8	–	-0.2	–	–	–	–	–	–	0.2	–	-0.1	0.1	2.2	0.7	1.1
Production	0.5	1.2	0.4	–	–	-0.1	–	–	0.1	–	–	–	–	–	–	0.5	1.2	0.4
Specialized courses	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.0	0.0	0.0
Total (person yrs)	2.7	2.2	1.2	2.7	2.0	1.1	2.7	2.0	1.2	2.7	2.0	1.4	2.7	1.9	1.5	2.7	1.9	1.5
% of Program resources	11	20	10	10	18	8	9	18	9	9	18	9	8	19	9	8	19	9
Consulting	2.8	1.6	0.2	–	-0.2	–	–	–	–	-0.3	–	–	–	–	–	2.5	1.4	0.2
Total (person yrs)	2.8	1.6	0.2	2.8	1.4	0.2	2.8	1.4	0.2	2.5	1.4	0.2	2.5	1.4	0.2	2.5	1.4	0.2
% of Program resources	12	15	2	10	13	2	9	13	1	8	13	1	8	14	1	8	14	1
Management/ Administration	3.2	1.0	–	0.2	-0.1	–	–	–	–	–	–	–	–	–	–	3.4	0.9	0.0
Total (person yrs)	3.2	1.0	0.0	3.4	0.9	0.0	3.4	0.9	0.0	3.4	0.9	0.0	3.4	0.9	0.0	3.4	0.9	0.0
As % of Program Resources	13	9	0	13	8	0	11	8	0	11	8	0	11	9	0	11	9	0
Grand total (person yrs)	24.0	11.0	12.0	27.0	11.0	13.0	30.0	11.0	14.0	31.0	11.0	15.0	32.0	10.0	16.0	32.0	10.0	16.0

E = essential Senior Staff; D = desirable Senior Staff; and O = postdoctoral fellows, associate scientists, and associate staff.

Table 4.7. Wheat Program human resource allocations between headquarters and outreach, by activity (Essential + Desirable)

	1989		1994	
	Headquarters PY*	Outreach PY*	Headquarters PY*	Outreach PY*
Germplasm improvement	6.7	5.8	8.6	5.8
Genetic resources	3.1	0.0	4.1	0.0
Crop protection	1.5	1.6	3.0	1.7
Crop management and physiology	1.2	1.6	3.0	3.0
Training	2.8	2.1	3.0	1.6
Consulting	1.9	2.5	2.4	1.5
Management/Administration	2.8	1.4	2.9	1.4
Total	**20.0**	**15.0**	**27.0**	**15.0**

*PY=Senior staff person years.

As in the Maize Program, the focus of wheat germplasm improvement and crop management research is largely governed by considerations embodied in the mega-environment concept (see Chapter 3). Planning has provided an opportunity for an improvement in congruence, in particular through strengthening attention to the largest spring wheat mega-environment (temperate, irrigated), which had fallen short on resources relative to other environments.

Current resource allocations--Of the Program resources allocated to essential activities, 41% goes to germplasm improvement work, from 6% to 9% goes to each of genetic resources, crop protection, and crop management/physiology, and approximately equal amounts (between 11 and 13%) to training, consulting, and administration (Table 4.5). These relative allocations to activities change somewhat when viewed in terms of total person years (essential, desirable, and other), especially for crop protection and crop management/physiology.

Planned growth and changes to 1994--With respect to reallocations, we are moving five person years from desirable activities to work in essential areas, namely spring bread wheat breeding, genetic resources, septoria resistance, Karnal bunt, and component agronomy. These shifts will bring the total person years allocated to essential activities up to the earlier (1987) "authorized" level of 29 (Table 4.5).

As for growth, we believe it necessary to add three person years to essential work in molecular biology, crop protection, and crop management/physiology, increasing total resource allocations to the essential category from 29 to 32 person years.

In terms of total person years, the changes through 1994 would boost research in genetic resources and crop management/physiology substantially, and research in germplasm improvement and crop protection modestly; training, consulting, and management/administration would change little. As a proportion of total Wheat Program resources, germplasm improvement research would drop slightly. The number of senior staff would increase by 7 (to 42), and a greater proportion of these would be at headquarters. The geographic deployment of outreach positions would not change dramatically, and linkages with key wheat regions would be maintained.

Germplasm improvement--The Wheat Program currently allocates 18.3 person years to work in germplasm improvement. This area is scheduled to grow moderately and we will be seeking a closer correspondence to mega-environment-based priorities.

- *Spring bread wheat:* The bulk of our germplasm improvement resources are allocated to work concentrating on spring wheats for ME1 (temperate, irrigated). This work produces significant spillover benefits for all other mega-environments, especially for ME 2 (high rainfall, temperate). One person year currently allocated to desirable activities will be shifted to headquarters in 1990, adding to the two already in place and thereby boosting research in this essential area. A fourth person year in spring bread wheat is located at ICARDA and is focused on ME 4 (dry, winter rainfall) as part of the CIMMYT/ICARDA collaborative program. A fifth person year is allocated in Southeast Asia, where good potential for wheat exists in poor, largely nontraditional warmer areas. All of this work is classified as essential. Two other regional activities are classed as desirable: Eastern Africa (MEs 2, 1, 5) and the warmer, nontraditional regions of South America (MEs 3 and 5 in Paraguay, Bolivia, Brazil, northern Argentina).

- *Winter and facultative wheats:* Even though these wheats comprise more than 30% of the bread wheat index (Chapter 3), they have been neglected in the past by CIMMYT. Winter wheats from Europe or North America do not satisfactorily fulfill developing world varietal requirements, being either too late or disease susceptible. On the other hand, experience has revealed that selected progeny of winter x spring wheat crossing at our highland site in the Toluca Valley, Mexico, have useful adaptation to these regions. Also the involvement of an international center such as CIMMYT is necessary to facilitate seed and information exchange between developing countries with winter and facultative wheats. For these reasons, we have recently assigned 1.4 person years to improvement work focusing on these materials. These activities are essential. Based on the agreement between CIMMYT and ICARDA, winter wheat work will be carried out in Turkey, Syria, and Mexico.

- *Durum wheat:* This crop rates only about 1/15th the importance of bread wheat on our index, and commonly occupies dry areas of lower yield potential. Durum wheat breeding occurs in Mexico as well as under the auspices of the CIMMYT/ICARDA collaborative agreement. CIMMYT resources allocated to this work are classified as essential.

- *Triticale:* Although still insignificant as a food grain, triticale is important because of the crop's potential in certain stressed environments such as those typified by acid soils, intense foliar disease pressure, or drought stress. Moreover, our unique experience and progress with the crop over the last two decades gives the Center a strong comparative advantage in

triticale improvement. Eight-tenths of a person year is devoted to triticale and is considered the minimum critical mass; this improvement activity is regarded as essential.

- *Barley:* As part of the CIMMYT/ICARDA collaborative agreement, an ICARDA barley breeder was located at CIMMYT/Mexico in 1983. This is not counted here as a Wheat Program activity, but Center staff do service the barley program through their work in international testing and crop protection; such work is incorporated within that devoted to wheat. In turn, ICARDA staff provide such services for the joint CIMMYT/ICARDA program.

- *International testing:* Encompassing all the Wheat Program's crops, international testing constitutes a large and logistically complex task necessary for the distribution of germplasm and the study of genotype x environment interaction. The many opportunities for upstream research related to the latter area of study gave rise to a position for this purpose which was re-allocated from a regional breeder post in 1988. We classify all this work as essential.

