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RESOURCE ALLOCATIONS TO NATIONAL AGRICULTURAL RESEARCH: TRENDS IN THE 1970s

(A Review of Third World Systems)

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FOREWORD

This report is the result of the first cooperative study carried out by IFPRI and ISNAR staffs. The subject -- The Allocation of Resources for Agricultural Research -- is one of importance and interest to the CGIAR members and national programs. The study must be viewed as a part of a continuing effort to update and analyze the resources available and being utilized in national agricultural research programs in the developing countries.

There is great variability in the information available from various countries. In the process of the study it became apparent that in many countries there is little understanding of the level of resources that may be required for effective agricultural research programs.

The data on research resource allocation provides one important step on the way to analyzing policies for using those resources more effectively to achieve development objectives. Subsequent analyses will require measures of research input which are not attempted in this paper. However, we believe that the present information, combined with a continuing effort to update and upgrade the quality of the data, will make an important contribution to the understanding of resource requirements -- financial and human -- for truly productive national agricultural research systems.

In preparing this study we were able to draw on a wide range of sources, thanks to the help received from many collaborators. In particular, we express our appreciation to Dr. John Monyo and Mr. Brian Webster of the Research Development Center of FAO, to Drs. Martin Pineiro and Eduardo Trigo of IICA in Costa Rica, to Dr. A.M. Ahmad and Dr. John K. Coulter of the World Bank, to Dr. W. MacNally of the CGIAR Secretariat, to Dr. Jose Kohout of IDB, to Dr. Colin McClung and his colleagues at IADS, and to persons in numerous bilateral aid organizations who have been generous with their time and material in supplying information on donor contributions to research.

We give particular recognition to Mr. Peter Oram of the IFPRI staff, who carried the primary burden for the report preparation, and Dr. Fred Haworth of ISNAR and Mr. Vishva Bindlish of Cornell University, who worked closely with Mr. Oram throughout the study. Recognition must be given to the staffs of both institutions and to the CGIAR for financial support, and to the various agencies which supplied data. We appreciate generous help with information from many sources.

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1. SUMMARY AND POLICY ISSUES

THE STUDY AND ITS OBJECTIVES

This report represents the first stage of a collaborative effort between the International Service for National Agricultural Research (ISNAR) and the International Food Policy Research Institute (IFPRI) to upgrade and analyze available knowledge on the current state of national agricultural research systems in Third World countries. The first objective is to assess progress in the development of those systems during the last decade, and particularly since 1975, and from this to draw conclusions as to action required by the countries themselves, by donors, and by ISNAR to further strengthen them during the present decade. A second objective is to delineate issues requiring further study and research so as to clarify some of the areas of uncertainty identified in the report. Finally, the report draws attention to the need for an enhanced effort to improve the information base on national agricultural research systems and maintain it up-to-date, and presents suggestions for doing this.

The current state the information base in research expenditures and scientist numbers as assembled for this report is as follows:

Developing Market Economies	No. of Countries	Total Population (mil.)	Share of DME Total %
1. Adequate data available for 1970-80 time series	41	1642	75.5
2. Data available for 1980, but inadequate for time series	10	110	5.0
3. Data limited; mainly prior to 1977 and/or intermittent	25	214	9.8
4. No information after 1972	48	210	9.7

The report draws most of its conclusions from studying the 51 countries in groups 1 and 2 above, for which 1980 information is available (Annex 1). For 41 of these we have been able to develop 1970-80 time-series (Annex 2). For most of the 51 countries the information is drawn either from their replies to questionnaires or from studies by consultants and donor agencies which provide a comprehensive picture of the national research system. Thus we

consider the data to be sound, even though some qualitative aspects cannot easily be tabulated or confidential reports quoted to support our conclusions. Twenty-five countries for which we only have pre-1977 data are also listed in Annex 1. Information on these has been extrapolated to 1980 and added to that for the 51 countries to provide a broader view of the current situation covering 76 countries.

THE EXPANSION OF NATIONAL SYSTEMS IN THE 1970s

Time-series data indicate substantial real growth in many national agricultural research systems during the 1970s, with a number of countries maintaining annual growth rates exceeding 10 percent in expenditures and/or scientist numbers (Annex 2).

For the 76 countries included in Annex 1 the estimated total expenditure in 1980 was U.S. $890 million, and the number of scientists almost 36,000, an average scientist cost of approximately $25,000. Compared to IFPRI's estimates for 1975, national expenditures have risen overall by 71 percent and scientist numbers by 38 percent in five years. Since all expenditures are expressed in constant 1975 prices, costs per scientist must also have risen in real terms. This may in part reflect higher real salaries, but it may also indicate larger elements of capital investment in total costs, and an expansion of non-salary components.

The latter, however, is a matter for further research, since a recurrent theme in numerous reports is the inadequacy of budgetary provisions for operating cost once salaries and capital investments have been covered. This is difficult to tabulate, since few reports present a breakdown of budgets in a comparable fashion and many provide no detailed breakdown, but it nevertheless comes through as a strong signal from those that do. If it is as widespread as these reports seem to indicate, then it merits serious consideration by those responsible for allocation of financial resources in national governments, as well as for donors, some of whom tend to prefer financing capital investments rather than recurrent expenditures.

The analysis in Table 2 for 47 comparable countries in 1971, 1975, and 1980 indicates that considerably more resources are being invested in national agricultural research systems now than a decade or even a quinquennium ago; in relation to agricultural GDP the average level for the 51 countries has risen from 0.3 percent in 1975 to 0.56 percent in 1980. The latter is above the U.N. World Food Conference suggested 1985 target of 0.5 percent (which equates with $900 million at constant 1970 prices). In terms of scientist numbers the 1980 figure is also higher than that of 29,100 proposed by the World Bank in its Sector Policy Paper on Agricultural Research as a target for all Third World countries by 1984. The 1970-80 geometric growth rates for the 41 time-series countries both for expenditures and scientist numbers are often well above those listed for 1968-74 in the World Bank paper, suggesting an accelerated development in the second quinquennium of the 1970s.

THE DISTRIBUTION OF RESEARCH RESOURCES AMONG COUNTRIES

The report draws attention to two aspects of this generally encouraging picture which give some cause for disquiet. The first of these is the uneven distribution of research resources in the Third World. Excluding the People's Republic of China (which might have as many researchers as all of the rest of the Third World); Table 4 shows that 62 percent of expenditures and 46 percent of the scientist manpower among the 51 developing market economy study countries is concentrated in only five countries; 88 percent of expenditures and 85 percent of scientists in 15 countries.* Thus, 61 percent of these countries had only 15 percent of the number of scientists.

The fact that this uneven distribution of resources is more or less in balance with the distribution of population among the 51 countries highlights the second (and related) problem. How can small countries with limited financial resources afford to build up and maintain efficient and adequate national research systems, since there probably must be a minimum establishment for effectiveness in any system?

An overview of the situation in 1980 based on Annexes 1 and 2 suggests that probably about 25 Third World countries now have national agricultural research systems which are adequately financed and staffed for self-sustaining growth and capable of covering national and regional needs. A similar number of countries are at an intermediate stage, with adequate staff for research on key commodities, but lacking a critical mass for all purposes. These have to be particularly selective in their choice of priorities while gaining strength and experience.

There is a third category which even if adequately equipped to undertake applied research on selected key national priorities may never have a comprehensive agricultural research system simply because national resources are insufficient to support it. This probably embraces about 20 of the 76 countries included in Annex 1 (mostly in sub-Saharan Africa and the island communities), but includes a much higher proportion of the 50 or so other countries on which we have no information at all, 29 of which (55 percent) have a population of under one million. All together there are 66 Third World countries (about half of the total number) with less than five million people, a third of which are low-income countries. It is imperative to find solutions to their problems, and as time goes by this may come via increasing assistance provided by the stronger Third World national systems working with the International Centers (or as proxy for them), rather than through the traditional donor agency/technical assistance route.

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*IFPRI's Working Paper No. 30 (1978) noted a similar situation, with two-thirds of all scientists among the 65 countries studied being located in only seven countries: Bangladesh, India, the Philippines, Thailand, Nigeria, Brazil, and Mexico. All of these are also in the top 15 in 1980.

RESOURCE ALLOCATIONS BY CATEGORIES

The report examines the distribution of resources by geoclimatic region by income group and in relation to rates of agricultural growth for 51 countries. These are categorized in Annex 4.

Resource Allocation by Geoclimatic Region (Table 3)

The sample of 51 countries is unavoidably biased towards Asia (15 countries) and Latin America (21 countries) by the availability of 1980 data. North Africa and the Near East (3 countries) is weakly represented in absolute terms, and sub-Saharan Africa (12 countries) is weak relative to the large number of countries in the region. Extrapolating earlier data to 1980 for another 25 countries adds another 5 countries to North Africa/Middle East and 17 to Africa, but only 1 to Asia and 2 to Latin America. (Table 15). This does not greatly alter the conclusion that scientists are predominantly concentrated in Asia (53 percent), followed by Latin America (22 percent); but it improves the North Africa/Middle East share of the total (raising it from 0.9 percent to 12.6 percent), where the large scientific establishment in Egypt is a major factor.

In relation to population as well as in absolute terms, Africa (especially the semiarid sub-Saharan tropics), and the Central American-Caribbean region emerge as the least well-equipped in numbers of scientists; and East Asia and South America as the strongest. South Asia, despite having 34 percent of all scientists and 45 percent of total expenditure, has one of the lowest scientist: population ratios, indicating a need for further strengthening. Southeast Asia and the Middle East (Mediterranean climatic zone) are at an intermediate stage. To the extent that the epicentres of production of major commodities tend to be linked to certain geoclimatic regions we conclude that national research on wheat, barley, rice, subtropical pulses, and possibly potatoes is probably stronger than that for maize, millet, sorghum, cowpeas, and tropical roots and tubers such as yams and cassava. However, this is largely inferred from the subregional distribution of resources; too few countries publish details of resource allocations by commodity or discipline for us to examine the issue in-depth, and the distribution of publications is not felt to be a sufficiently reliable guide to the weight and direction of research in Third World countries.

Distribution by Income Group (Table 5)

There is a marked relationship between income group and the allocation of resources to agricultural research among the 51 countries. Research expenditures per scientist, per million totalpopulation, per 1,000 hectares cropped area, and as a proportion of agricultural GDP are all higher on the average for the middle income (per capita $360 - $1,250) compared to the low-income countries (per capita less than $360 per annum), and for the high-income countries (per capita more than $1,250) compared to the

other two groups. So are scientist numbers in relation to population. Although there are some inconsistencies by subregion due to the weight of India in the low-income group and the high scientist cost in Africa, the income group differences are on the whole quite striking.

Distribution According to Agricultural Growth Rate (Tables 6 & 7)

Using the same criteria to compare the allocation of resources among countries whose 1970-80 agricultural growth was rapid (more than 3.5 percent per annum), medium (3.5 - 1.5 percent per annum), and slow (less than 1.5 percent per annum) shows no consistent direction. The 15 slow growth countries spend on average almost as much per million population, per scientist, per hectare, and as a percentage of GDP as the 22 high-growth countries, and rather more than the medium-growth countries. However, while no particular relationship is detectable from the regional and subregional averages, there are 44 percent of high-growth countries in the sample of 51 compared to only 29 percent of slow-growth countries. The ratio of fast to slow-growth countries among the 15 large investors in Table 4 is much wider -- 60:20 percent. Yet some of the slow-growth countries included there (e.g., Bangladesh and Nigeria) have had a very fast expansion of their research systems in recent years. This may not yet be reflected in their agricultural growth because of the time-lag between investment and output from research.

QUALITY ASPECTS OF NATIONAL RESEARCH SYSTEMS

These are more difficult to quantify, specify and document than resource allocations. The report looks at levels of scientist education, provision of research assistants, and adequacy of supporting seed distribution and extension services. It also examines some aspects of research management.

Levels of Scientific Education (Table 8)

Information could be gathered for only 32 countries and around 20,000 scientific staff. The average of those countries was just under 9 percent of Ph.D level, 27 percent of M.Sc. level, and about 64 percent of B.Sc. or equivalent graduates. The fact that 36 percent are post-graduates is an improvement from the past, and several countries show an upward trend, but the Ph.D. component is well below the target of 20 percent suggested in the World Bank Sector policy paper. While there are marked differences among the countries listed in Table 8, about 40 percent of them have 5 percent or less Ph.Ds in their system, indicating possible weaknesses in their ability to conceptualize, plan, and direct research. The high overall proportion of lower level graduates suggests an important task ahead of upgrading education and training.

Provision of Research Assistants (Table 9)

In Working Paper No. 30 IFPRI noted that there was inadequate provision of scientific assistants in many countries (most had under one per scientist), and that this appeared to place an important constraint on the conduct of research. A larger number of countries (64 compared to 33) is included in the present study and overall there seems to be a significant improvement over 1975 in the ratio of technicians to scientists. Nearly half of the countries now provide at least one trained assistant per scientist, but there are marked regional differences. For example, numbers of technicians per scientist are high in Asia and very low in Latin America. This may be due to lower technical staff costs in Asia.

Other Supporting Services

Seed and other biological inputs. The report concludes from a number of sources that inadequate production and distribution services for seed, inoculum, and veterinary medicines, remain a serious constraint on the effective use of the results of both crop and livestock research. This limits the impact both of international and national research systems, and particularly of efforts to improve resource productivity through biological means of raising productivity.

Extension Services (Table 10 and 11, Annex 5). An extensive survey of extension resources conducted recently by Swanson and Rassi of the University of Illinois (1981) facilitated comparisons with research. This suggests that research services have recently been expanding faster than extension and that a good deal has been done to correct the earlier underinvestment in research compared to extension referred to by Boyce and Evenson (1975).

While total staff numbers are still much higher in extension (due principally to large numbers of low level field assistants in Asia), mere numbers do not determine the effectiveness of a system, and levels of graduate staff are much more comparable both in total numbers and their regional distribution. Almost 70 percent of graduate extension staff (and 80 percent of all staff) is in Asia, 24 percent of graduates are in Latin America, and only about 3 percent in the Near East and Africa, respectively. In general, where research services are weakest extension seems likely also to be weakest, e.g., in Africa and the Caribbean, although the Illinois study has serious information gaps on African countries. Empirical evidence is lacking to indicate the optimum balance of investment in research and extension, but it is clear from Annex 5 that in general extension services in Third World countries are still woefully inadequate compared to those in industrialized countries (staff ratios to agricultural population 0.26 per 1000 and 1.27, respectively). Yet the task of communication is much simpler in the latter. This does not suggest that efforts to build up extension services should be relaxed; all key components of technology delivery systems should be strengthened in parallel in a balanced

fashion, and in many countries research and extension should be linked more closely than at present.