- *Industrial quality:* Besides its special significance for durum wheat and triticale, this area has become increasingly important as developing countries approach bread wheat self-sufficiency and demand better quality germplasm and information. Of the resources allocated to this area, 0.4 person year is considered essential.

- *Support to germplasm improvement:* A portion of the efforts of plant pathologists and physiologists in germplasm screening and of agronomists in nursery management are in support of essential germplasm improvement work and, because of their connection with germplasm Improvement, are considered essential themselves.

Genetic resources--The genetic resources activity is currently allocated 3.5 person years and is scheduled to increase substantially, to 6.4 person years by 1994. The work done in wide crosses and that of the gene bank are considered essential; allocations to germplasm enhancement are currently classed as desirable, but under a growth budget would become essential by 1993.

There is considerable potential for the application of biotechnology tools in wheat breeding. We believe a new genetic resources position in this area will be needed by 1990 to facilitate the rapid exploitation of new techniques and to link Program breeders with work in biotechnology. We view such work as essential.

In addition, we feel it is necessary to add one post doc to boost upstream research in this area.

Crop protection--The Wheat Program currently allocates 6.6 person years to crop protection, covering most major wheat diseases. In addition, 35% of their time goes to supporting germplasm improvement. The majority of these resources are devoted to research on the rusts of wheat, though notable allocations are made to leaf blights and barley yellow dwarf virus. This work is classified as essential. Resources are also allocated to research on fusarium head scab (based in Paraguay) and general wheat pathology (in the Andean zone of South America and in the West Asia, North Africa region). The work associated with these allocations is classified largely as desirable. At present, crop protection activities depend heavily on postdoctoral and associate scientist support.

The crop protection activity is scheduled to grow moderately by 1994. Most of this growth will be at headquarters and will strengthen basic research on all major wheat pathogens. This would place the subprogram in a strong position to take advantage of the initial applications of biotechnology, which are likely to be in the area of disease resistance.

Two positions (one from reallocation and one addition) are proposed at headquarters to deal with Karnal bunt (1990) and septoria diseases (1991). While Karnal bunt is a disease of low-to-moderate severity in India, Pakistan, and Mexico, it seriously affects seed movement on a global level and within the CIMMYT breeding program. A professional to pursue genetic and managerial control of this organism is needed immediately. *Septoria tritici* is a major disease in MEs 2 and 3, and progress has been difficult to achieve. Moreover, an additional position dedicated to septoria would free current resources for work on *Helminthosporium* spp., pathogens of growing importance for warmer areas (such as ME 5), and for research on tillage systems aimed at enhancing sustainability (such as crop residue retention). This work is classified as essential.

Soilborne diseases of wheat have been almost entirely neglected by CIMMYT. Fungi, such as *Gaumenomyces graminis* or *Fusarium* spp., and nematodes can have a major effect on productivity. Biotechnology as well as conventional methods offer reasonable prospects of making long awaited progress on genetic resistance; integrated pest management also needs to be explored. An additional desirable soil pathologist position is sought for 1992. Considerable interaction with the growing crop management research on sustaining productivity is foreseen. The work is seen as essential.

The pathology position in the Andean region, a region with a small and stagnant wheat area (< 0.3 million ha), will be transferred to eastern Africa--a key hotspot for rusts, *Septoria* spp., and *Helminthosporium sativum*. Activities would both complement base breeding work for resistance and support weak national programs moving into increased wheat production. Still, this work will be classified as desirable rather than essential. Work in the Andean zone will be done from Mexico.

Crop management/physiology--There are currently 3.7 person years allocated to this activity. In addition, 20% of their time goes to supporting germplasm improvement. About half of the total is assigned to adaptive CMR, nearly all of which is done outside Mexico. All adaptive agronomy is classified as desirable. Strategic CMR focused on sustaining productivity of the rice-wheat cropping system in South Asia (estimated to cover some 9 million ha) was initiated in 1988, and is considered essential work. Finally, crop management training, classified as desirable, consumes a large part of one person year (see training). We also note that ICARDA handles wheat agronomy in the West Asia, North Africa region.

We propose a new strategic CMR position in 1991 at headquarters aimed at producing an expert system for wheat agronomists in ME 1. Crop modelling would be part of this work. As well, another post would be reallocated in 1991 to deal with the physiology of yield determination in wheat, with a long term view toward directing the efforts of molecular biologists onto wheat yield constraints. CIMMYT has a clear comparative advantage when it comes to doing physiological work in the context of a plant breeding program. The work associated with both positions is classified as essential.

Adaptive CMR, considered desirable, would be continued in eastern Africa and in South or Southeastern Asia. In the countries of these regions--representing ME 1, ME 2, and ME 5--wheat is often a nontraditional crop but with good potential. National programs are weak and faced with special agronomic problems such as high temperatures and nutrient deficiencies. In contrast, regional adaptive agronomic work, classified as desirable, is no longer needed in South America due to strong national programs. The regional adaptive agronomist position in South America would therefore be converted by 1992 into a strategic research position on sustaining the region's highly erodible wheat-based cropping systems, especially the predominant wheat-soybean rotation. Finally, we believe it necessary to increase post doctoral scientific support by one position, possibly located with one of the research projects outside Mexico focusing on sustaining productivity.

Training--Most scientific staff currently contribute to training, participating either in formal courses at headquarters on wheat improvement (with a pathology component) and on wheat CMR, in attending to visiting scientists, or in regional courses. As well there are two scientists assigned primarily to training. Most such activities are rated essential, with the exception of entry-level crop management training, for which CIMMYT is not considered to have a unique advantage.

Training resources will change little through 1994 as additional staff in other areas and upstream research create training opportunities that are balanced by reduced training activities for existing staff. There will be a shift toward more specialized training at base in all areas, while the decentralization of CMR training will be tested. If successful, decentralized CMR training will reach more people and contribute more to CIMMYT's mission.

Consulting--Currently most scientific staff--especially subprogram leaders and those located outside Mexico--contribute to essential consulting services with national programs. These activities will decline slightly through to 1994, partly as a result of a greater emphasis on research and partly because of reduced need.

Management/Administration--The 1989 values in Table 4.5 already reflect the recent shift in some administrative load from the director's office to subprogram leaders and liaison persons outside Mexico. It is anticipated that the management/administrative activity will increase very little, even as the Program grows, due to the increased efficiency of the Program's new structure.

Economics Program Resource Allocations

Economics became CIMMYT's third major research program in the early 1970s. There are now 15 international staff (senior staff, associate scientists, and post docs) engaged in various aspects of economics research. Five of these are located at headquarters, and 10 are involved in cooperative research and training activities in 4 regional programs and 3 bilateral projects (serving Mexico, Pakistan, and Haiti). Regional Economics staff are found in Central America and the Caribbean, Eastern Africa, Southern Africa, and Southeast Asia (Tables 4.8 through 4.10).

Program staff engage in a range of activities, including: 1) technology design and evaluation for the development of research methods and the analysis of issues related to sustaining agricultural productivity; 2) the analysis of research resource allocations and impacts, as well as commodity sector analyses, both of which relate to CIMMYT decision making and are also aimed at developing improved methods; 3) training and 4) consulting, both of which largely support national programs in on-farm research.

Table 4.8. Economics Program, human resource allocations to activities, 1989-94.

	1989			Reallocations[a]			1994[b]		
	E	D	O	E	D	O	E	D	O
Germplasm improvement									
Total (person yrs)	0.7	0.0	0.0	2.3	0.0	0.5	2.3	0.0	0.5
% of Program resources	18	0	0	33	0	25	29	0	25
Crop management and physiology									
Total (person yrs)	0.9	1.5	0.2	1.1	0.3	0.5	1.5	0.3	0.5
% of Program resources	24	16	10	16	5	25	19	5	25
Economic analysis									
Total (person yrs)	1.2	1.4	1.0	2.3	2.0	1.0	2.9	2.0	1.0
% of Program resources	32	15	50	33	33	50	36	33	50
Training									
Total (person yrs)	0.2	3.4	0.5	0.5	1.7	0.0	0.5	1.7	0.0
% of Program resources	5	37	25	7	28	0	6	28	0
Consulting									
Total (person yrs)	0.0	2.4	0.3	0.0	1.5	0.0	0.0	1.5	0.0
% of Program resources	0	26	15	0	25	0	0	25	0
Management/Administration									
Total (person yrs)	0.8	0.5	0.0	0.8	0.5	0.0	0.8	0.5	0.0
% of Program resources	21	5	0	11	8	0	10	8	0
Grand total (person yrs)	**3.8**	**9.2**	**2.0**	**7.0**	**6.0**	**2.0**	**8.0**	**6.0**	**2.0**

E = essential Senior Staff; D = desirable Senior Staff; and O = postdoctoral fellows, associate scientists, and associate staff.

[a]Reallocated total essential person years are equal to 1987 TAC-approved positions (this column shows reallocations among activities and from desirable to essential activities, holding total human resources at present approved levels).

[b]Final human resource allocations, including additional essential positions.

Table 4.9. Economics Program, breakdown by year of shifts in human resource allocations to activities and projects, 1989-94.

	Changes																	
	1989			1990			1991			1992			1993			1994		
Activity/Project	E	D	O	E	D	O	E	D	O	E	D	O	E	D	O	E	D	O
Germplasm improvement																		
Information and analysis	0.7	–	–	0.8	–	–	0.2	–	0.5	0.6	–	0.0	–	–	0.0	2.3	0.0	0.5
Total (person yrs)	0.7	0.0	0.0	1.5	0.0	0.0	1.7	0.0	0.5	2.3	0.0	0.5	2.3	0.0	0.5	2.3	0.0	0.5
% of Program resources	18	0	0	23	0	0	24	0	25	29	0	25	29	0	25	29	0	25
Crop management and physiology																		
Adaptive CMR	0.6	1.5	0.2	-0.1	-0.3	0.3	0.0	-0.3	–	–	-0.5	–	–	-0.3	–	0.5	0.0	0.5
Strategic CMR	0.3	–	–	0.3	–	–	0.2	–	–	0.2	–	–	0.0	0.3	–	1.0	0.3	0.0
Total (person yrs)	0.9	1.5	0.2	1.1	1.2	0.5	1.3	0.9	0.5	1.5	0.4	0.5	1.5	0.4	0.5	1.5	0.3	0.5
% of Program resources	24	16	10	17	18	25	19	14	25	19	7	25	19	7	25	19	5	25
Economic analysis																		
Policy issues in technology utilization	–	1.0	–	–	–	–	–	0.2	–	–	0.1	–	–	0.1	–	0.0	1.4	0.0
Research resource allocations and impacts	0.6	0.4	0.8	0.7	–	-0.1	–	0.1	-0.3	0.1	–	-0.1	–	0.1	0.1	1.4	0.6	0.5
Commodity analysis	0.6	–	0.2	0.7	–	-0.2	0.1	–	0.2	0.1	–	0.2	–	–	0.2	1.5	0.0	0.5
Total (person yrs)	1.2	1.4	1.0	2.6	1.4	0.7	2.7	1.7	0.6	2.9	1.8	0.7	2.9	2.0	1.0	2.9	2.0	1.0
% of Program resources	32	15	50	40	21	35	39	27	30	36	31	35	36	33	50	36	33	50
Training																		
Production	–	3.2	0.5	–	-1.2	0.1	–	-0.6	-0.2	–	-0.1	-0.1	–	-0.1	-0.3	0.0	1.2	0.0
Specialized courses	–	0.2	–	–	–	–	–	0.2	–	–	–	–	–	0.1	–	0.0	0.5	0.0
Visiting scientists	0.2	–	–	0.3	–	–	–	–	–	–	–	–	–	–	–	0.5	0.0	0.0
Total (person yrs)	0.2	3.4	0.5	0.5	2.2	0.6	0.5	1.8	0.4	0.5	1.7	0.3	0.5	1.7	0.0	0.5	1.7	0.0
% of Program resources	5	37	25	8	32	30	7	28	20	6	29	15	6	28	0	6	28	0
Consulting	–	2.4	0.3	–	-0.9	-0.1	–	–	-0.2	–	–	–	–	–	–	0.0	1.5	0.0
Total (person yrs)	0.0	2.4	0.3	0.0	1.5	0.2	0.0	1.5	0.0	0.0	1.5	0.0	0.0	1.5	0.0	0.0	1.5	0.0
% of Program resources	0	26	15	0	22	10	0	23	0	0	25	0	0	25	0	0	25	0
Management/Administration		0.8	0.5	–	–	–	–	–	–	–	–	–	–	–	–	–	0.8	0.5
Total (person yrs)	0.8	0.5	0.0	0.8	0.5	0.0	0.8	0.5	0.0	0.8	0.5	0.0	0.8	0.5	0.0	0.8	0.5	0.0
% of Program resources	21	5	0	12	7	0	11	8	0	10	8	0	10	8	0	10	8	0
Grand total (person yrs)	3.8	9.2	2.0	6.5	6.8	2.0	7.0	6.4	2.0	8.0	5.9	2.0	8.0	6.1	2.0	8.0	6.0	2.0

E = essential Senior Staff; D = desirable Senior Staff; and O = postdoctoral fellows, associate scientists, and associate staff.

Table 4.10. Economics Program human resource allocations between headquarters and outreach, by activity (Essential + Desirable)

	1989		1994	
	Headquarters PY*	Outreach PY*	Headquarters PY*	Outreach PY*
Germplasm improvement	0.4	0.3	1.5	0.8
Crop management and physiology	0.2	2.2	0.2	1.6
Economic analysis	0.6	2.0	1.5	3.4
Training	0.3	3.3	0.2	2.0
Consulting	0.5	1.9	0.6	0.9
Management/Administration	1.0	0.3	1.0	0.3
Total	**3.0**	**10.0**	**5.0**	**9.0**

*PY=Senior staff person years.

All these activities are relevant to fulfilling the Center's mission. After applying the general framework for distinguishing essential and desirable activities, however, especially the low cost criterion, we now believe that the first two sets of activities are essential while training and consulting are largely desirable.

This conclusion is reinforced by an assessment of changes in the environment of agricultural research and how those changes will affect the research emphases of the Program, as well as its selection of clients. First, on-farm research, which has received the bulk of Program resources in the past, will receive fewer resources, especially for training and consulting. This reduction reflects the availability of alternative sources of supply in this area. Second, national program economists rather than agronomists are expected to become the Program's primary clients as the number of national program economists, presently low, continues to grow. Third, research managers at CIMMYT and in national programs are increasingly required to justify research priorities and to document the productivity of research expenditures. One result of this trend will be a growing demand for information and analysis on research priorities and evaluating the impacts of research. Finally, many countries are experiencing substantial shifts in relative wheat and maize prices and demand because of policy reforms instituted as part of the structural adjustment programs of the 1980s. These changes in the macro-economic environment will have important implications for agricultural research systems into the 1990s.