Management Factors

Probably about a third of the countries studied have now reached a stage in the evolution of their agricultural research systems where the main constraint on their impact is not lack of money, buildings, equipment, or absolute lack of trained researchers, so much as weaknesses in the management of those resources. This conclusion stems from study of many documents and conversations with research managers; although it is hard to quantify.

The report attemps to look at mechanisms for the planning, coordination and direction of research, at problems arising from overcentralization and conversely from excessive dispersion of resources (Table 13), at the use of recurrent funds, and at the balance of resources to needs. It is concluded that while no hard and fast management prescriptions can be laid down, fragmentation of responsibility among several ministries is still common and that many countries still have to work out appropriate machinery for coordination (including that of donor aid to research); that excessive dispersion of resources in an attempt to meet all local needs is still widespread; and that the congruence of the allocation of resources to priority fields of research could still be improved. The shortage of operating funds compared to capital allocations and salaries appears to compound some of these problems. We feel that more research on these and other issues of how management affects research efficiency is needed and would be fruitful.

TRAINING REQUIREMENTS FOR AGRICULTURAL RESEARCH SERVICES IN THE 1980s

The report concludes that a massive training and retraining need still has to be met, despite important progress in the last decade. An attempt has been made to indicate 1990 needs and their possible cost in Table 16, based on an assumption of a 3.5 percent growth of agricultural GDP over the 1980s and 1 percent of GDP target for research expenditures by 1990. At constant 1975 costs per scientist, 107,600 scientists would be employed by 1990 in the countries studied, implying a total training requirement to M.Sc. level of the order of 113,600 scientists from a 1980 base, allowing for staff attrition and dropouts in the educational system, but not for upgrading lower level graduates already in the system. We have assumed that a much higher proportion will be trained in future in Third World countries. This reduces costs, but the estimate of $4.0 billion to train scientists and research technicians still represents a massive challenge to Third World countries, donors and international centers. It also suggests that a higher growth rate target of research expenditures in relation to GDP may be difficult to attain.

DONOR SUPPORT TO NATIONAL AGRICULTURAL RESEARCH IN THIRD WORLD COUNTRIES (TABLE 15 AND ANNEX 3)

There was a major increase in donor funding of national agricultural research from the early until the late 1970s, in addition to expenditure on the CGIAR system. This increase stemmed from expanded contributions by traditional bilateral donors, new donors, and the World Bank and regional banks. The biggest increase in bilateral aid seems to have been to Africa, with funds to Asia and Latin America coming more from the Banks, the latter often providing large sums to large, populous countries. Total allocations in 1980 approach half a billion dollars in constant 1975 terms, nearly double that in 1975, and an average real growth rate of 13.5 percent per annum.

This represents an important advance compared to the narrow and limited base of external assistance reported at the beginning of the decade by Boyce and Evenson. Nevertheless, the expansion of donor support has not been without problems for the recipient countries.

The report notes that although large sums of capital may be difficult for poor countries to match and absorb, some donors are still reluctant to support recurrent costs, and that grants and loans for expansion of research facilities sometimes exceed the managerial and implementation capacity of a country. Training and staff development should be matched to the provision of funds, but neither donors nor recipients always recognize this need or manage to maintain a balance.

Annex 3 shows that a very large number of countries now receive donor support for agricultural research in one form or another. Often there are several donors supporting more than one project each in one country. It is often unclear how much projects with minor research components contribute to building national research capability or fit into the overall system; indeed a proliferation of projects may well draw off resources from higher priority research. The advent of the International Centers, with outreach and special projects, has added a new dimension, although this on the whole seems likely to be a source of strength to collaborating countries.

It is concluded that at the least there is the need for better coordination of donor activities within countries, and possibly for more radical rethinking of how best to achieve critical mass among donors at the national level.

Information on annual disbursements for the 1975-80 period received from individual countries indicates declining real levels of support for national agricultural research since 1978 or 1979 in the case of several bilateral donors. This coincides with a tightening of funds for the CGIAR system. It is still uncertain whether this reflects a reduction in priorities for support to agricultural research or simply a general retrenchment due to changes in government policies towards aid, and/or economic recession.

If the latter is the case there is little to be done but hope that things will improve. If it is the former, there is grave cause for concern. The fact that developing countries have practically

doubled the resources going to research in a quinquennium by combining their own efforts with those of donors is meritorious but should not generate any false illusions. Even to approach parity with the scientifically advanced countries would require 1980 expenditures to be increased 2 1/2 times overall, and scientist numbers more than threefold. For many of the less developed countries the multiples are greater. Even for the better equipped ones the study indicates continuing gaps in staff, management deficiencies, and weaknesses in support services, which reduce the effectiveness and impact of research. Instant results cannot be expected; successful research requires both time and stability. The time is not yet ripe for cutbacks in donor's support.

ISSUES FOR FURTHER STUDY

As mentioned in the introduction, this is the first stage of a continuing effort by ISNAR and IFPRI. A number of the issues raised above and others listed in the concluding section of the report (such as the role of the private sector in research), cannot be clarified without further in-depth study either by a country case-study or "stripe-analysis" approach. We believe th this would be fruitful and beneficial, both to Third World countries and to the CGIAR, and hope to obtain resources to pursue some of the priority questions.

2. INTRODUCTION

The development and application of new knowledge is central to the improvement of agricultural production and post-harvest technology. New knowledge is basic to economic growth, increased employment, and the reduction of poverty and malnutrition in a high proportion of low-income countries. This is the fundamental reason for the expenditure of scarce resources on agricultural research and technology transfer systems, whether those resources be from international or national sources. There is widely quoted evidence of high rates of return to well-planned and targeted agricultural research, and thus we will not attempt to justify it here.

But it has been suggested by Ruttan, Univ. Minnesota (1978) that a reason for such high rates of return is widespread underinvestment in agricultural research, even in high-income countries. Less attention seems to have been focused on the reasons for low rates of return to research; but the absence of significant growth in productivity in many Third World countries suggests that this may be a phenomenon of equal or greater importance. Is it simply that not enough money is being invested in national systems, and that there are insufficient well-trained researchers, or are there more subtle and less tractable reasons?

These issues can be examined by looking at trends in the allocation of resources to national systems, both by the countries themselves and from external assistance agencies; by studying the effectiveness of the use of those resources within research systems; and by comparative analysis of the factors which have contributed to success or, alternatively, have hampered the development of those systems. In order to identify cause and effect, these factors need to be monitored and evaluated over time.

This is the main purpose of this study, which represents a collaborative effort by staffs of the International Service for National Agricultural Research (ISNAR) and the International Food Policy Research Institute (IFPRI). The present report represents a follow-up to earlier work by IFPRI in 1977 on priorities for international agricultural research, on behalf of the Technical Advisory Committee (TAC) to the Consultative Group on International Agricultural Research (CGIAR); work on training requirements for agricutural research, undertaken in 1978 for CGIAR Centers Week meeting, and on expenditures and manpower in national research systems (1978). Although the latter was presented as an IFPRI working paper (No. 30) rather than as a research report, it aroused considerable interest and has been widely quoted.

The primary objective of this report is to present revised, refined, and updated numbers for as many developing countries as possible, to assess the progress made in the past decade in building national systems, and at the same time to provide baseline data for ISNAR's assistance to those systems.

A secondary objective is to identify important areas of uncertainty concerning the state of agricultural research in the developing countries, areas which require further research and which seem to merit more detailed examination through country case studies or by "stripe analysis" across countries by IFPRI, ISNAR, or through collaborative efforts with other interested institutions. We consider that there is a rich field of policy analysis on research that would repay the application of additional resources, with beneficial results for national planners, research directors, international agencies, the CGIAR, and donors.

In reading the discussion and conclusions drawn from the data presented here, it should be borne in mind that the work was completed in a matter of four months by two researchers working part-time. We have assembled and drawn on a larger and more comprehensive spectrum of data than we had imagined would be available on the basis of our 1978 experience.

3. CURRENT INFORMATION ON NATIONAL AGRICULTURAL RESEARCH SYSTEMS IN DEVELOPING COUNTRIES

We have adequate data to construct 10-year time series on expenditures and manpower with reasonable confidence for 41 countries plus actual 1980 data on another 10 for which we do not have time-series. These 51 countries represent 80 percent of the population of the Third World outside the People's Republic of China. (This study did not attempt also to review agricultural research systems in industrialized countries). We have compiled information on donor assistance which we did not have in 1978. There are still important gaps and many "gray" areas. (A major omission is the lack of detailed information on China, which a recent report [Nunn 1976] states may have had about 12 large national institutes under the Academy of Agricultural and Forestry Sciences in 1976, plus a number of others concerned with basic research in life sciences and in engineering; with nearly 300 others forming part of provincial or municipal academies. There may be as many as 4,000 middle-level researchers [trained between 1943 and 1952], plus another 135,000 more junior and less experienced research staff. These very large numbers are more than all other developing countries combined, but little is known about the scientific quality and level of training of the more junior staff. As with many other Third World countries, the report identifies a shortage of experienced senior staff in China as a serious constraint on the development of new knowledge.)

We found a shortage of up-to-date, quantified information on practically all of the Near East and North African countries, and on the activities of the several Arab donor countries and funds in relation to national research systems in that region.

By comparison with Asia and Latin America, current information on national agricultural research systems in sub-Saharan Africa is also weak, although not as scanty as for North Africa and the Near East. But the large number of countries in Africa, the high proportion of relatively small, low-income, food-deficit countries there, and the fact that most of them have achieved independence more recently than many Asian, Near East, and Latin American countries (Table 1), makes support to African systems urgent.

When looking at parameters other than money and manpower, the weaknesses of the information base become more apparent. For example, while scientist manpower numbers for 1980 are available for 51 countries, data concerning the levels of academic qualification of the scientists cover only 33 countries. The breakdown of costs into capital and recurrent expenditures, operating costs, and salaries is available for a smaller number of countries than is total expenditures. Data on the allocation of expenditures or staff

Table 1: Achievement of Independence: Third World Countries by Region 1/ 2/

Region	Before 1945	1945-55	1955-65	1965-79	Total Number	Percent of Countries below 1 m. population
South and S.E. Asia/ Pacific	4	9	3 (1)	8 (4)	24 (5)	20
N. Africa/W. Asia	3	5	8	6 (4)	22 (4)	18
West Africa	1	-	13 (1)	2 (2)	16 (3)	19
East Africa	1	-	9	6 (4)	16 (4)	25
South/Central Africa	-	-	7 (1)	5 (4)	12 (5)	42
Middle America/Caribbean	9	-	3	4 (4)	16 (4)	25
South America	10	-	-	2 (2)	12 (2)	17
Total Number	28	14	43 (3)	33 (24)	118 (27)	23
Percent of total by period	24	12	36	28	100	

1/ Figures usually refer to year of independence, or occasionally to year of a radical change of government if one occurred since independence.

2/ Countries with less than 1 million population in 1977 shown in parentheses.

Source: Modified from International Agricultural Development Service, New York. Agricultural Development Indicators, 1978.

by subsector (crops, livestock, forestry, and fisheries) are listed by only a limited number of countries (28, mainly in Asia and Latin America), as are data concerning the allocation of resources to specific crops or disciplines. A considerable number of country reports indicate the numbers and nature of research stations and their geographical distribution, but few give details on the allocation of funds and staff to those stations -- an essential requirement for judging their likely operational impact. This randomness in the way data are classified and presented in different reports restricts the size of the sample for qualitative comparative analysis across countries.

There are also difficulties of definition, for example, concerning academic levels for degrees from different educational systems. Technicians are sometimes listed under research staff, sometimes as technicians, sometimes as assistants or "others," and their qualifications range from B.Sc. to high school level or below. For purposes of this report we have tried to include in the research assistant category only those staff with a definite technical qualification (B.Sc, diploma in agriculture, or other post-high school grade).

Assessment of the nature and adequacy of support to national agricultural research systems is difficult, and we have sometimes had to exercise judgment in dealing with two or three series of statistics from different sources for a single country. Such differences seem often to be the result of the omission of data of some components of the overall system; typical reports include only information on a central or national organization in a federal political system that has state as well as national research systems; or they deal with only one sector of agriculture such as crops (or even food crops) and leave out data on livestock (or more commonly on forestry and fisheries). Universities are frequently poorly recorded, probably because they are often funded and controlled by a ministry other than agriculture. Even where staff numbers at universities are listed, the amount of time they spend on research is rarely stated clearly.

As indicated later in this report, records of donor assistance to national agricultural research systems is far from adequate. They often lack precision of definition, confound research expenditures with those on extension and/or education, fail to separate capital and recurrent costs, and are presented in a way which makes it almost impossible to identify disbursements in any given year or over a time series.

Despite the difficulties described above, and the caveats we have entered regarding the validity and reliability of the data base, we have found this to be a worthwhile, informative, and revealing exercise. We believe it sheds new light on the problems facing national agricultural research systems and the progress made in the last 10 years in finding solutions to them. It suggests that as nations approach critical mass in building up their scientific staffs, they face new challenges of management which replace the constraints imposed earlier by lack of trained people. We hope that this study will indicate where some of these problems may lie and

something about their nature, even if it is not always possible to offer solutions.

One clear conclusion from this study is that there needs to be a more systematic, precise, and consistent approach to the collection, collation, and presentation of information on national agricultural research systems and the resources being allocated to them by their governments and from external sources. In the final section of this report some suggestions have been made with this objective in view. We believe that continuing attention to collecting and analyzing these data is justified and important. Both ISNAR and IFPRI consider this report an initial phase in a continuing collaborative effort. Readers are invited to submit to IFPRI or to ISNAR information which may add to that already collected. It would be helpful if this could be presented along the lines indicated in Annex 6.

4. PAST LEVELS OF SUPPORT FOR NATIONAL AGRICULTURAL RESEARCH SYSTEMS

There have been several reviews of past levels of support for national agricultural research systems, notably by Evenson and Kislev (1975) and Boyce and Evenson (1975). Both deal with extension as well as research and include an assessment of expenditure by industrialized and Third World countries. The Boyce and Evenson analysis covers the period 1959-74 and involves the construction of time series for about 60 developing countries.

Important conclusions from these studies were that the low-income countries of the Third World, as a whole, were spending insufficient money on research compared to extension during the period under study; the high-income countries spent more on research, both in absolute terms measured by various comparative criteria (value of agricultural product, expenditure per scientist manyear, the proportion of research in agriculture-related sciences) and relative to their extension expenditures.

Thus the higher-income countries were better able to develop and conceptualize original research; the poorer countries were more dependent on borrowing new knowledge from elsewhere and either attempting to transfer it direct to farmers through their extension services or, at best, trying to modify it to their needs and local environment through adaptive research. The study points to the fallacy of policy makers in assuming that low priced extension resources are substitutable for higher priced research resources to improve the efficiency of agriculture; it argues that in fact they are not. A further constraint to raising productivity in the lower-income countries could be the limited involvement of the private sector in research, since this is an important source of strength to supplement public sector systems in relation to seed, fertilizer, pesticides, machinery, and equipment in the industrialized countries.

Although Boyce and Evenson noted that national research programs at all income levels were becoming more closely matched to their economies over time, congruence of these elements remained lower in the poorer countries up to the early 1970s. While expenditures on research as a percentage of agricultural product grew more rapidly in the low-income than the higher-income groups during the 1959-1974 period, expenditures on extension (although increasing more slowly than those for research in most income groups) actually rose faster than those for research in the lowest income group.

Boyce and Evenson also concluded that external support for research in developing countries fell significantly during the period under review. It declined from 40 to 50 percent of total

funding for the development of agricultural research systems in 1959 to less than 20 percent by 1971. External funding for extension is estimated to have represented 10 to 20 percent of investment in the earlier part of the period. Although the authors note that extension support may have also declined subsequently, they state that it has probably been offset by increased and massive investment in "integrated rural development," "package," and credit programs totalling many times the amount of aid going to research.

Other analyses of progress in the development of national research systems, focusing mainly on Third World countries, were undertaken for the United Nations World Food Conference in 1974; by Oram and Devred for the 1974 "Bellagio Six" meeting; by the TAC Secretariat, also in 1976; and during 1977 and 1978 in the IFPRI papers by Oram.

INCREASES IN INVESTMENT AND SCIENTIST NUMBERS

The most recent of these, IFPRI Working Paper No. 30, concludes that a good deal of progress was made in strengthening national research systems in many of those countries between 1970 and 1975. Expenditures -- based on latest data (mainly for 1975 or 1976) expressed in 1975 dollars -- were 37 percent higher in 1975, and numbers of scientists were 67 percent higher than estimates made in 1974 for the World Food Conference (based mainly on 1970 or earlier data). Agricultural research expenditures had risen overall in relation to agricultural gross domestic product (GDP) from 0.25 to 0.31 percent.

For the 65 developing countries for which IFPRI had 1975 or later data, total expenditure was estimated to be $458 million, while scientists numbered 23,320. An estimate pro-rated to include countries outside those 65 raised these figures to $515 million and 26,300 scientists. Table 2 of the present paper which compares 1971, 1975, and 1980 data for 47 of the countries covered in this report (and also included in the Boyce and Evenson study and IFPRI's Working Paper No. 30) confirms that substantial advances have been made in the decade of the 1970s and that growth has been accelerating.

UNEVEN GROWTH ON REGIONAL BASIS

However, on a regional and geoclimatic basis progress has been uneven. Weaknesses were noted in the humid tropics, particularly in Central America and the Caribbean, Equatorial Africa and in East Africa. These tend to confirm Evenson's earlier conclusions on weak support to geoclimatic zones in the tropics. There were great regional differences in scientist manyear costs, those in South Asia being particularly low (presumably reflecting a relatively adequate supply in India and generally low salaries); and those in

Table 2: Change in Expenditures on Agricultural Research and Numbers of Agricultural Scientists, 1970-80: 47 Countries 1/

Region	Expenditures (000 US $ constant 1975 terms)					Scientist Numbers				
	1971 2/	1975 3/	1980 4/	Change 1971/75	Change 1975/80	1971 2/	1975 3/	1980 4/	Change 1971/75	Change 1975/80
South Asia (5)	41,219	73,278	139,656	78	91	2,529	6,120	12,293	42	101
Southeast/East Asia (5)	28,009	46,732	101,013	67	116	2,285	4,400	5,830	95	31
N. Africa/Middle East (5)	21,943	21,867	35,122	-1	50	1,432	1,163	1,375	-21	18
West Africa (6)	41,777	86,454	112,480	107	30	915	3,239	1,897	154	-42
East/Southern Africa (5)	18,044	18,950	27,865	5	47	513	605	861	18	42
Central America/ Caribbean (11)	18,626	22,718	59,949	22	86	967	1,393	1,680	44	21
South America (10)	110,139	160,373	342,826	46	214	4,100	5,291	5,939	29	12
Total (47)	279,757	430,372	818,911	54	90	12,741	22,251	29,875	75	33

Sources for Expenditures and Scientist Numbers:

1/ These are countries for which we have data for all three years.
2/ 1971: Boyce, J.K. and Evenson, R.E. Agricultural Research and Extension Programs, Agric. Development Council, New York, 1975. Data taken from constructed time-series tables (Table 2.1) for 1971 expressed in constant 1975 dollars.
3/ 1975: Oram, P.A. Current and Projected Agricultural Research Expenditures in Developing Countries, Working Paper No. 30, International Food Policy Research Institute, Washington, November 1978, Annex 1.
4/ 1980: From Annex Table 1 of this report for the same countries as 1971 and 1975 data.

Note: The figures in parentheses denote the number of countries in each region.

sub-Saharan Africa high (reflecting continuing expatriate involvement, high training costs, and scarcity of experienced local scientists). There was a marked concentration of scientists in a few mainly large and populous countries.

WEAKNESS IN ORGANIZATION AND MANAGEMENT

Weaknesses in organization and management, and in particular an apparently excessive dispersion of resources to regional and substations poorly endowed with scientific staff, were noted by Oram and Devred (1974) and are reflected in several other reports. In the early 1970s about 50 percent of all research stations appeared to have had fewer than five scientists. That issue was not examined in Working Paper No. 30, but serious deficiencies were noted in support services to research, notably as a result of low availability of qualified technicians to back up scientists, a weakness strongly related to low investment in research generally and to low numbers of scientists per million agricultural population. Widespread deficiencies in seed production and multiplication services were also noted as weaknesses, both constraining output and availability to farmers of improved genetic materials and diverting scientists' time from their primary task of research. Another management problem noted in these reports -- and subsequently in more recent studies by Pineiro and Trigo (1981) on three South American national systems, by Idachaba (1980) on Nigeria, and in numerous consultant reports we have received -- is a lack of effective linkages between policymakers and research planners and directors, leading on the one side to misallocation or fluctuations in the provision of resources to research and on the other side to misalignment of research programs with national priorities. As a consequence, morale of researchers may be depressed, and a common feature of these reports is the need to provide long-term stability and consistency in funding and other national support to research and career structure, factors which are often considered to be more important than actual levels of salary in retaining a productive staff.

THE NEED FOR SCIENTIFIC EDUCATION AND TRAINING

Finally, education and training are seen as requiring high priority; a number of reports rate lack of trained staff as a more severe constraint than lack of money. In projections reported in its Working Paper No. 30, IFPRI estimated need in relation to targets for the growth of research. Subsequently, in its study of Investment Requirements for Accelerating Food Production in Low-Income Countries by 1990 (Research Report No. 10), Oram et al. (1979) looked at future training needs for research and extension services, concluding that (allowing for wastage) nearly 24,000

senior and field-level extension workers, over 4,200 research scientists, and 8,450 technicians would have to be trained annually to meet estimated needs for those services by 1990 -- just for those 36 countries. The estimated cumulative cost over the 15 years would be $6.2 billion at 1975 prices. The estimates were based on a 1990 average research expenditure of 0.6 percent of agricultural GDP (twice the 1975 level), two technicians per research scientist, and a ratio of one field extension worker to 500 farm families.

More recently the World Bank (1981) has suggested a long-term (15 years) investment target of 2.0 percent of agricultural GDP for the expansion of research. (Agricultural Research. Sector Policy Paper).

This seems an ambitious target; it surpasses rates of investment in research in nearly all high-income countries. However, the World Bank has also suggested a shorter-range Indicative Plan to 1984, which would involve a growth rate of 10 percent or more in all developing regions for both research and extension, leading to an increase of 70 percent in overall expenditures. In the case of research, an increase of 43 percent in scientific staff is suggested, from an estimated 20,300 in 1979 to 29,100 in 1984: Data in Table 2 above suggest that this target has already been passed in total, although progress has been uneven between countries. The development of sufficient scientific strength in Third World countries, nevertheless, remains a major challenge to world development objectives.

In the next section we examine recent progress and the extent and direction of change by developing countries and by donor agencies in meeting some of the constraints facing national research systems.

5. RECENT TRENDS IN THE EVOLUTION OF NATIONAL SYSTEMS

CURRENT 1980 RESEARCH EXPENDITURES AND THEIR GROWTH DURING THE 1970s.

Table 3 shows actual 1980 expenditures on agricultural research by geoclimatic region for the 51 developing market economy countries referred to in section 3 above. For these countries as a whole, the total expenditure amounts to about $813 million. This figure includes capital as well as recurrent expenditures, since in many reports these are not separated. The inclusion of capital leads to problems of year-to-year variability, since capital investments are "lumpy" by nature. Several countries (including Bangladesh, India, Sri Lanka, Pakistan, Indonesia, the Philippines, and Thailand in Asia; Kenya, Mali, the Sudan, Senegal, and Tanzania in Africa; and Mexico, Jamaica, Bolivia, Brazil, Colombia, and Peru in Latin America) have had loans or grants for research that involve large capital elements, which in some cases exceed recurrent costs in certain years. However, analyses of country reports, replies to FAO questionnaires, etc., suggest that an average of 15 percent of annual research expenditures tend to be for capital investments, the remainder supports recurrent operating expenditures and salaries. Full 1970-1980 time series data and growth rates for 41 of the countries are shown in Annex 1, Tables A-D, part(i).

Most countries have increased expenditures on research. But although Table 3 and Annexes 1 and 2-A show that a majority of countries in every income group have increased expenditures in real terms during the 1970s, many of them substantially, the picture is possibly distorted by the weight of resources in a few large and relatively prosperous countries. Thus in 1971 and 1975, 52 percent of total identified expenditures were concentrated in five countries (India, Nigeria, Mexico, Brazil and Argentina), and Table 4 shows that by 1980 this figure had risen to 62 percent. While 88 percent of all expenditures in that year were concentrated in 15 of the 51 countries, those 15 countries contained 87 percent of the population of the 51 countries (Figure 1). They were also, on the whole, countries with broad-based economies and fairly active private sectors. It is noteworthy that 80 percent were either in the fast or medium agricultural growth category, mostly in the former.

For a number of other countries we have no information on agricultural research expenditures beyond 1975 or 1976. These have not been included in Table 3 but have been extrapolated to 1980 from data for the mid-1970s at 1975 prices and are shown in Annex 1, Tables A - D (ii) after the countries for which we have full time series. This extrapolation is based on the assumption that their expenditures will have grown between 1974 and 1980 at the same rate

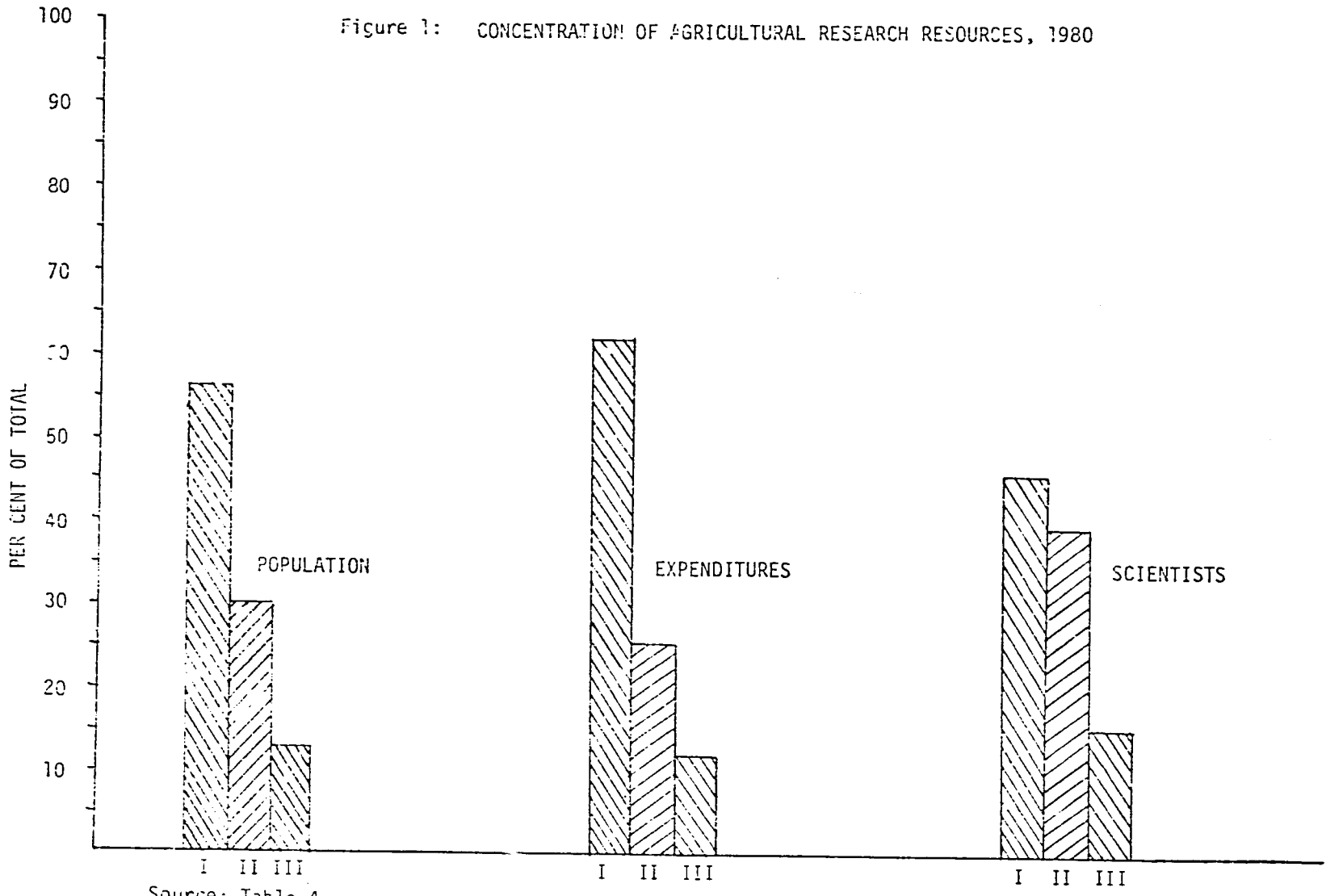
Table 3: Agricultural Research Expenditures and the Number of Research Scientists Relative to Population, Crop Area and Agricultural GDP, by Agro-Climatic Region, 1980: 51 Countries