These changes imply a shift in emphasis away from adaptive and toward applied/strategic research, as reflected in the projected resource allocations (Table 4.8). Some on-farm research will be required for capturing farmers' perspectives in the design, evaluation, and use of technology, but future on-farm research will generally concentrate on strategic issues related to the development of improved methods, on empirical estimates of parameters for assessing new technologies, and on issues of sustainability. The highest priority of the Program will continue to be technology design and evaluation, which is included in the budget under "germplasm improvement" and "crop management research."

Current resource allocations--In 1989, a large share of Program resources are allocated to training (4.1 person years) and consulting (2.7 person years). Germplasm improvement and crop management and physiology currently receive a total of 3.3 person years. Various projects grouped under the heading "economic analysis" receive a total of 3.6 person years, while management/administration is allocated 1.3 person years. As indicated above, however, a significant reallocation of resources will occur by 1994.

Planned growth and changes to 1994--We believe that over the five years covered by this plan, regional organizations and national programs themselves will be able to assume much of the responsibility for training and support to national programs in on-farm research. Furthermore, we believe our cost advantage lies with technology design and evaluation, and with work related to research resource allocations and commodity sector analyses. These areas of research are strengthened considerably in the five-year allocations (Table 4.8).

Germplasm improvement-related work--Providing information and analysis for varietal development in CIMMYT and national programs is a relatively new area for the Program, one that we consider essential and one requiring a sharp increase in resources. Examples of this research include: evaluating the potential of triticale and quality protein maize as food and feed in selected environments; channeling back to breeding programs the results of on-farm research on farmers' preferences for grain type, marketing characteristics, and other varietal traits; and evaluating losses to specific pests and analyzing strategies for reducing those losses. Person years will increase from 0.7 to 2.8, with 2.3 considered essential.

Crop management research--Over the past decade CIMMYT has gradually increased its commitment to CMR by adding agronomists to its crops programs and strengthening the Economics Program. In the next five years, Economics Program staff will collaborate further with Maize and Wheat Program scientists as they take the lead on strategic crop management research, for example on maize-based systems on steep, eroded hillsides in Central America, and on rice-wheat systems in Asia. Note that although essential resource allocations to crop management research will increase from 0.9 to 1.5 staff years, total resource allocations will decline slightly over the budget period, as germplasm improvement and economic analysis receive more emphasis.

Economic analyses--CIMMYT devotes a small but increasingly important proportion of its resources, mainly in the Economics Program, to the study of policy issues in technology utilization, studies of research resource allocation and impacts, and commodity sector and policy analysis. The relative importance of all three types of studies is expected to grow, with a total increase of some 2.3 person years between 1989 and 1994. Much of this work is considered essential and is concentrated in the areas of research resource allocation and commodity sector studies.

- *Policy issues in technology utilization:* Adoption and utilization of improved technology is still often constrained by the policy/institutional environment. Hence, studies of policy issues related to technology utilization will be conducted by social scientists in national programs in collaboration with

CIMMYT economists and will focus mostly on constraints to the supply and delivery of inputs at the farm level. During the next five years the Program will evaluate the usefulness of this research and identify appropriate methods for analyzing policy issues in technology utilization. The Program will also initiate a limited research program on issues related to technology transfer, in most cases undertaken as PhD theses.

- *Research resource allocation and impacts:* Decisions about research resource allocations are made between commodities; between regions/environments for a given commodity; between basic, applied, maintenance, and adaptive research; between germplasm improvement and crop management research; and between problem areas for a given commodity. Among national programs, major clients for studies of research resource allocation will be found at the subnational level--regional research directors who allocate research resources across commodities within a region, or national maize and wheat coordinators who are charged with allocating maize/wheat research resources across regions. CIMMYT's involvement is conditional on strong interest and participation by national program scientists; the product of this joint work will be improved methods of research resource allocation that can be applied readily by national programs.

  Within the Center, the Program will continue to provide information and analysis as requested by the Maize and Wheat Programs to aid in their resource allocation decisions. Our work will be closely coordinated with that of other centers, especially ISNAR, who is developing methods for research resource allocation at the national and global levels.

  The analysis of research impacts will treat two major themes: 1) the productivity of specific types of research and 2) the impacts of research and technological change on the poor. Greater emphasis in the future on problem environments, where gains are likely to be much slower, will require a more careful analysis of returns to research. In addition, studies of research productivity have nearly always emphasized plant breeding and have provided little information on returns to other types of research important to CIMMYT, especially "maintenance" research and CMR. A modest effort will be made to improve estimates of returns to other types of research (much of the analysis will be done as PhD theses). This work, which looks at returns to past research investments, will be closely integrated with work on research resource allocations, which analyzes potential research investments.

Studies of the potential impact of maize and wheat research on the poor have been initiated. Much of this research will focus on the distributional consequences of technological change at the macro-level to determine how poor producers and consumers might benefit from research aimed specifically at marginal environments, compared with the indirect benefits to the poor that might result from research aimed at favored environments (e.g., through labor market effects or lower food prices). Initial work will focus on countries that have seen rapid technological change in food grains in the past two decades.

- *Commodity sector and policy analyses:* These analyses cover all aspects of long-term trends in demand and supply for maize and wheat (including policy influences) that have a bearing on agricultural research decision making, whether at CIMMYT or in national programs. Recent major changes in world grain markets and widespread policy reforms instituted by many countries in the 1980s have increased the complexity of the environment in which research managers must allocate resources and establish priorities. In the case of maize, many countries (especially in Asia) are seeing a rapid switch in demand from food to feed that needs to be addressed by researchers. Likewise, the potential of wheat in nontraditional environments, such as sub-Saharan Africa, is a major research and policy issue in a number of countries. Research planners will require more information to interpret long-term trends in the wheat and maize economies at the global and national levels, as well as information about the policies that shape those trends.

  The growing need for commodity sector and policy analyses within national programs and in CIMMYT is reflected in an increase in resource allocations of 0.9 person years between 1989 and 1994. This research, which we consider essential, will produce both specific studies at the national, regional, and global levels, and also improved methods for undertaking these studies.

Training--Most of the resources devoted to training are in the desirable category and reflect current commitments to on-farm research training in Africa and Central America. This allocation will be reduced over the budget period from 3.4 to 1.7 staff years as those commitments decrease. Training resources allocated to the essential category will grow slightly from 0.2 to 0.5 staff years as funding for Visiting Economists, who will work on projects of common interest to CIMMYT and national programs, is increased.

Consulting--Resources allocated to this activity will decline by just over one staff year and all of this activity will be classed as desirable. The largest decrease will

occur in Africa with the end of the USAID training project, which includes many workshops and similar activities supporting national programs. In the future, greater emphasis will be placed on consulting with economists in national programs, rather than biological scientists.

Management/Administration--The Economics Program foresees no change in its resource allocations to management and administration.

Research Support and Administration

Research Support--Research Support includes biometrics, biotechnology, data processing, experiment stations, information services, laboratories, and seed health. In 1989 there were 12 senior staff (all among the "authorized" positions) and 11 associates and postdoctorals (Table 4.11). All are engaged in essential activities with some of the funding from extra core projects. For 1994 we anticipate 15 international staff members and 17 associates and postdoctorals, again all in essential activities and, again, some to be financed through extra-core funding. The following paragraphs briefly discuss the needs of each unit.