	Number of Countries	Research Expenditure (000 Constant 1975 US$)	Number of Research Scientists	Research Expenditure: Per Scientist	Research Expenditure: Per Million Total Population	Research Expenditure: Per 1000 Hectares of Crop Area	Research Expenditure: Proportion of Agricultural GDP	Percent of Total Scientists	Research Scientists: Per Million Total Population	Research Scientists: Per 1000 Hectares of Crop Area
				-------- (Constant 1975 US$) --------			(Percent)			
ASIA	15	246,238	18,289	13,464	205,109	1.0	0.33	62.2	15.2	.07
Temperate East Asia	1	18,962	960	19,752	499,276	8.5	0.23	3.3	25.3	.43
South Asian Sub-Continent	5	139,656	12,293	11,361	156,187	0.7	0.32	40.4	13.7	.06
Indo-Malaysian Humid Tropics	9	87,620	5,036	17,399	326,474	1.8	0.40	13.5	18.8	.10
NORTH AFRICA/MIDDLE EAST	3	5,587	262	21,324	447,497	0.8	0.33	0.9	21.0	.04
Mediterranean Climatic Region	3	5,587	262	21,324	447,497	0.8	0.33	0.9	21.0	.04
SUB-SAHARA AFRICA	12	149,905	2,970	50,473	760,870	2.5	0.64	10.1	15.1	.05
Semi-Arid Tropics	3	95,593	1,401	68,232	945,398	2.8	0.71	4.8	13.9	.04
Lowland Humid Tropics	5	29,635	776	38,189	576,433	2.2	0.45	2.6	15.1	.06
Eastern and Southern Africa	4	24,677	793	31,119	554,627	1.8	0.73	2.7	17.8	.06
LATIN AMERICA	21	411,721	7,854	52,422	1,191,185	3.0	0.92	27.5	22.7	.06
Central America/Caribbean	11	62,634	1,819	34,433	614,547	2.0	0.52	7.0	17.8	.06
Tropical South America	7	230,951	4,468	51,690	1,139,750	3.7	0.94	15.2	22.0	.07
Temperate South America	3	118,136	1,567	75,390	2,875,195	2.8	1.49	5.3	38.1	.04
TOTAL OF FIFTY ONE COUNTRIES	51	813,451	29,375	27,692	463,329	1.8	0.56		16.7	.06

Table 4: Concentration of Agricultural Research Resources, 1980

1980 Expenditure (over $50 mil.)	Actual 1980 Expend. ($ 000)	Population 1975	Country as % Tot. Expend.	Country as % Tot. Population	Country as % Tot. Ag. GDP	Expend. as % Nat'l Ag. GDP	Growth Nat'l Ag. GDP 1970/80	Number of Scientists	Percent Total No. Scientists	Number Post-Grads.	Post-Grads. as % of Total Nat'l Researchers
Brazil	160,026	126,377	19.8	7.2	9.6	1.15	5.3	2,957	10.1	1,684	57
Argentina	108,648	27,056	13.4	1.5	4.6	1.64	2.3	1,064	3.6	285	27
India	101,098	693,887	12.5	39.5	24.2	0.29	2.6	7,103	24.1	2,059	29
Nigeria	79,634	77,082	9.8	4.4	7.9	0.70	- 1.5	1,084	3.7	276	25
Mexico	54,181	69,994	6.8	4.0	5.7	0.65	2.1	1,269	4.3	395	31
Tot. Budget (over $50 mil)	503,587	994,396	62.3	56.6	52.0	0.67	--	13,477	45.8	4,699	35
2. 1980 Expenditure ($10-49 mil. or over 1000 scientists)											
Colombia	31,455	26,907	3.9	[illegible]	3.2	0.67	4.9	333	1.1	184	55
Indonesia	29,056	151,894	3.6	8.6	4.6	0.44	4.0	1,473	5.0	71	5
Malaysia	29,023	13,640	3.6	0.8	2.5	0.81	5.0	822	2.8	n.a.	n.a.
Venezuela	25,586	14,914	3.2	0.8	1.3	1.32	3.5	365	1.2	115	31
Korea, Rep.	18,962	37,979	2.3	2.2	5.7	0.23	4.0	960	3.3	190	20
Bangladesh	17,385	88,705	2.1	5.0	2.5	0.48	1.6	1,642	5.6	1,262	77
Thailand	15,203	47,674	1.9	2.7	4.0	0.26	5.6	1,525	5.2	242	16
Pakistan	16,510	82,441	2.0	4.7	2.8	0.41	1.9	2,900	9.9	1,638	56
Kenya	14,204	16,402	1.8	0.9	0.9	1.08	5.5	400	1.4	356	89
Philippines	8,769	50,996	1.1	2.9	3.8	0.16	4.9	1,050	3.5	618	59
Tot. ($10-49M)	206,153	531,555	25.5	30.3	31.3	0.46	--	11,470	39.0	4,676	41
Total 1 and 2	709,740	1,525,951	87.8	86.9	83.4	0.59	--	24,94[illegible]	84.8	9,375	38
3. Tot. Below $10M	98,662	229,714	12.2	13.1	16.6	0.41	--	4,451	15.2	n.a.	--
Grand Tot. 1+2+3	808,402	1,755,665	100.0	100.0	100.0	0.56	--	29,398	100.0	n.a.	--

Figure 1: CONCENTRATION OF AGRICULTURAL RESEARCH RESOURCES, 1980



Source: Table 4

I = Countries with expenditures exceeding $50 million (5 countries)
II = Countries with expenditures between $10 million and $49 million (10 countries)
III = Countries with expenditures less than $10 million (36 countries)

as the average for their income group. The assumption that these countries will grow at the same rate as those for which we have 1980 or time series data may be shaky to the extent that lack of current information may indicate relatively less interest in increasing support for research subsequent to 1975. However, that assumption seems better than one of declining or static support for research, especially as nearly 80 countries have received external financial assistance to research in the last five years: (according to our somewhat incomplete donor records), and a good many have received it from two or more donors (See Annex 3.)

On the basis of the total picture provided by Annex 1, which includes 76 countries and 90 percent of the population of the Third World outside the People's Republic of China, overall expenditures on agricultural research would have risen by 94 percent in constant 1975 prices between 1975 and 1980 -- from an estimated $458 million in 1975 (IFPRI Working Paper No. 30), to $890 million in 1980. This is $77 million above the actual 1980 cost figures quoted for the 51 countries shown in Table 3 and thus reduces the concentration of expenditures in a few large countries referred to above.

Research Expenditures by Regions

In regional terms, Table 3 and Figure 2 show that the 21 Latin American countries are investing over 50 percent of all research expenditures among the 51 countries, although as Figure 3 indicates, the Asian countries have more than twice as many scientists (62 percent of the overall total). These figures reflect the high salaries and other costs in South America which exceed $50,000 per scientist, and by contrast the low salaries in Asia overall, particularly in South Asia. Relatively high costs per scientist are also typical of Africa, especially semi-arid West Africa, but total numbers of scientists are low compared to Asia or Latin America. Expenditures seem to have increased more slowly in sub-Saharan Africa (both West and East) in the second quinquennium of the 1970s -- the pattern for other regions is the opposite.

Research Expenditures by Income Groups and Agricultural Product

Among other factors, we have also looked at the distribution of national research expenditures by income group (Table 5) and with respect to growth rates of agricultural production (Table 6). The various indicators on which these Tables are based are shown for each country in Annex 4.

There seems to be a strong relationship between high levels of investment in agricultural research and higher incomes. The proportion of gross agricultural product (GDP) represented by research expenditures is widely used as a measure of the adequacy of agricultural research investment. The World Food Conference recommended the use of 0.5 percent of agricultural GDP as a target for developing countries to aim for by 1980. Based on 51 countries, Table 5 shows that in 1980 the average ratio of actual expenditures

Figure 2: AGRICULTURAL RESEARCH EXPENDITURE AS PROPORTION OF TOTAL, BY INCOME GROUP AND REGION (51 Countries)

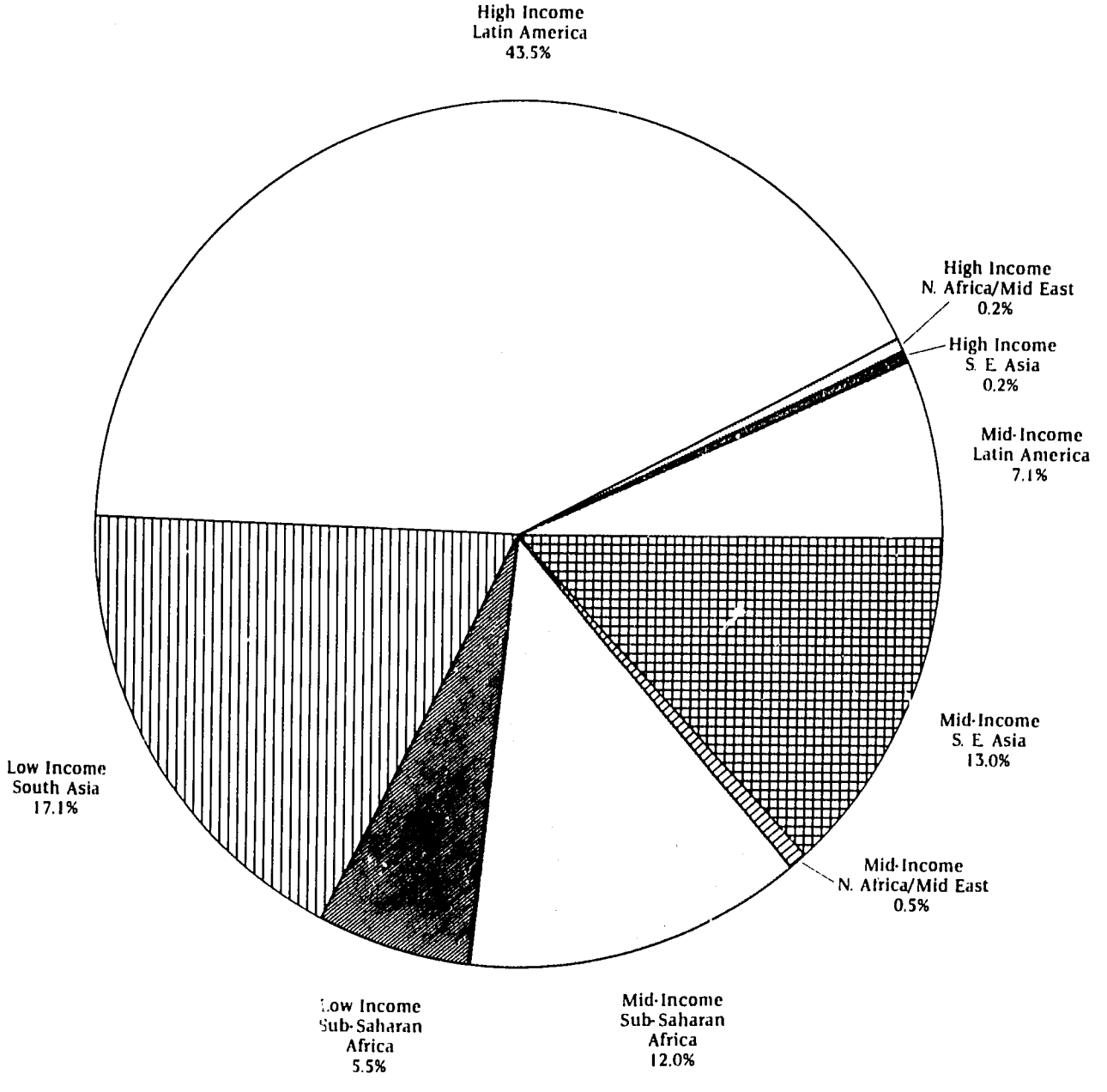


Figure 3: RESEARCH SCIENTISTS AS PROPORTION OF TOTAL, BY INCOME GROUP AND REGION (51 Countries)

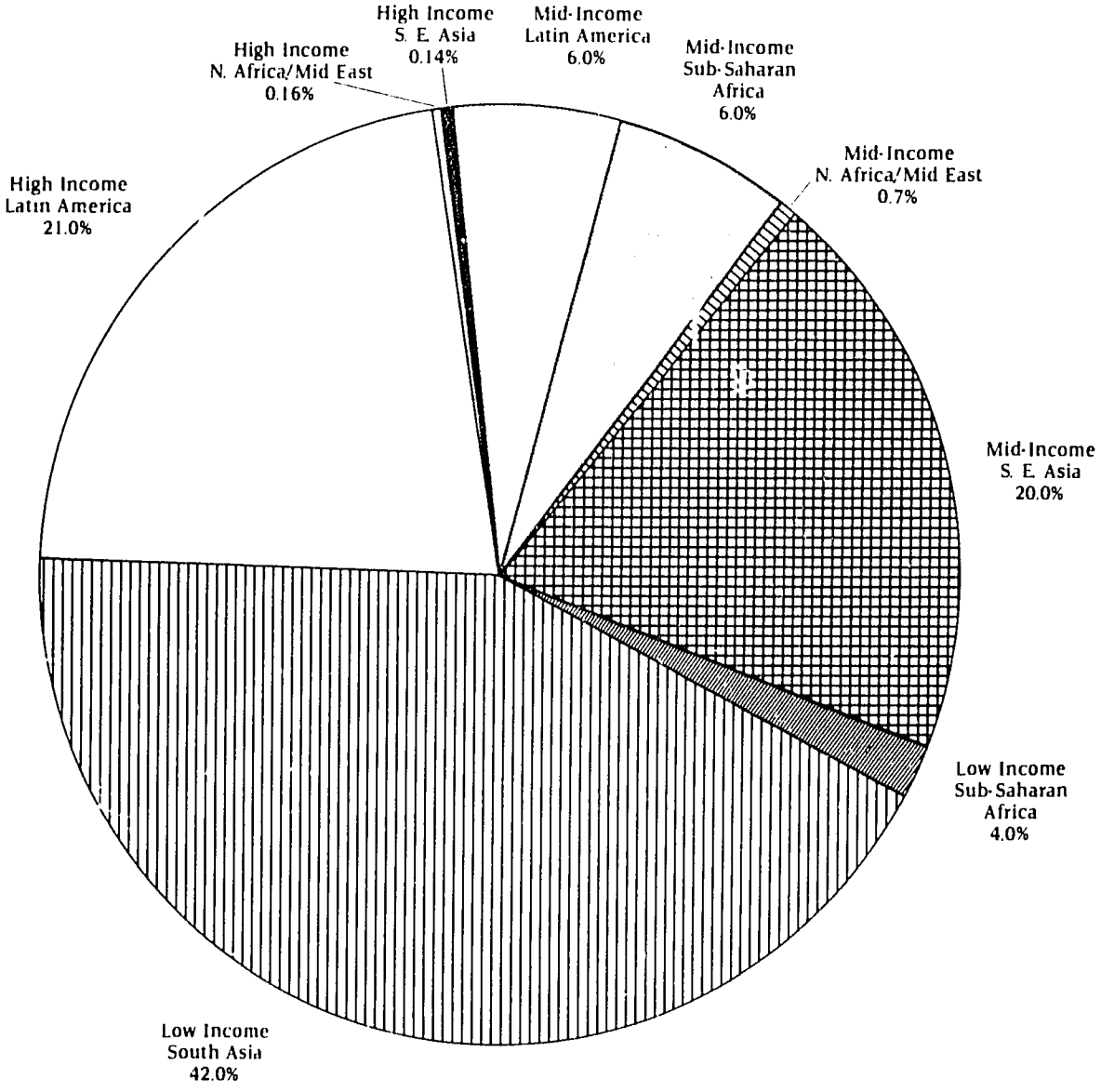


Table 5: Agricultural Research Expenditure and the Number of Research Scientists Relative to Population, Crop Area and Agricultural GDP, by Income Group, 1980.