Biometrics--The increased emphasis on research will require additional support in the form of biometric analysis. Thus, biometrics shows an increase of one international staff year during the planning period.

Biotechnology--We believe that new initiatives in this area require in-house capabilities and laboratory facilities, and are currently establishing a biotechnology laboratory complex that will include a molecular genetics laboratory, together with tissue culture and cytogenetics. The Center's strategy regarding biotechnology is to test and adapt techniques and applications developed through basic science and, when appropriate, incorporate these into our breeding programs and assist in their transfer to developing countries. We will also encourage collaborative research in the development and testing of new gene technologies.

We currently have one core-funded international position year in biotechnology, well below anticipated demands and the needed critical mass of research talent. Biotechnology is scheduled for an increase of one senior staff year and five postdoctoral and associate scientist person years.

Data processing--It is anticipated that data processing services, especially those relating to data management, will become increasingly important during the next five years. We expect to meet most demands for staff through the national market. Even so, because of the increase in the scale of operations and the almost international

Table 4.11. Research Support, breakdown by year of shifts in human resource allocations to section units, 1989-94.

				Changes														
	1989			1990			1991			1992			1993			1994		
Unit	E	D	O	E[a]	D	O	E	D	O	E	D	O	E	D	O	E	D	O
Experiment stations	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4	0	0
Data processing	1	–	3	1	–	–	–	–	–	–	–	–	–	–	–	2	0	3
Laboratories	1	–	2	-1	–	–	–	–	–	–	–	–	–	–	–	0	0	2
Biotechnology	1	–	–	–	–	2	1	–	2	–	–	1	–	–	–	2	0	5
Seed health	1	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1	0	1
Biometrics	1	–	1	1	–	–	–	–	–	–	–	–	–	–	–	2	0	1
Information	3	–	5	–	–	–	1	–	–	–	–	–	–	–	–	4	0	5
Grand total	12	0	11	13	0	14	15	0	16	15	0	17	15	0	17	15	0	17

E = essential Senior Staff; D = desirable Senior Staff; and O = postdoctoral fellows, associate scientists, and associate staff.

[a]Shows reallocations among research support units, as well as a shift of one position from administration to research support, which occur in 1990.

character of the local market for professionals, we are adding one position at the senior level.

Experiment Stations--No change is contemplated in the international staff for the experiment stations. However, we anticipate some differences in the allocation of the energies of the staff. In particular, we see the need to develop one and perhaps two new facilities. One of these is a new mid-altitude station for maize. The station currently used does not offer the desired spectrum of disease pressures and better suited sites are available in Mexico. The second case may or may not arise, depending on developments at our Toluca station where disease and drainage problems seem likely to limit our work in the future. Developing these facilities will absorb a significant amount of staff time; we expect to cover these requirements through a reduction in some administrative responsibilities now assigned to station staff. Anticipated capital costs are included in the capital budget found in Chapter 5.

Information services--Work in this area is also seen to be of growing importance as we add emphasis to research and as the information needs of national programs change. It is anticipated that productivity gains from the use of new information technologies will offset some of the growth in demand for services. Even so, we see clear advantage in adding one senior position to this unit over the budget period.

Laboratories--The future of CIMMYT's laboratories is highly dependent upon directions taken by the programs they support. We expect a decline from the current three international staff positions to two such positions. The activities of laboratory staff are not expected to change as a result of this shift, though the volume of work will be reduced somewhat.

Seed health--The primary function of the seed health unit is to ensure that incoming and outgoing experimental seed is disease free and properly treated to protect against seed-borne pathogens. As well we expect to contribute to the growing dialogue on seed health through an expansion in our research in the area. We therefore anticipate an increase of one postdoctoral person year during the planning period. We have budgeted for the necessary scientific apparatus (Chapter 5).

Administration--Included here are the office of the Director General, finance, administration, and training coordination. We project a reduction of one position, that of training coordinator (Table 4.12). The current position's administrative, logistical, and trainee support functions will be taken over by local staff and the coordinating role itself will go to the DDG of Research, assisted by each program's training supervisor. Two new positions--one in human resources and

one to assist the DG's office and the Board of Trustees--were added in early 1989 at the suggestion of the External Management Review panel.

Table 4.12. Administration, breakdown by year of shifts in human resource allocations, 1989-94.

				Changes														
	1989			1990			1991			1992			1993			1994		
Unit	E	D	O	E	D	O	E	D	O	E	D	O	E	D	O	E	D	O
General administration	8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	8	0	0
Training coordination	1	–	–	-1	–	–	–	–	–	–	–	–	–	–	–	0	0	0
Grand total	9[a]	0	0	8	0	0	8	0	0	8	0	0	8	0	0	8	0	0

E = essential Senior Staff; D = desirable Senior Staff; and O = postdoctoral fellows, associate scientists, and associate staff.

[a]Equal to seven 1987 TAC-approved positions plus two positions recommended by the 1988 External Management Review.

Chapter 5

Capital

CIMMYT has $21 million of capital on its balance sheet, of which $10 million is fixed capital and $11 million is machinery, equipment, and vehicles. In view of the Center's aging physical plant and the fact that capital expenditures are a significant portion of the budget, in 1987 CIMMYT formed a Standing Committee on Capital to plan capital needs in the context of a five-year horizon. The Committee makes recommendations to management on the level and composition of the annual capital budget.

Essential Capital

Capital expenditures considered to be essential are replacement of most existing capital equipment and additions required to support essential research activities. The plan anticipates a reduction in the size of capital inventory over the five-year period.

Capital replacements--Capital replacement requirements were determined for each category of asset using the existing capital base as a starting point.

Replacements of field, laboratory, office, and vehicles are assumed to occur evenly over the period. Computer equipment replacements are higher in the earlier years because of replacement of components of the mainframe system in 1991 and of terminals with PCs over the 1990-1992 period (Table 5.1).

Table 5.1. Capital replacements, 1990-94 ($000's)

	Inventory Cost	Net Replacement Cost				
		1990	1991	1992	1993	1994
Field	2,900	330	330	330	330	330
Laboratory	1,170	130	130	130	130	130
Office	675	75	75	75	75	75
Vehicle	3,710	700	700	700	700	700
Computer	2,685	515	450	320	170	170
Total capital replacements		1,750	1,685	1,555	1,405	1,405

Although CIMMYT has made every effort to keep its fixed plant facilities well-maintained, the age of these facilities (most are at least fifteen years old) implies rising maintenance costs and potential major repair expenditures. The capital replacement fund was started in 1986 to cover the latter financial exposure. In that year, $400,000 was contributed to the fund. CIMMYT intends to add $200,000/year to the fund until it reaches a maximum of $1,000,000.

Capital additions--Capital additions are categorized as equipment or buildings/land (Table 5.2).

Equipment

- Maize physiology/agronomy. Additional equipment is required to support the higher level of this research activity. The most expensive item will be a gas-powered drier for whole plants.

- Biotechnology. Equipment is budgeted for the Wheat and Maize Programs to integrate the RFLP research and other similar biotechnology activities into the programs.

- Seed health. The seed health unit was split out from the Wheat Program in 1989. Laboratory equipment is budgeted to complete the equipment needed for the unit.

- Audio visual. This equipment is required for the development of training materials.

- Computer. Computer additions included equipment to network PCs to the mainframe ($160,000 over four years) and processors to expand capacity on the mainframe.