	Number of Countries	Research Expenditure (000 Constant 1975 US$)	Number of Research Scientists	Research Expenditure: Per Scientist	Research Expenditure: Per Million Total Population	Research Expenditure: Per 1000 Hectares of Crop Area	Research Expenditure: Proportion of Agricultural GDP	Research Scientists: Per Million Total Population	Research Scientists: Per 1000 Hectares of Crop Area
				--------- (Constant 1975 US$) ---------			(Percent)		
LOW INCOME COUNTRIES	13	184,646	13,521	13,656	185,244	0.8	0.36	13.6	.06
Asia (South)	5	139,656	12,293	11,361	156,187	0.7	0.32	13.7	.06
Sub-Sahara Africa	8	44,990	1,228	36,637	438,448	1.5	0.58	12.0	.04
MIDDLE INCOME COUNTRIES	27	271,638	9,643	28,169	542,365	2.4	0.46	19.3	.08
Asia (Southeast)	9	105,048	5,965	17,611	343,583	2.1	0.35	19.5	.12
North Africa/Middle East	2	4,012	207	19,382	339,023	0.6	0.26	17.5	.03
Sub-Sahara Africa	4	104,915	1,742	60,227	1,111,317	3.3	0.67	18.5	.05
Latin America	12	57,663	1,729	33,350	648,942	2.4	0.50	19.5	.07
HIGH INCOME COUNTRIES	11	357,167	6,211	57,506	1,384,084	3.1	1.07	24.1	.05
Asia (Southeast)	1	1,534	31	49,484	2,478,191	n.a.	0.88	50.1	n.a.
North Africa/Middle East	1	1,575	55	28,636	2,419,355	3.6	1.12	84.5	.13
Latin America	9	354,058	6,125	57,805	1,378,822	3.1	1.07	23.9	.05
TOTAL OF FIFTY ONE COUNTRIES	51	813,451	29,375	27,692	463,329	1.8	0.56	16.7	.06

Table 6: Agricultural Research Expenditure and the Number of Research Scientists Relative to Population, Crop Area and Agricultural GDP, by Agricultural GDP Growth Category, 1980.

	Number of Countries	Research Expenditure (000 Constant 1975 US$)	Number of Research Scientists	Research Expenditure: Per Scientist	Research Expenditure: Per Million Total Population	Research Expenditure: Per 1000 Hectares of Crop Area	Research Expenditure: Proportion of Agricultural GDP	Research Scientists: Per Million Total Population	Research Scientists: Per 1000 Hectares of Crop Area
				(Constant 1975 US$)			(Percent)		
SLOW GROWTH COUNTRIES	15	135,165	4,519	29,910	531,274	2.3	0.52	17.8	.08
Asia	2	19,212	1,868	10,285	186,595	1.7	0.42	18.1	.16
North Africa/Middle East	1	1,575	55	28,636	2,419,355	3.6	1.12	84.5	.13
Sub-Sahara Africa	6	102,570	1,806	56,794	833,327	2.6	0.56	14.7	.05
Latin America	6	11,808	790	14,947	425,974	1.5	0.40	28.5	.10
MEDIUM GROWTH COUNTRIES	14	296,377	13,322	22,247	314,382	1.1	0.50	14.1	.05
Asia	6	121,179	10,450	11,596	153,066	0.6	0.31	13.2	.05
Sub-Sahara Africa	2	6,730	193	34,870	198,314	0.6	0.33	5.7	.02
Latin America	6	168,468	2,679	62,885	1,438,484	2.6	1.00	22.9	.04
RAPID GROWTH COUNTRIES	22	382,203	11,533	33,140	684,314	2.9	0.64	20.6	.09
Asia	7	105,847	5,971	17,727	346,036	2.1	0.35	19.5	.12
North Africa/Middle East	2	4,012	207	19,382	339,623	0.6	0.26	17.5	.03
Sub-Sahara Africa	4	40,605	971	41,818	1,015,201	4.1	1.30	24.2	.10
Latin America	9	231,739	4,379	52,921	1,154,050	3.7	0.96	21.8	.07
TOTAL OF FIFTY ONE COUNTRIES	51	813,745	29,374	27,703	463,497	1.8	0.56	16.7	.06

in research to agricultural GDP was 0.36 in the 13 low-income countries, 0.44 in the 26 middle-income countries, and 1.10 in the 11 high-income countries. Overall the average was 0.56, but it varied from 1.94 in temperate South America to 0.22 in humid tropical Africa.

In 1975 we calculated an average of 0.31 percent for the 65 countries included in IFPRI's Working Paper No. 30, with 0.26 percent in the low-income countries, 0.42 percent in middle-income, and 0.33 percent in high-income countries. About a third of the countries surveyed had reached or passed the 0.5 percent goal. Thus, the 1980 figures represent a distinct change; the overall average has risen and about 50 of the countries have now exceeded 0.5 percent.

However, there are certain problems in using percent of agricultural GDP as a yardstick; if a country's research funds are effective in accelerating the growth rate of agricultural production, there may be a problem in raising research expenditures pari passu with the additional flow of money. This could apply particularly to countries with a modest number of trained scientists whose systems lack absorptive capacity for large increments of funds, or where foreign exchange is a constraint. Conversely, research expenditures and research results may have had little impact on production because of other (non-research) constraints.

Thus, some caution needs to be exercised about the use of agricultural GDP as the basis for judgment as to the adequacy of research systems. For this reason we feel that the 1990 target of 2 percent of agricultural GDP for Third World countries suggested in the 1981 World Bank Sector Study on Agricultural Research needs to be viewed with considerable reserve. We will review later some of its implications for expenditures and training.

Expenditures in Relation to Population and Cropland

The expenditure/income group relationship appears more striking when looked at in the light of other criteria. Expenditure per million of total population ranges from $156,000 in the five poor countries of South Asia (Bangladesh, India, Nepal, Pakistan, and Sri Lanka) which contain half of the total population of 1.75 billion of the 51 countries, through $1.4 million in the middle-income countries of Africa and the high-income Latin American countries, and rising to over $2.40 million in two high-income Asian and African countries. By average of income group, it is $185,000 per million population for the 13 low-income countries, $517,000 per million for the 26 middle-income countries, and $1,414 million for the high-income group of 12 countries. The overall mean is $460,000, depressed by South Asia.

In relation to 1,000 hectares of cropped land ("arable and permanent crops" as defined in the 1980 FAO Production Yearbook), expenditure was under one dollar ($0.7 in South Asia) for the low-income countries, $2.3 in the middle-income, and $3.2 dollars in the high-income group. The latter countries are almost all in Latin America. The overall mean was $1.8 expenditure per 1,000 hectares.

STAFF DEVELOPMENT IN NATIONAL RESEARCH SYSTEMS 1970-1980

In terms of numbers of scientists, there has been a major growth between 1975 and 1980. For the 47 countries with data for all three years in Table 2, the number has risen from an estimated 12,740 1971 to 22,250 in 1975, and to almost 30,000 in 1980: an increase of 134 percent over 1971 and a compound growth of nearly 6.10 percent. Since in this study we were able to draw to a large extent on reports obtained direct from countries or through donor agencies, the information for 1980 can be considered more reliable than that available for 1975, of which much was from secondary published sources (UNESCO, the Commonwealth Bureau, etc.).

Distribution of Scientists

The distribution of scientific staff among Third World countries seems less uneven than that of expenditures. In Table 4, the numbers of scientists located in the five countries with the largest expenditures represent about 46 percent of the total for the 51 countries for which we have 1980 data; the distribution of funding indicated 62 percent of expenditures in the five countries. However, when the ten next largest investors are included, the 15 comprise 86 percent of all scientific staff. Even so, a considerable number of countries outside this group have establishments of around 100 or more scientists, including Nepal, Papua New Guinea, Sri Lanka, Syria, Senegal, Sudan, Ghana, Tanzania, Zambia, Dominican Republic, Guatemala, Jamaica, Bolivia, Ecuador, Peru, Chile, and Uruguay. Applying the yardstick suggested by Sprague (1973), which IFPRI used in Working Paper No. 1, a staff of about 100 would permit three national commodity programs to be operated, each with a central station and three to four substations. Several of the countries mentioned above have graduate staffs of 200 to 300.

On a regional basis (Annex 1 Tables A & D), many Asian and S. American countries have now achieved what we consider to be a critical mass of scientists able to contribute significantly to the solution of their national agricultural problems and to make an important future impact on increasing knowledge of how to manage resources of the tropics and subtropics for more efficient, and sustained agricultural use. Bangladesh, the People's Republic of China, India, Indonesia, Korea, Pakistan, the Philippines, and Thailand each have more than 1,000 scientists; Malaysia, Sri Lanka, and Taiwan each have over 400. These countries represent 90 percent of the population of Asia (outside the Near East), and two-thirds of the world population. In South America eight countries have over 250 scientists, and these represent 86 percent of the regional population.

Numbers of scientists are lower in most of Africa, although rapid progress has been made in training local scientists in Ghana, Ivory Coast, Kenya, Nigeria, Senegal, Sudan, Togo, and Tanzania. Few other countries approach 100 scientists in all, and the majority fall well below this number. We found it particularly difficult to

obtain information on the countries of Southern Africa (Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, Swaziland, and Zimbabwe). Several of the countries are small, somewhat isolated, and recently independent after a period of political uncertainty and instability. They have had little chance to build viable research systems.

Two other areas which appear to face difficulties for somewhat the same reasons, are the Pacific Islands and the Caribbean. Central American countries -- although generally larger and less isolated than the islands and mostly not newly independent -- are relatively small in size, population, and resources (with the exception of Mexico). Most have between 60 and 120 scientists.

Next to Southern Africa, the Near East-North African region is now the one where data on staff numbers and research establishments are weakest. A ten-year time series could only be presented on four countries (Cyprus, Jordan, Syria, and Sudan), and for most others information seems to be lacking beyond 1976. However, in that year we recorded nearly 2000 scientists working in Egypt, around 500 in Iran and Morocco, 206 in Tunisia, and over 100 in Libya and Iraq. Projected to 1980 at the average growth rate for the middle-income group countries of 8.50 percent per annum, there would now be 2,750 in Egypt, 690 in Morocco, and 285 in Tunisia. Iran, Iraq, and Libya are high-income countries whose average growth rates of scientist numbers have been of the order of 5.4 percent annually during the 1970s. Projected at this growth rate from 1976, their numbers of scientists would have risen to 620, 164, and 138, respectively. Thus a majority of the countries within the Mediterranean climatic region may have moderately strong agricultural research systems at the present time. Afghanistan, Cyprus, Jordan, and Lebanon are probably exceptions, because of the small size of their research staffs and because of the political instability they have suffered.

When examined in the light of economic and social criteria, marked differences are apparent by income group and geographical region in investment per scientist and scientist numbers per million of total population and per 1,000 hectares of cropped area. The differences are illuminated by Tables, 5, 6, and Annex 2.

Expenditure per Scientist by National Income Level

Although the low-income countries of South Asia had the largest number of scientists in 1980 (42 percent of the overall total for the 51 countries), the expenditure per scientist there was the lowest of any region, less than one-third of that in the African low-income countries.

Among the middle-income countries, expenditures per scientist were also lowest in Asia and second lowest among all categories next to the Asian low-income countries. The African middle-income countries were spending more per scientist than any other regional or income group, nearly $60,000 per scientist in 1975 dollars. Next, and close behind, were the high-income Latin American countries, with 21 percent of all the scientists and an average expenditure of $57,000. Asia has the most scientists (62.2 percent

of the total), then Latin America with 27.5 percent, sub-Saharan Africa with 9.4 percent, and the Near East with just under 1 percent. However, as emphasized above, we have been able to include only a small sample of Near East and North African countries.

Numbers of Scientists in Relation to Population and National Income

As with the expenditure figures, there is a strong upward progression of scientist numbers by income groups. Numbers of sciencists per million agricultural population rose from 13.6 in the low-income group, through 18.9 in the middle-income countries, to 24.8 in the high-income countries, with a mean of 16.7. Latin America and Southeast Asia emerge as having the highest scientist:population ratios. In this analysis, however, there is one marked difference from the expenditure classification. The region with the least numbers of scientists in relation to population contains the eight low-income countries of sub-Saharan Africa, with 12.0 per million; with the middle-income group of African countries ranking third. This highlights a potential problem in Africa: not only are its scientists relatively costly, they are not numerous. Unless the quality of their work is first class and the support they are given both directly and indirectly (seed services, extension, etc.) is also good, rates of return to investment in research in Africa may be low.