- Unidentified. Expenditures on new capital equipment over the past five years are estimated to have been $300,000 per year. We expect that level of expenditure to continue in the future but have not yet specifically identified all needs.

Buildings/land

- Maize mid-altitude experiment station. As pointed out by the EPR and our strategic plan, an additional maize mid-altitude station allowing two crop seasons per year and good disease screening potential is a priority item for CIMMYT. The Maize Program is currently searching for a

suitable 25-30 ha. facility. The projected cost of the land is $10,000/ha.; improving and equiping the facility are estimated to cost $400,000.

- Wheat high-altitude experiment station. Because of the quarantine on the Toluca experiment station, the budget includes development costs and rental of an alternate site on a short-term basis.

- Greenhouses. Costs for the construction of two greenhouses are included in the budget. The first would house seed health activities which must be physically separated from other greenhouse activities. The second would house maize/wheat physiology activities. Stricter quarantine regulations may require isolation of incoming materials and would require more greenhouse space. This item has not been included now.

- Germplasm bank. Included in the budget are provisions for a maize long-term preservation facility, an extension to the maize medium-term storage facility, and a long-term wheat storage facility. Improved facilities were recommended by the EPR.

- Unidentified. The building and land expenditures during the first years of the plan are specifically identifiable. We do not expect that level of expenditure to continue over the five-year period. We do however, expect that there will be expenditures which cannot be identified at this time and an appropriate provision is made.

Desirable Capital

Equipment

- Biotechnology equipment. Construction of the biotechnology laboratory was initiated in 1988 and will be completed in 1989. CIMMYT is funding the construction and equiping of the laboratory largely through special project funding. Final equipment needs will not be known until the construction is completed and research is started. Recognizing that there may be additional equipment needs that are not currently identified as essential we are including $200,000 under desirable capital in 1990.

- Other. Unidentified capital requirements to support desirable activities are included at $50,000 per year.

Table 5.2. Capital additions, 1990-94 ($000's).

	1990	1991	1992	1993	1994
Equipment					
Maize Physiology/Agronomy	55	–	–	–	–
Biotechnology	–	65	65	–	–
Seed Health	80	–	–	–	–
Audio Visual	50	–	–	–	–
Computer	40	30	180	30	180
Unidentified	75	205	55	270	120
Sub-total	**300**	**300**	**300**	**300**	**300**
Buildings/land					
Maize mid-altitude experiment station	400	300	–	–	–
Wheat high-altitude experiment station	150	50	50	50	–
Seed health greenhouse	–	100	–	–	–
Physiology greenhouse	–	–	150	–	–
Germplasm bank	50	250	–	–	–
Unidentified	–	–	100	150	200
Sub-total	**600**	**600**	**300**	**200**	**200**
Total capital additions	**900**	**900**	**600**	**500**	**500**

Table 5.3. Total capital budget, 1990-94 ($000's).

	1990	1991	1992	1993	1994
Replacement					
Equipment	1,750	1,685	1,555	1,405	1,405
Buildings (Building fund)	200	200	200	200	200
Additional					
Equipment	300	300	300	300	300
Buildings	600	600	300	200	200
Total	2,850	2,785	2,355	2,105	2,105

Table 5.4. Desirable capital, 1990-94 ($000's).

	1990	1991	1992	1993	1994
Additional equipment	250	50	50	50	50

Chapter 6

Budget

The funding requested to cover 1990 essential activities is at the level of core funding authorized for 1989. Even so, the total requirement for 1990 (essential plus desirable) is $1.7 million or 5.2% above 1989 due to the anticipated growth in person years. The 1990 desirable activities include some work which was core funded in 1989 and which must be continued until an orderly shift in program activities can be made. Desirable activities in 1990 are $1.7 million more than the 1989 special projects and this represents a potential shortfall unless additional funds are allocated. Desirable activities will reduce through 1993 as the internal shifts from desirable to essential activities are completed.

Over the five-year period 1990-1994, essential activity costs increase 11.3%, desirable activity costs decrease by 17.7%, and the total costs increase 4.7%. This is substantially less than the proposed increase in international staff positions and underscores the management objective of increasing operating efficiency.

Cost Assumptions

Staff--The 1989 budget was used as a base for calculating standard cost per senior staff person year. Senior staff is defined as staff internationally recruited, with a PHD and/or relevant international experience. Other staff categories that are internationally recruited are post docs and associate scientists.

Standard costs vary between programs and activities. For budgeting purposes costs determined by program at the activity level were applied to senior staff person years to estimate financial requirements for 1990-1994. The average cost per senior staff year is $277,000 in 1989 and $275,000 in 1994. The composition of that cost is 34% senior staff salaries and benefits, 18% support staff salaries and benefits, and 48% operational and other costs.

Research Support--Costs related to the experiment stations, laboratories, seed health, and data processing services were proportionally allocated to appropriate activities. Experimental stations costs include a net increase in 1991 and 1992 for operational costs of the maize mid-altitude experiment station. Cost increases in the other units are based on staff additions. Operating efficiencies are expected to offset any real cost increases over the period 1992 through 1994, where costs are held constant.

The projected growth in the biotechnology unit is reflected in research support, making it the highest growth area within CIMMYT over the plan period.

Administration and Operations--Administration costs shown in the budget include both the administration within the programs and general administration. General administration costs were assumed constant in real terms over the period while program administration costs were a function of person years. Plant operations costs were also held constant over the period. We expect efficiencies in operations to allow for the higher level of service required to support the additional program activities planned.

Inflation/Exchange Rates--CIMMYT experienced high levels of dollar-denominated inflation during 1987 and 1988. Such inflation is not expected to continue over the period of this plan. A 5% inflation and exchange rate factor is included in the budget, with the assumption that higher levels of dollar-denominated inflation will be compensated through the stabilization fund.

Working capital--CIMMYT currently has a balance of $2,765,000 in its operating fund, representing 38 days of working capital. The five-year budget includes required additions based on increased costs, and additions to bring the level of working capital to 45 days.

	($000's)				
	1990	1991	1992	1993	1994
Operating fund beginning	2,765	2,968	3,500	3,881	4,189
Working capital additions	203	532	381	308	311
Operating fund end balance	2,968	3,500	3,881	4,189	4,500

Budget tables

Tables 6.1 through 6.10 follow. The first three tables present budget requirements in dollars for all of CIMMYT over the period 1990 through 1994 for essential, desirable, and essential plus desirable categories. Tables 6.4 through 6.7 present budget requirements in person years and dollars at the activity level for each program. The next two tables compare core and special project funding and positions to essential and desirable. The last table lists CIMMYT activities compared to TAC activities.

Table 6.1. CIMMYT, budget for essential activities, 1989-94 ($000's).