Scientists per Cropped Area

The positive relationship noted above between higher incomes and scientist/population numbers was not apparent with numbers of scientists per 1,000 hectares of cropped area. Scientist numbers do not seem to be strongly related with population pressure on arable land, since there were .06 scientists per 1,000 hectares in South Asia, where pressure is extremely high, and also in South America, where it is generally much lower (only 24 economically active agricultural people per square kilometer of arable land, compared to 104 in Asia). The proportion of arable area irrigated and the cropping intensity per hectare are also higher in South Asia than in either Africa or South America; but scientist intensity per hectare is not strikingly different among all income groups and regions, with the notable exception of middle-income Southeast Asia, where, for a sample of nine countries, it is about double that in most other regions.

Scientists and Agricultural Growth Rates

Southeast Asia is a region of high population pressure on land, with a fairly high proportion of irrigated land, high cropping intensities, and widespread adoption of high-yielding rice varieties. One would therefore expect it to be a region of rapid agricultural growth, and this is the case. Seven of the nine Southeast Asian countries are in the rapid-growth category in Table 6; and the other two, Tonga and West Samoa (which have a different type of agriculture), are in the medium-growth category.

Looking at the larger picture, we see no obvious relationship over the 51 countries as a whole between rapid agricultural growth and either numbers of scientists per million total population or per 1,000 hectares of cropped area. Neither the aggregated averages of slow, medium, and rapid-growth countries nor the regional averages within these three broad groupings show consistent trends. However, the eight countries of sub-Saharan Africa in the slow and medium-growth classes are notably weaker than those in most other regions in terms of these criteria; many have had low or even negative rates of growth of food and agricultural production in the past decade.

This and one other factor suggest that there may be a link between investment in research and scientific training and agricultural growth, which may be masked by lag time between investment and payoff. That other factor is the concentration of rapid-growth countries among the 15 listed in Table 4, in which the bulk of agricultural research investment and scientific manpower is located. Sixty percent of those countries have a record of rapid growth over the 1970s; 20 percent are in the medium-growth class; and only 20 percent are slow-growth countries. Although they spend the most in absolute terms, and all have moderately strong to strong scientific establishments, their investment performance relative to agricultural GDP is mixed. It ranges from 1.64 percent (with four countries exceeding the 1.0 percent level), to as low as 0.16 percent (with four countries spending under 0.3 percent). Their agricultural growth rates vary -- neither the four spending the most nor the four spending the least are clearly superior in agricultural performance. However, a look at the growth-rate data for scientific staff from time series data in Table 7 shows that two of the three slow-growth countries (Bangladesh and Nigeria) have had an exceptionally rapid build-up of national research staff since the mid-1970s. This period is too short to have made a major impact on growth, although there are signs of growth in production now in Bangladesh.

Characteristics of Scientific Staff in 1980

A breakdown of scientific staff by level of training is available for at least one recent year for 32 countries (Table 8), although few reports cite long time series. These figures do not always tally with those for total numbers of scientists, since the two statistics are sometimes to be found in different reports. Moreover, the category indicated as "others," which contains staff trained to first-degree level (B.Sc, B. Vet, Ing. Agronomo, Ing. Agronome, etc.), is often split between the scientist and scientific assistant categories. Also, such information is sometimes cited only for parts of a national research system or for the universities. Thus, the figures in Table 8 should be viewed with some caution and treated at their face value rather than as a means of checking on total numbers of scientists.

A total of 19,732 scientific staff is listed in Table 8 for 32 countries in the latest year, of which 1,743 (8.8 percent) are at

Table 7: 41 Countries Arranged in Order of Growthrates of Scientific Staff, 1970/80.

Countries	Growthrate of Staff	Expenditures as % of Ag. GDP	Growthrate of Ag. GDP 1970-1979 1/	Income Group
Bangladesh	33.32	0.48	1.9	Low
Malaysia	21.90	0.81	5.0	Middle
Togo	20.74	0.76	0.3	Low
Nigeria	17.27	0.70	-0.3	Middle
Ecuador	16.11	0.35	0.7	Middle
Sri Lanka	15.12	0.41	2.6	Low
Indonesia	14.78	0.44	3.6	Middle
Thailand	14.66	0.26	5.4	Middle
Guatemala	14.18	n.a.	5.1	Middle
Uruguay	13.35	0.59	0.2	High
Tanzania	11.34	0.35	4.9	Low
Syria	9.70	0.24	6.4	Middle
Nicaragua	8.82	0.27	4.2	Middle
El Salvador	8.44	0.17	3.2	Middle
Senegal	8.17	1.21	3.6	Low
Brazil	7.49	1.15	5.0	High
Paraguay	7.13	0.28	6.8	Middle
Chile	6.82	0.81	3.5	High
Kenya	6.48	1.08	5.4	Low
Peru	6.26	0.33	0.1	Middle
Bolivia	5.48	0.34	3.1	Middle
Sudan	5.46	0.57	2.7	Low
Mexico	5.16	0.65	2.2	High
Jordan	4.93	0.44	n.a.	Middle
Cyprus	4.85	1.12	n.a.	High
Zaire	4.85	0.20	1.2	Low
Burundi	4.47	0.81	1.8	Low
Venezuela	3.55	1.32	3.8	High
Zambia	3.39	0.80	2.3	Middle
Nepal	3.23	0.20	0.8	Low
Philippines	3.19	0.16	4.9	Middle
Barbados	2.82	1.36	n.a.	High
Korea, Rep.	2.67	0.23	4.8	Middle
India	2.25	0.29	2.1	Low
Costa Rica	1.56	0.24	2.6	High
Argentina	1.05	1.64	2.5	High
Panama	0.30	0.53	2.2	High
Madagascar	-0.64	0.39	0.1	Low
Honduras	-1.82	0.16	1.3	Middle
Jamaica	-3.65	2.16	1.3	Middle
Colombia	-6.23	0.67	4.8	Middle
Average	6.10			

1/ Agricultural GDP growthrates for 1970-1979 taken from World Bank 1981 World Development Report.

Table 8 : Distribution of Scientists Engaged in Agricultural Research by Qualification in Selected Developing Countries

(Parentheses indicate percent of total)

Region/Country	Year	Ph.D.	MSc. (or equivalent)	Others[1/]
ASIA				
Bangladesh	1979	144 (9.0)	1,118 (70.2)	252 (15.8)
Indonesia (AARD)	1979	27 (2.7)	44 (4.4)	934 (92.9)
Korea, Rep.	1972	15 (3.0)	42 (8.5)	438 (88.5)
(Main ORD)	1978	60 (10.2)	130 (22.1)	399 (67.7)
Nepal	1967/68	2 (1.0)	76 (36.4)	131 (62.6)
	1973/74	14 (3.4)	106 (25.5)	296 (71.1)
	1977	9 (4.1)	92 (41.8)	119 (54.1)
Pakistan	1977/78	233 (8.3)	1,405 (49.5)	1,196 (42.2)
Philippines	1970/71	181 (9.7)	400 (21.3)	1,294 (69.0)
	1974	237 (10.6)	509 (22.8)	1,488 (66.6)
	1978	246 (8.1)	593 (19.5)	2,207 (72.4)
Thailand	1974	9 (1.6)	32 (5.5)	533 (92.9)
	1975	9 (1.5)	33 (5.5)	554 (92.9)
	1976	50 (3.9)	196 (15.3)	1,034 (80.8)
	1977	48 (3.6)	187 (14.2)	1,085 (82.2)
	1978	47 (3.5)	193 (14.4)	1,101 (82.1)
	1979	50 (3.5)	192 (13.4)	1,187 (83.1)
NORTH AFRICA/MIDDLE EAST				
Sudan (ARC, Ag. Economics and Livestock)	1980	65 (23.8)	123 (44.7)	84 (31.5)
SUB-SAHARA AFRICA				
Kenya	1970	80 (25.8)	95 (30.6)	135 (43.6)
	1971	89 (25.3)	108 (30.7)	155 (44.0)

Table 8 (page two)

(Parentheses indicate percent of total)

Region/Country	Year	Ph.D.		MSc. (or equivalent)		Others[1/]	
Kenya (continued)	1972	97	(24.3)	134	(33.6)	168	(42.1)
	1973	121	(28.8)	148	(35.2)	151	(36.0)
	1974	149	(32.7)	152	(33.3)	155	(34.0)
	1975	164	(32.7)	172	(34.3)	166	(33.1)
	1976	163	(33.4)	167	(34.2)	158	(32.4)
	1977	161	(31.9)	169	(33.5)	175	(34.6)
	1978	163	(30.8)	193	(36.5)	173	(32.7)
Madagascar	1980	10	(8.4)	37	(31.1)	72	(60.5)
Nigeria	1977/78	151	(30.7)	125	(25.5)	215	(43.8)
LATIN AMERICA							
Argentina	1980	30	(2.5)	235	(19.3)	949	(78.2)
Barbados	1980	3	(16.7)	6	(33.3)	9	(50.0)
Bolivia	1980	----------	23	(9.1)	----------	230	(90.9)
Brazil	1980	280	(9.6)	1,404	(47.8)	1,251	(42.6)
Chile (universities)	1980	59	(24.7)	97	(40.6)	83	(34.7)
Colombia	1974	34	(6.6)	77	(14.9)	406	(78.5)
	1976	32	(8.2)	155	(39.5)	205	(52.3)
	1979	39	(12.1)	145	(45.2)	137	(42.7)
Costa Rica	1980	2	(2.7)	6	(8.0)	67	(89.3)
Dominican Republic	1979	11	(1.1)	109	(10.6)	907	(88.3)
Ecuador	1980	6	(2.2)	67	(24.3)	203	(73.5)
El Salvador	1980	1	(0.8)	7	(5.4)	122	(93.8)
Haiti	1980	3	(8.1)	14	(37.8)	20	(54.1)
Honduras	1980	1	(1.7)	6	(10.0)	53	(88.3)
Jamaica (crops related research only)	1980	2	(5.0)	14	(35.0)	24	(60.0)
Mexico (total)	1974	154	(14.3)	241	(22.3)	684	(63.4)
(INIA only)	1977	43	(8.7)	112	(22.7)	338	(68.6)

Table 8 (page three)

(Parentheses indicate percent of total)

Region/Country	Year	Ph.D.	MSc. (or equivalent)	Others 1/
Nicaragua	1980	----------10 (17.5)----------		47 (82.5)
Panama	1980	4 (10.2)	9 (23.1)	26 (66.7)
Paraguay	1976	2 (6.1)	12 (26.4)	19 (57.5)
	1977	2 (5.5)	15 (41.7)	19 (52.8)
	1978	3 (7.3)	16 (39.0)	22 (53.7)
	1979	2 (4.5)	18 (40.9)	24 (54.6)
	1980	2 (5.1)	17 (43.6)	20 (51.3)
Peru (universities)	1978	37 (6.9)	82 (15.3)	418 (77.8)
(INIA)	1980	4 (1.2)	33 (10.0)	294 (88.8)
Uruguay (university)	1980	---	---	151 (100.0)
(CIABB)	1980	---	9 (12.7)	62 (87.3)
Venezuela	1980	12 (3.3)	103 (28.2)	250 (68.5)

1/ Others: BSc. or equivalent: Ingenieur Agronome, Ing. Agronomo, etc.

Sources of basic data:

ASIA:

Bangladesh: Elias 1981 (Table 1, p.6).
Indonesia: Boyce 1980 (Table 3.8, p.32).
Korea, Rep.: Boyce 1980 (Table 6.2, p.95).
Nepal: 1967/68 and 1973/74: Yadav 1976 (Table 1, p.31).
1977: Report of the Joint Review Committee 1976 (Appendix V, p.2).
Pakistan: Ahmed 1981 (Table 7, p.18).
Philippines: 1970/71: Boyce 1980 (Table 4.5, p.51).
1974 and 1978: Drilon et al. (Table 3).
Thailand: Isarangkura 1981 (Table 8, pp. 25-27).

SUB-SAHARA AFRICA:

Madagascar: Personal communication 1980.
Kenya: Jamieson 1981 (Table 3.5, p.85).
Nigeria: Idachaba 1980 (Table 15, p.30).
Sudan: Agricultural Research Capabilities (Report of Joint Review Team 1977: pp. 26-40. Tables 4 and 5 and Annex 3).

LATIN AMERICA:

Pineiro & Trigo in all cases except Colombia.
Colombia: Chapparo et al. 1981 (Chart No. 10, p.16).

Ph.D. level, 5,263 (26.7 percent) at M.Sc. or unspecified post-graduate level, and 12,726 (64.5 percent) are at first-degree level. In comparison with an earlier year (1974 or 1975 where possible), there has been a notable improvement in the numbers of post-graduate staff, which have risen by 42 percent in the eight countries with time series data for level of education; although many countries still rely heavily on first-degree level staff as the backbone of their research services, and the proportion of post-graduate staff in the eight countries mentioned above (28 percent) has changed little over time. Many of the first-degree staff have acquired considerable experience and valuable local knowledge over time, but their level of training varies considerably with the different origins and standards of their national educational systems. Their wisdom is not to be belittled, but they may lack conceptual and management skills for running an expanded, modern research system. Twelve of the countries have under 10 Ph.D. level scientists, indicating a continuing need for higher scientific education.

The sample of 32 countries is small from which to draw regional conclusions, but the 7 Asian and 20 Latin American countries show fairly consistent characteristics, with 64 to 68 percent first-degree staff, about 23 to 28 percent at the masters level, and 7 to 8 percent with a Ph.D. or equivalent. The four African countries (Kenya, Nigeria, Madagascar, and Sudan) probably represent a typical sample for the current state of national systems on that continent, as they have on average a higher proportion of post-graduate staff to first graduates (27 percent Ph.D., and 37 percent at M.Sc. or equivalent) than either the Asian or Latin American countries included in Table 8. Three of them (Nigeria, Kenya, and Sudan) have relatively large scientific staffs, whereas in most other African countries there is a severe shortage of trained local persons.

In a number of cases local staff are still being supplemented by expatriate scientists and, although there is no complete published record of their numbers, a review of recent reports presented to the CGIAR, to FAO, and from correspondence with IFPRI, indicates that they total at least 5,000. Another report states that 10 European countries have between them as many as 10,000 agricultural professionals in overseas assistance programs.* While their distribution is widespread, the largest number of expatriate scientists is in the francophone countries of Africa, Southern Africa, the Caribbean, and the Pacific Islands -- the regions where they are probably needed most and provide a valuable, if somewhat ephemeral, leavening of experience in research management while national expertise is being built up.

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*Preparing Professional Staff for National Agricultural Research Programs. International Agricultural Development Service, New York, N.Y., 1979.

Several donors have established special organizations to provide backstopping to their field staff and to undertake joint research with Third World institutions.

SUPPORT SERVICES TO AGRICULTURAL RESEARCH

In IFPRI's Working Paper No. 30 it was concluded that, in many countries, scarce scientific staff were neither adequately supported by trained assistants nor properly backstopped by well-equipped national seed distribution and extension services. As a result their attention was being diverted from research to other duties, and their results were not getting out to farmers.

Technician to Scientist Ratios

With respect to supporting scientific assistants, the situation seems to have improved, but with marked regional differences. The data in Table 9 covers 64 countries, twice as many as we were able to include in 1975; 47 percent of those 64 countries have at least one research technician per scientist, compared to 37 percent in the 1975 analysis -- which was mostly based on UNESCO data from 1969 or the early 1970s. (The present analysis is mostly drawn from 1976 or later country data and relates strictly to agriculture, whereas the UNESCO data also covered other technicians and scientists.)

However, scientists in some regions are still served by few technicians, especially in Latin America. Only 20 percent of the countries in that region have a ratio of one or more assistants per scientist, and only one of the nine higher-income South American countries is in that position. By contrast the four South Asian countries all exceeded a 1:1 ratio, as did five of the seven Southeast and East Asian countries. The 14 countries of the Near East and 19 of sub-Saharan Africa occupy an intermediate position: 44 percent of those from the former region and 53 percent from Africa having one or more technicians per scientist. In the 1975 analysis the percentages were 20 percent for Latin America; 43 percent for Asia and the Near East; and 47 percent for sub-Saharan Africa. Thus, in Latin America the position has not improved, in Africa it has shown some progress, and national systems in Asia have made considerable advances. The more satisfactory technician: scientist ratios in Asia may stem from the good facilities for training intermediate level technical staff there and their relatively low salary costs.

Extension services

Initially it was not thought feasible under the time limitations of this study to obtain adequate information concerning extension services to derive any inferences about technology transfer systems. The useful data on extension from Boyce and Evenson had not been updated, and IFPRI had been unable to incorporate any new material into Working Paper No. 30.

Table 9: Ratio of Technicians to Scientists in National Agricultural Research Systems: 1970's

Region/Sub-Region and Country	Ratio Technicians: Scientists	Year of Reference
ASIA		
South Asia		
Bangladesh	1.25[c]	1978
India	1.08[d]	1978
Nepal	1.27[e]	1980
Southeast/East Asia		
Fiji	2.57[a]	1976
Indonesia	2.09[a]	1980
Korea, Rep.	0.37[a]	1976
Malaysia	3.61[f]	1980
Papua/New Guinea	1.14[a]	1976
Philippines	1.85[a]	1976
Sri Lanka	1.27[a]	1976
Thailand	0.51[g]	1979
NORTH AFRICA/MIDDLE EAST		
Afghanistan	1.38[a]	1976
Algeria	0.41[b]	1972
Cyprus	1.29[a]	1976
Egypt	0.93[a]	1976
Iran	0.68[a]	1976
Iraq	1.04[a]	1976
Jordan	0.38[a]	1976
Libya	0.33[a]	1976
Morocco	1.44[a]	1976
Oman	0.38[a]	1976
Sudan	2.59[h]	1977
NORTH AFRICA/MIDDLE EAST (continued)		
Syria	0.53[a]	1976
Tunisia	1.32[a]	1976
Turkey	1.00[a]	1976
Yemen PDR	0.77[g]	1976
SUB-SAHARA AFRICA		
West Africa		
Congo	0.69[a]	1976
Ghana	2.71[i]	1980
Ivory Coast	0.14[k]	1980
Liberia	1.60[a]	1976
Nigeria	7.36[l]	1980
Senegal	1.03[a]	1976
Togo	0.32[g]	1980
Upper Volta	0.67[a]	1976
Zaire	0.85[a]	1976
Eastern/Southern Africa		
Botswana	0.75[b]	1973
Ethiopia	1.65[a]	1976
Kenya	1.16[m]	1980
Madagascar	1.40[g]	1979
Rwanda	0.39[a]	1976
Somalia	0.79[a]	1976
Swaziland	2.67[a]	1976
Uganda	0.52[a]	1976
Zambia	1.73[a]	1976

Table 9 (page two)

Region/Sub-Region and Country	Ratio Technicians: Scientists	Year of Reference
LATIN AMERICA		
Central America/Caribbean		
Costa Rica	0.41[j]	1980
Dominican Republic	1.63[j]	1979
El Salvador	1.12[j]	1980
Guatemala	0.67[j]	1980
Haiti	1.97[g]	1976
Honduras	0.75[a]	1976
Jamaica	0.78[j]	1980
Mexico	1.77[b]	1971
Nicaragua	0.46[j]	1980
Panama	0.67[j]	1980
Trinidad/Tobago	0.50[b]	1970

Region/Sub-Region and Country	Ratio Technicians: Scientists	Year of Reference
LATIN AMERICA (continued)		
South America		
Argentina	0.38[j]	1980
Bolivia	0.32[j]	1980
Brazil	2.56[j]	1980
Colombia	0.68[j]	1976
Ecuador	0.31[i]	1980
Paraguay	0.38[j]	1980
Peru	0.61[a]	1976
Uruguay	0.94[b]	1971
Venezuela	0.59[b]	1970

Data Sources:

a/ FAO 1978. (CARIS Project.)
b/ Oram 1978. (IFPRI Working Paper No. 30.)
c/ Boyce 1980 (Table 5.3, p.78); the figure refers to 1977/78.
d/ Government of India 1979 (p.273). The figure is the ratio of the technical staff to the scientific staff employed by the ICAR and its research institutes.
e/ Sharma 1980 (Tables 3 and 4).
f/ Mustapha 1980 (Table 4, p.11); the figure refers to MARDI.
g/ Personal communication.
h/ Joint Research Review Team Report 1977.
i/ Council for Scientific and Industrial Research. ACCRA 1980.
j/ Pineiro & Trigo.
k/ Commission des Programmes de Recherches, Ministre de la Recherche Scientifique 1981.
l/ The figure reported is from the Green Revolution National Committee, "Report of Research Institutes Review Panel 1980/81" (Vol. 1). Other estimates for Nigeria are:
0.98 for 1976 from FAO 1978
5.63 for 1977/78 from Idachaba 1980 (Table 14, p.29)
m/ S. N. Muturi, Resource Allocation to Agricultural Research in Kenya. National Council for Science and Technology, Nairobi.

It was found, however, that a comprehensive study of the state of national extension services in developing and industrialized countries was published recently by the University of Illinois (Swanson and Rassi 1981). The data are presented, with some re-ordering, in Annex 5. Although these do not give time series data or costs, they provide a great deal of other useful information on the nature, staffing, location, and levels of training of extension staffs in 70 countries. Not all these countries are covered in our study, while some countries included here are not in the Illinois report. These are mainly in Africa. There are, nevertheless, about 40 countries covered in both studies, and this makes a useful base for comparison.

In 1980 there were about 284,000 extension staff in Third World countries as a whole, of whom about 25 percent were graduates. The distribution of extension graduates and of total numbers is compared to that of research staff in Table 10. This shows marked similarities in the proportionate distribution of extension and research staffs, especially with respect to graduates.

Graduates in Research and Extension. About 70 percent of graduates in both research and extension services, and a somewhat higher proportion of the total staff, are located in Asia and about a quarter are in Latin America. There are inter-regional differences -- for example, there are relatively more graduates in research services in Southeast Asia than South Asia, and the reverse is the case with extension. There are more research graduates relative to extension graduates in the Central America/Caribbean and temperate South America regions than in tropical South America. In the latter, the figure is biased by the large number of graduate extensionists in Brazil, similar to the case of India in Asia. However, the average level of graduation of extension staff (15 to 16 years of formal education) is probably lower than for the research services.

Nevertheless, the salient fact is that two geographical regions (the Near East and Africa) with almost half of the countries (34 in all out of a total of 71) have only about 12 percent of the total recorded extension staff, while one region of 17 countries has nearly 80 percent. As with research staff this seems to be an imbalance but it is not in terms of the distribution of agricultural population in the Third World. Annex 5 shows that the match on a regional basis is actually good with 76.4 percent of total agricultural population in Asia, 6.8 percent in the Near East, 6.8 percent in sub-Saharan Africa, and 11.8 percent in Latin America. The corresponding percentages of total extension staff in each region are 79.3, 6.1, 6.2, and 8.4. Subregionally the comparison is not as good: more staff could be allocated to extension in South Asia compared to population and less in East and Southeast Asia; more to Eastern/Southern Africa relative to West Africa; and in the Central American Caribbean region compared to South America.

The same is basically true of research, except that the distribution of graduate research staff compared to population is more skewed towards Latin America, particularly towards South

Table 10: Distribution of Extension and Research Staffs 1980: 34 Comparable Countries[1/]

Region	Extension				Research			
	Total number	% of total	Graduate staff	% of total as graduates	Total number	% of total	Graduate staff	% of total as graduates
Asia (14)	155,334	88.0	37,992	24.4	37,976	68.8	16,816	44.2
S. Asia (5)	118,233	67.0	29,469	24.9	25,986	47.1	12,293	47.3
S.E. Asia (9)	37,101	21.0	8,523	22.9	11,990	21.7	4,523	37.7
Near East (3)	591	0.3	264	44.7	561	1.1	262	46.7
Africa (2)	1,966	1.1	122	6.2	278	0.5	154	55.4
Latin America (15)	18,646	10.6	13,740	73.7	16,342	29.6	6,584	40.3
Central America (8)	4,405	2.5	2,209	50.0	2,386	4.3	1,593	66.8
South America (7)	14,241	8.1	11,531	81.0	13,956	25.3	5,056	36.2
Totals	176,537	100.0	52,118	29.6	55,157	100.0	23,816	43.2

1/ Total staff for both extension and research includes non-graduate technical personnel.

Note: the figures in parentheses denote the number of countries in each region.

Source for Extension: Adapted from Swanson, B.E. and Rassi, J., International Directory of National Extension Systems, University of Illinois, 1981.

America, than is the case with extension staff. However, when considered in terms of the distribution of graduate extension staff, the imbalances are greater: only 3.4 percent of total graduate staff is located in the Near East, 3.6 percent in sub-Saharan Africa, and 3.9 percent in the Central America/Caribbean region. 51 percent is in South Asia and 19 percent in Tropical South America. Since graduates are employed to a large extent in managerial, administrative, and subject-matter specialist capacities, it appears that the direction of extension services is likely to be poorest in the difficult semi-arid environment of the Near East and Africa and in the small or poor countries of Africa, Central America, and the islands, which have limited capacity to support a viable technology development system.

In view of Evenson's earlier observations on the imbalance between investment and research and extension in the Third World countries, it is pertinent to consider whether and how this situation may have changed in the 1970s. Direct comparisons are not easy, partly for lack of financial data and partly because of missing links between Evenson's and Swanson's data, both in terms of time and in country coverage. These are particularly large with respect to African and Near East countries, for which the data are really not comparable. Asia and Latin America are more complete.

Total Extension Staffing. For these two regions Swanson's 1980 tables indicate a total extension staff of approximately 177,500 for Asia and 19,000 for Latin America. Boyce and Evenson's figures for the same countries, taken for 1971 from their time-series, are 130,300 and 10,760 respectively. The 1980 indices are 136 for Asia and 177 for Latin America, taking 1971 as 100. For research the comparative indices (shown in Table 11 below) are 376 and 150. Earlier we noted that the figures cited by Evenson showed that although investment in research was increasing faster over time than that for extension in most income groups, this did not appear to be the case for the poorest countries. Measured in terms of staff, this situation now appears to have changed in some regions.

Table 11 shows that the poorest subregions in each continent, South Asia and Central America/Caribbean, show the fastest expansion of both extension and research staffs. For Asia as a whole, the expansion of research systems seems to have been consistently higher than that of extension, presumably reflecting their rapid build-up in the 1970s for such countries as Bangladesh, India, Indonesia, Korea, Malaysia, and Thailand. In Latin America, particularly in the higher income countries of South America, there are a number of countries with relatively old, established national research systems; with a few exceptions, such as Brazil and Ecuador, these have expanded more slowly than those in Asia.

Research to Extension Balance. A question often asked is "What is the optimum balance between investment in research and extension systems?" It is difficult to generalize, and perhaps the question can only be answered on an individual country basis. The World

Table 11. Indices of Change (Numbers of Staff), 1971-1980, Asia and Latin America

	Extension			Research		
	1971	1980	Index	1971	1980	Index
Asia	130,300	177,480	136	4,814	18,123	376
East Asia	19,300	25,473	132	550	960	174
South Asia	77,000	115,200	150	2,529	12,293	486
S.E. Asia	34,000	36,807	108	1,945	4,870	250
Latin America	10,762	19.004	177	5,067	7,619	150
Central America/ Caribbean	1,988	4,639	233	967	1,680	175
S. America	8,774	14,365	164	4,100	5,939	144

Sources: 1971: Boyce & Evenson, 1975 (op cit). 1980: Extension, Swanson & Rassi, 1981.

Bank, which has been investing considerable sums in both research and extension during the 1970s, has been spending about one-third on research and two-thirds on extension. Its sector policy paper on research advocates raising expenditure on research so that the balance of investment is about 1:1 in the 1980s.

We are not able to present a reasoned view of this suggestion. As in the case of expenditure targets as a proportion of agricultural GDP, we feel that there is no empirical evidence to show that a given figure will or will not result in some sort of scientific take-off. These are interesting issues for further research. All that can be said from our current study is that, at least in some of the low-income regions, research investment now seems to be moving faster than that in extension.

Whatever the ideal balance may be, extension systems in Third World countries are still seriously understaffed in practically all geographical regions compared to those in the industrialized countries. On the basis of the relation between staff and agricultural population (which is probably a better measure of adequacy for extension than for research), only one subregion -- East Asia -- has staff/agricultural population ratios comparable to any industrialized region. (This applies to total staff rather than to graduate staff.)