Activity	1989	1990	1991	1992	1993	1994
Germplasm improvement	7,783	8,145	8,461	8,767	8,767	8,767
Genetic resources	1,302	1,920	2,667	2,850	3,026	3,026
Crop protection	1,659	1,920	2,200	2,683	2,683	2,683
Crop management and physiology	1,157	1,361	1,968	2,199	2,229	2,229
Economic analysis	227	476	494	531	531	531
Training	2,470	2,560	2,566	2,771	2,771	2,771
Information	1,346	1,304	1,454	1,454	1,454	1,454
Consulting	439	422	427	375	375	375
Subtotal	16,383	18,108	20,237	21,630	21,836	21,836
Management/Administration*	6,028	6,091	6,091	6,091	6,091	6,091
Indirect costs	–600	–600	–600	–600	–600	–600
Total operating	**21,811**	**23,599**	**25,728**	**27,121**	**27,327**	**27,327**
Capital (additions)	1,150	900	900	600	500	500
(replacements)	2,893	1,950	1,885	1,755	1,605	1,605
Total (operating & capital)	**25,854**	**26,449**	**28,513**	**29,476**	**29,432**	**29,432**
Working capital	0	203	532	381	308	311
Inflation/exchange rates	0	1,322	2,814	4,429	6,122	7,899
Total Essential	**25,854**	**27,974**	**31,859**	**34,286**	**35,862**	**37,642**
Sources of funds						
Interest & other income	183	250	250	250	250	250
Funds required from Donors	**25,671**	**27,724**	**31,609**	**34,036**	**35,612**	**37,392**

*Includes program administration and general administration.

Table 6.2. CIMMYT, budget for desirable activities, 1989-94 ($000's).

Activity	1989	1990	1991	1992	1993	1994
Germplasm improvement	597	509	509	509	509	509
Genetic resources	176	176	176	176	0	0
Crop protection	461	423	423	423	423	423
Crop management and physiology	1,430	1,660	1,594	1,542	1,520	1,559
Economic analysis	256	256	311	329	366	366
Training	2,889	3,098	2,749	2,197	2,156	2,156
Information	–	–	–	–	–	–
Consulting	652	337	268	268	268	268
Subtotal	6,461	6,459	6,030	5,444	5,242	5,281
Management/Administration*	489	473	473	473	473	473
Indirect costs	600	600	600	600	600	600
Total operating	**7,550**	**7,532**	**7,103**	**6,517**	**6,315**	**6,354**
Capital (additions)	–	250	50	50	50	50
(replacements)	–	–	–	–	–	–
Total (operating & capital)	**7,550**	**7,782**	**7,153**	**6,567**	**6,365**	**6,404**
Working capital	–	–	–	–	–	–
Inflation/exchange rates	–	389	766	1,133	1,508	1,903
Total desirable	**7,550**	**8,171**	**7,919**	**7,700**	**7,873**	**8,307**
Sources of Funds	–	–	–	–	–	–
Interest & Other income	–	–	–	–	–	–
Funds required from donors	**7,550**	**8,171**	**7,919**	**7,700**	**7,873**	**8,307**

*Includes program administration and general administration

Table 6.3. CIMMYT, budget for essential + desirable activities, 1989-94 ($000's).

Activity	1989	1990	1991	1992	1993	1994
Germplasm improvement	8,380	8,654	8,970	9,276	9,276	9,276
Genetic resources	1,478	2,096	2,843	3,026	3,026	3,026
Crop protection	2,120	2,343	2,623	3,106	3,106	3,106
Crop management and physiology	2,587	3,021	3,562	3,741	3,749	3,788
Economic analysis	483	732	805	860	897	897
Training	5,359	5,658	5,315	4,968	4,927	4,927
Information	1,346	1,304	1,454	1,454	1,454	1,454
Consulting	1,091	759	695	643	643	643
Subtotal	22,844	24,567	26,267	27,074	27,078	27,117
Management/Administration*	6,517	6,564	6,564	6,564	6,564	6,564
Total operating	**29,361**	**31,131**	**32,831**	**33,638**	**33,642**	**33,681**
Capital (additions)	1,150	1,150	950	650	550	550
(replacements)	2,893	1,950	1,885	1,755	1,605	1,605
Total (operating & capital)	**33,404**	**34,231**	**35,666**	**36,043**	**35,797**	**35,836**
Working capital	0	203	532	381	308	311
Inflation/exchange rates	0	1,712	3,580	5,562	7,630	9,803
Total Essential + Desirable	**33,404**	**36,146**	**39,778**	**41,986**	**43,735**	**45,950**
Sources of funds	–	–	–	–	–	–
Interest & other income	183	250	250	250	250	250
Capital fund	700	–	–	–	–	–
Funds required from Donors	**32,521**	**35,896**	**39,528**	**41,736**	**43,485**	**45,700**

* Includes program administration and general administration.

Table 6.4. Maize Program budget, 1989-94

Activities	1989		1990		1991		1992		1993		1994	
	PY*	$000s	PY	$000s	PY	$000s	PY	$000s	PY	$000s	PY	$000s
Essential												
Germplasm improvement	14.3	2,945	14.5	2,986	14.9	3,069	15.2	3,130	15.2	3,130	15.2	3,130
Genetic resources	1.8	300	2.2	367	3.5	583	3.6	600	3.6	600	3.6	600
Crop protection	1.8	515	2.0	572	2.0	572	3.0	858	3.0	858	3.0	858
Crop management and physiology	2.6	508	3.6	703	3.9	762	4.4	860	4.4	860	4.4	860
Training	2.5	1,012	2.7	1,093	2.7	1,093	3.2	1,295	3.2	1,295	3.2	1,295
Consulting	2.0	231	2.0	231	2.0	231	1.6	185	1.6	185	1.6	185
Management/Administration	3.0	770	3.0	770	3.0	770	3.0	770	3.0	770	3.0	770
Total	**28.0**	**6,281**	**30.0**	**6,723**	**32.0**	**7,080**	**34.0**	**7,699**	**34.0**	**7,699**	**34.0**	**7,699**
Desirable												
Germplasm improvement	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Genetic resources	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Crop protection	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Crop management and physiology	3.5	684	3.5	684	3.5	684	3.8	743	3.8	743	4.0	782
Training	2.7	1,093	4.2	1,700	3.6	1,457	2.3	931	2.3	931	2.3	931
Consulting	2.1	242	0.6	69	0.0	0	0.0	0	0.0	0	0.0	0
Management/Administration	0.7	180	0.7	180	0.7	180	0.7	180	0.7	180	0.7	180
Total	**9.0**	**2,199**	**9.0**	**2,633**	**7.8**	**2,321**	**6.8**	**1,853**	**6.8**	**1,853**	**7.0**	**1,892**
Essential + Desirable	**37.0**	**8,480**	**39.0**	**9,356**	**39.8**	**9,401**	**40.8**	**9,552**	**40.8**	**9,552**	**41.0**	**9,591**

*PY = person years

Table 6.5. Wheat Program budget, 1989-94

Activities	1989		1990		1991		1992		1993		1994	
	PY*	$000s	PY	$000s	PY	$000s	PY	$000s	PY	$000s	PY	$000s
Essential												
Germplasm improvement	9.8	2,168	11.0	2,433	11.6	2,566	12.1	2,677	12.1	2,677	12.1	2.677
Genetic resources	2.2	431	3.2	627	3.2	627	3.2	627	4.1	803	4.1	803
Crop protection	1.9	730	2.5	960	3.2	1,229	3.7	1,421	3.7	1,421	3.7	1,421
Crop management and physiology	1.4	415	1.4	415	3.1	919	3.4	1,008	3.5	1,038	3.5	1,038
Training	2.7	1,102	2.7	1,102	2.7	1,102	2.7	1,102	2.7	1,102	2.7	1,102
Consulting	2.8	87	2.8	87	2.8	87	2.5	78	2.5	78	2.5	78
Management/Administration	3.2	698	3.4	742	3.4	742	3.4	742	3.4	742	3.4	742
Total	**24.0**	**5,631**	**27.0**	**6,366**	**30.0**	**7,272**	**31.0**	**7,654**	**32.0**	**7,860**	**32.0**	**7,860**
Desirable												
Germplasm improvement	2.7	597	2.3	509	2.3	509	2.3	509	2.3	509	2.3	509
Genetic resources	0.9	176	0.9	176	0.9	176	0.9	176	0.0	0	0.0	0
Crop protection	1.2	461	1.1	423	1.1	423	1.1	423	1.1	423	1.1	423
Crop management and physiology	1.4	415	2.4	711	2.4	711	2.4	711	2.4	711	2.4	711
Training	2.2	898	2.0	817	2.0	817	2.0	817	1.9	776	1.9	776
Consulting	1.6	50	1.4	43	1.4	43	1.4	43	1.4	43	1.4	43
Management/Administration	1.0	212	0.9	196	0.9	196	0.9	196	0.9	196	0.9	196
Total	**11.0**	**2,809**	**11.0**	**2,875**	**11.0**	**2,875**	**11.0**	**2,875**	**10.0**	**2,658**	**10.0**	**2,658**
Essential + Desirable	**35.0**	**8,440**	**38.0**	**9,242**	**41.0**	**10,147**	**42.0**	**10,530**	**42.0**	**10,518**	**42.0**	**10,518**

*PY = person years

Table 6.6. Economics Program budget, 1989-94

Activities	1989		1990		1991		1992		1993		1994	
	PY*	$000s	PY	$000s	PY	$000s	PY	$000s	PY	$000s	PY	$000s
Essential												
Germplasm improvement	0.7	116	1.5	250	1.7	283	2.3	383	2.3	383	2.3	383
Crop management and physiology	0.9	199	1.1	243	1.3	287	1.5	331	1.5	331	1.5	331
Economic analysis	1.2	220	2.6	476	2.7	494	2.9	531	2.9	531	2.9	531
Training	0.2	53	0.5	132	0.5	132	0.5	132	0.5	132	0.5	132
Consulting	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Management/Administration	0.8	155	0.8	155	0.8	155	0.8	155	0.8	155	0.8	155
Total	**3.8**	**743**	**6.5**	**1,256**	**7.0**	**1,351**	**8.0**	**1,532**	**8.0**	**1,532**	**8.0**	**1,532**
Desirable												
Germplasm improvement	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Crop management and physiology	1.5	331	1.2	265	0.9	199	0.4	88	0.4	88	0.3	66
Economic analysis	1.4	256	1.4	256	1.7	311	1.8	329	2.0	366	2.0	366
Training	3.4	898	2.2	581	1.8	475	1.7	449	1.7	449	1.7	449
Consulting	2.4	360	1.5	225	1.5	225	1.5	225	1.5	225	1.5	225
Management/Administration	0.5	97	0.5	97	0.5	97	0.5	97	0.5	97	0.5	97
Total	**9.2**	**1,943**	**6.8**	**1,424**	**6.4**	**1,307**	**5.9**	**1,189**	**6.1**	**1,226**	**6.0**	**1,203**
Essential + Desirable	**13.0**	**2,686**	**13.3**	**2,680**	**13.4**	**2,659**	**13.9**	**2,721**	**14.1**	**2,757**	**14.0**	**2,735**

*PY = person years

Table 6.7. Research Support budget, 1989-94 ($000's).

Activity	1989	1990	1991	1992	1993	1994
Experiment stations	2,144	2,144	2,244	2,294	2,294	2,294
Data processing	773	923	923	923	923	923
Laboratories	349	300	300	300	300	300
Biotechnology	150	520	1,040	1,200	1,200	1,200
Seed health	150	225	225	225	225	225
Biometrics	184	250	250	250	250	250
Information	1,304	1,304	1,454	1,454	1,454	1,454
Total	**5,054**	**5,666**	**6,436**	**6,646**	**6,646**	**6,646**
Allocated to the following activities:						
Germplasm improvement	2,308	2,476	2,543	2,577	2,577	2,577
Genetic resources	530	926	1,457	1,623	1,623	1,623
Crop protection	362	388	399	404	404	404
Training	228	233	239	242	242	242
Consulting	107	104	109	112	112	112
Information	1,304	1,304	1,454	1,454	1,454	1,454
Management/Administration	216	235	235	235	235	235
Total	**5,054**	**5,666**	**6,436**	**6,646**	**6,646**	**6,646**

Table 6.8. 1989 Budget Reconciliation ($000's).

	Core	Special Project	Total	Essential	Desirable	Total
Uses						
Maize	7,166	1,314	8,480	6,281	2,199	8,480
Wheat	6,831	1,609	8,440	5,631	2,809	8,440
Economics	1,323	1,363	2,686	743	1,943	2,686
Research support	5,009	45	5,054	5,054	0	5,054
Administration/ operations	4,701	0	4,701	4,701	0	4,701
Capital expenditures	2,493	1,150	3,643	3,643	0	3,643
Indirect costs	–600	600	0	–600	600	0
Total *(Uses)*	**27,323**	**6,081**	**33,404**	**25,853**	**7,551**	**33,404**
Sources						
Grants 1989	26,440	6,081	32,521	24,970	7,551	32,521
Capital fund	700	0	700	700	0	700
Interest/other	183	0	183	183	0	183
Total *(Sources)*	**27,323**	**6,081**	**33,404**	**25,853**	**7,551**	**33,404**

Table 6.9. International staff positions, 1987-94.

	1987 approved		1987 actual		1988 actual		1989 budget		1994 budget	
	Core	Special Project	Core	Special Project	Core	Special Project	Core	Special Project	Essential	Desirable
Maize	32	8	31	7	32	6	32	6	34	7
Wheat	29	7	29	7	31	4	30	4	32	10
Economics	7	4	7	4	6	5	7	6	8	6
Research Support	12	–	12	–	12	–	12	–	15	–
Training	1	–	1	–	1	–	1	–	0	–
Administration/Operations	6	–	6	–	6	–	8	–	8	–
Total	**87**	**19**	**86**	**18**	**88**	**15**	**90**	**16**	**97**	**23**
(Research Support breakdown)										
Experiment Stations	4	–	4	–	4	–	4	–	4	–
Data Processing	2	–	2	–	1	–	1	–	2	–
Laboratories	2	–	2	–	1	–	1	–	0	–
Biotechnology	1	–	0	–	1	–	1	–	2	–
Seed Health	0	–	1	–	1	–	1	–	1	–
Biometrics	0	–	0	–	1	–	1	–	2	–
Information Services	3	–	3	–	3	–	3	–	4	–
Total	**12**	**–**	**12**	**–**	**12**	**–**	**12**	**–**	**15**	**–**

Table 6.10. Comparison of CIMMYT and TAC activities.

CIMMYT Activities	TAC Activities	
Germplasm improvement	4.e)	Plant Breeding
	4.f)	International Trials
Genetic resources	4.b)	Collection and acquisition of germplasm
	4.c)	Genebanks
	4.d)	Germplasm enhancement
Crop protection	9.	Crop Protection Research
Crop management and physiology	6.	Crop Systems Research
Economic analysis	22.	Economic and Social Analysis at Micro level
	24.	Policy Analysis
	25.	Nutrition and Consumption Research
	26.	Research on Research
Training	15.	Human Resource Enhancement
Consulting	16.	Conferences, Seminars and Workshops
	19.	Counselling and advising NARS
	20.	Technical Assistance
Information	17.	Documentation and Dissemination of Information and Materials
Management/Administration		

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