All other developing countries fall short of these ratios. The averages of total staff per 1000 agricultural population are 1.27 in the industrialized regions and 0.26 in the Third World countries; of graduate staff, .775 and .064, respectively. The United States and Canada have nearly three graduates per 1000 agricultural population. When the vast areas, poor communications, low levels of literacy, and large numbers of small farmers in the Third World are taken into account there is clearly a heavy task of improving the whole system of technology transfer, including research, extension, and other supporting services.

Standards of Seed Production and Distribution Systems

In Working Paper No. 30 we noted, "The successful dissemination of the improved genetic material developed by the International Agricultural Research Centres or national research systems, as well as the direct transfer of improved seeds from one country to another depends heavily on efficient national seed production and distribution systems." On the basis of an FAO (1973) analysis of 30 countries, we concluded that many did not have adequate organizations either for varietal improvement or for the production and distribution of improved seed -- a weakness compounded by the absence of a strong private seed industry.

The FAO analysis was based on studies undertaken in 1971/72, and FAO has been giving high priority since the mid-1970s to helping countries improve their national seed organizations. Nevertheless, a number of reports for countries in every region stress that deficiencies in seed services still represent a constraint on the successful utilization of research results. It has not proved possible to obtain comprehensive information to update Table 4 in Working Paper No. 30 in a systematic fashion, but the seriousness of the situation is clear. The joint 1978 World Bank/IDB/AID/IADS report on Agricultural Research and Farmer Advisory Services in Central America shows large gaps between needs for seed and seed availability for the four basic grains in the six countries studied, as well as deficits in seed storage capacity averaging 80 percent of need -- the range is from 72 to 99 percent (Table 12).

Table 12. The Need and Availability of Seed of the Four Basic Grains in the Central American Region During the Period 1975-76.

Country	Needs (000 m.t.)	Availability (000 m.t.)	Public Sector	%	Private Sector	%	Storage Capacity (000 m.t.)	Deficit %
Honduras	8.13	0.86	0.86	--	--	--	1.14	86
Panama	13.32	4.99	4.99	--	--	--	2.27	79
Guatemala	21.49	1.87	0.39	20.7	1.48	79.3	0.28	99
El Salvador	9.02	3.37	0.56	17	2.81	83	2.50	72
Costa Rica	11.47	6.64	3.39	48	3.25	42	2.18	81
Nicaragua	9.26	1.73	0.07	.04	1.66	95	1.93	79
Totals	72.69	19.46	10.26		9.20		10.80	85

Source: Echandi and Gonzalez, IICA, 1978.

It is noteworthy that while these are mostly small countries with modest national research services, they are not among the lowest income group, and the report concludes that their extension services are adequate. If this conclusion is correct, availability of seed may be the factor limiting expansion of food production. For the 36 low-income countries which form the core of the world

food problem, deficits in seed supply and storage also impose serious constraints on production. (Oram et al 1979. IFPRI research Report No. 10).

Most national research systems are strongly oriented to crop improvement and to plant breeding as a major tool for this purpose. A priority aim of research, endorsed in global studies and by many donors, is to improve crop genetic adaptability to adverse soil and climatic conditions, resistance to pests and diseases, and ability to fix nitrogen biologically. If these aims of research are to be achieved, national services to develop and distribute improved seeds and inoculum will become even more critical to success.

MANAGEMENT FACTORS AFFECTING THE EFFICIENCY OF RESEARCH

One conclusion which emerges strongly from the analysis of many country reports is the importance of sound management and administration to the planning and successful conduct of research. Although this is a firm conclusion, it is hard to quantify because it bears largely on the quality of research systems. When money and/or trained people are critically short, it may be difficult to make much headway even with good management. As more countries reach critical mass in numbers of staff, and as levels of training of staff improve, management will increasingly become the main determinant of their effectiveness.

Efficient research management has many facets; all will not be discussed here, but we have singled out four aspects which cross-country analysis indicates as being particularly important. These are: (a) improving coordination and allocative mechanisms for research resources: (b) overcoming location specificity: (c) financing recurrent expenditures: and (d) the congruence of resource allocations to research priorities. Although these will be discussed briefly under these separate headings, they are, of course, closely inter-linked in terms of management policy and decision-making.

Mechanisms for Coordination and Resource Allocation

Like other subsectors of the economy, research has to compete for funds within an overall budget; it is allocated resources not simply because it is a good thing, but because those who manage it can demonstrate to policy-makers that the funds will be effective in achieving national objectives and priorities, as well as being efficiently utilized. If they perceive some important use for resources other than those indicated by the planners, research directors have to be able to convince planners of its worth. They also have to be able to communicate scientific problems and time horizons to politicians impatient for results.

This is not always easy and requires dialogue and communication between those who plan and manage research and those who give direction to the national economy and thus provide the broad

economic priorities for research. Evidence from several national reports suggests that this dialogue is often absent or infrequent, leading to a lack of understanding, "stop-go" funding of research, and misallocations of resources. Lack of regular contact and appropriate machinery of government for such a contact may be a major reason for this failure of communication. The repercussions extend through the research system and can seriously affect morale; Idachaba (1978), and Pineiro and Trigo (1980) have documented adverse effects on the conduct of research and the retention of qualified staff.

Another important reason for having an effective mechanism for coordination of planning and resource allocation is the frequent fragmentation of components of research among several ministries or other organizations, including universities. In some countries six or seven ministries are involved. This fragmentation, as opposed to planned dispersion, makes effective planning and resource allocation and the avoidance of unnecessary duplication extremely difficult. In consequence, research yields on investment are low and allocations of funds may be reduced. The presence of a number of donors in most developing countries, also undertaking research, may compound the difficulties.

These problems have led to pressure for the introduction of machinery for coordination, usually in the form of an agricultural research council or sometimes a science council. Such organizations have sometimes proved very effective; in other cases they have merely imposed another layer of bureaucracy in an already complex situation. Study of their history and usefulness in developed and developing countries could well be rewarding both to those who now have them and for those who may be considering setting them up.

Overcoming Location-specificity in Research

In many countries national research is not only highly fragmented among many ministries at the planning level, but also highly dispersed across the country in an attempt to meet local socio-economic situations, special environments, or particular commodity needs. The degree of dispersion of stations and staff identified by Oram and Devred, and referred to earlier, was based mainly on information collected by FAO from numerous sources, especially regional scientific organizations during the late 1960s. Since this is now out-of-date in many respects, we attempted to collate new information from recent reports on national systems; this is listed in Table 13. It is neither as elegant nor as precisely broken down by category of station according to size of staff as was the earlier FAO paper. Nevertheless, it does show that there are still many regional and substations in addition to national level institutions and laboratories, suggesting that a number of stations may lack funding and critical mass of staff for the effective conduct of research -- an indication confirmed by numerous individual comments in reports. This situation is widespread among all regions, and in large countries as well as small. The problem of trying to be all things to all people is probably most severe in:

* Countries with a wide environmental range, including some such as India, Thailand, China, Ghana, Nigeria, Turkey,

Table 13: Distribution of National and Regional Stations: Selected Developing Countries, 1980.

Country	National Stations	Regional or State Stations	Sub-Stations or Labs (L)	Number of Scientists
ASIA				
Bangladesh	9	35	15	1,642
People's Rep. of China 1/	50	138	* 1/	n.a.
India 2/	33	21 (Univ)	81	7,103
Indonesia	5	36	131	1,473
Malaysia	5	26	--	822
Nepal	15	--	36	226
Philippines	11	8	35	1,050
Sri Lanka	5	n.a.	n.a.	422
Thailand	12	4	180	1,525
Fiji	1	10	--	22
Papua New Guinea	6	--	n.a.	110
Solomon Islands	4	--	n.a.	8
AFRICA				
Ghana	9	n.a.	n.a.	352
Ivory Coast	7	n.a.	n.a.	210
Kenya	14	11	5	400
Madagascar	14	14	6	68
Nigeria	16	--	40	1,084
Sudan	2	5	12	212
Togo	8	n.a.	n.a.	49
Zambia	3	9	11	96

Country	National Stations	Regional or State Stations	Sub-stations or Labs (L)	Number of Scientists
LATIN AMERICA				
Costa Rica	1 (Univ)	3	6 (L)	75
El Salvador	5	--	--	116
Guatemala	--	8	--	123
Guyana 3/	1 (Univ)	8	--	27
Honduras	--	6	--	60
Mexico	8	11	54	1,079
Nicaragua	1	6	--	63
Panama	1	6	3 (L)	64
Argentina	1	13	30-40	1,064
Bolivia	--	15	--	114
Brazil 4/	12	35	* 4/	2,957
Chile	3 (Univ)	5	8	281
Colombia	--	23	13 (L)	333
Ecuador	5	--	--	276
Paraguay	--	13	--	63
Peru	16 (15 Univ)	7	19	269
Uruguay	2 (1 Univ)	10	--	222
Venezuela	6	19	46 (L)	360

1/ Stavis' estimates: 13,000,000 communal agricultural workers, at 200-400 per commune, with 80% of communes having own Research Stations = 17,333 Research Stations.

2/ Excludes Forestry Research Stations.

3/ Guyana's private Sugar Board has 1 headquarters, 7 stations, and 100 scientists, however, and their Rice Board and other private groups carry out other research.

4/ There were 575 sub-stations according to 1966 figures; also 59 in state of Sao Paulo and others in other states.

Sudan, Mexico, and Brazil, which cut across ecological zones due to size, and others which do so because of the influence of altitude (Ethiopia, Kenya, Tanzania, Nepal, and the Andean countries). Here widely different crops and disciplinary problems are encountered in each ecological zone; researchers may be dealing with temperate pastures, wheat, and dairy cattle in one part of the country and cassava and coconuts in another.

Countries with small staffs and poor communications -- the Sahelio/Sudanian zone of Africa, mountainous regions, etc. In the latter many micro-climates may be encountered.

* Among island communities.

It is difficult to describe how best to overcome problems arising from location-specificity, but it is important that all countries, as well as donor agencies which offer them funds or advice (and may add to their difficulties of resource allocation by locating new projects there), review their establishments from time to time to determine whether and where to consolidate resources most effectively.

A solution often attempted is to serve the needs of small countries by establishing regional research institutions. Several are in operation today; a number have also foundered and broken up, usually because of changing political circumstances. What role regional institutes might play for the smaller countries, and how their focus might change as larger, richer Third World countries build up their own systems, is a question yet to be resolved and one which is under active study by ISNAR.

Recurrent Funding Needs

A matter for concern is the high proportion of salaries to operating costs in some countries, perhaps many. Accurate information is not available on this for all countries, nor is it easy to tabulate. However, for a number of those where it is recorded, the bulk of recurrent expenditures seems to be for salaries. Inflation and increasing numbers of scientists returning from training are eroding operating budgets. In several cases little remains for operations, implying both a high degree of inefficiency in the use of the scarce resource of trained scientists and a high level of frustration among those scientists keen to do a good job. It could often be more productive to have a smaller but better supported research establishment, although this is a decision which the research managers themselves may be reluctant to make. Success in achieving food production objectives which may lead to a shortage of local currency as a result of the cessation of food aid shipments, may further confound recurrent cost financing problems.

To some extent also donors are culpable here since a number are hesitant to finance recurrent expenditures and some impose an absolute sanction on such support. Yet the fruits of capital investment depend on the effective deployment and retention of trained human resources.

We have received numerous reports of scientists leaving public sector research systems after only two or three years of service because of a lack of operational support. While this is especially so in Africa, where trained people are in great demand, it is also a matter of concern in Latin America -- as is apparent both from the study of South American countries by Pineiro and Trigo and from the joint report on Central American research systems cited earlier. This states, "The study team concludes that professional staff, in general, are not being used effectively and that one important reason is the lack of budgetary support for operational costs. There is a limit to the number of investigations that can be properly supported, and new ones should not be added unless there is a firm commitment to provide the budget needed to support them." Idachaba also stresses the need for continuing consistent government commitment to support for research which, because of its long-term nature, is particularly vunerable to short-term fluctuations in funding policy.

The Congruence of Resource Allocations to Needs

An important issue which we would like to examine in more depth is that of the relevance of the application of research resources to national priorities and, in aggregate, to the world's key crops and the needs of the major ecological zones. This was addressed in an innovative manner by Boyce and Evenson, under the heading of "congruence," using numbers of publications in various catagories as well as other criteria.

We were unable to obtain new information from sufficient countries on the distribution of resources or publications among the major crops and livestock to draw valid conclusions on their congruence to zonal environments. A few national studies give such details, e.g., Pray's analysis on Bangladesh and Pakistan, Idachaba's on Nigeria, Moseman et al on Nepal, as do a number of consultants' reports. In general, these suggest that adjustments could still be made in those countries to improve the goodness of fit of resources to needs.

One interesting fact emerging from certain of these reports is that the share of resources being devoted to export and/or cash crops, as opposed to food crops for national consumption, is still very considerable. Obviously a number of countries find that research on these crops is important to their economies and essential to the optimum use of their land resources. The latter perhaps applies most particularly to the perennial crops of the humid tropics, some of which -- such as rubber and palm oil -- have been the object of successful research. Nevertheless it is clear that much remains to be done on other tropical cash crops as well as to improve poorly utilized resources by research on tropical pastures, agro-forestry, and aquaculture. Even in the drier regions where cash crops compete more directly with food crops, research on cotton and groundnuts receives a significant share of total resources in several countries.

Much useful economic research could be done on the matching of research resources to national priorities; however, we were unable for a number of countries even to obtain the breakdown of the value of agricultural GDP into its four major subsectors of crops, livestock, forestry, and fisheries. While relating the allocation of research expenditures or manpower to these subsectors can give some indication of a gross misallocation of resources, it does not show whether specific crops or livestock are getting an appropriate share of resources, either in the light of their present value in the current national commodity mix or their future potential in an evolving national economy. One step forward here would be to update the information on product value in each country, which FAO once assembled for the Indicative World Plan and which is now obsolete.

Table 14 gives the subsectoral breakdown of scientific staff and expenditures for a number of countries. It shows that the main weight of agricultural research was being devoted to crops in all regions during the late 1970s but that there were significant regional differences in the resources being allocated to other subsectors. Livestock receives a lower weighting in Asia, where natural grazings are limited, than in African or Latin America; for forestry the position is reversed. However, a number of Latin American countries aggregate forestry, fisheries, and non-commodity specific research under the category of "other".

When the allocations in Table 14 are compared to the shares of the main subsectors in the total gross value of agricultural production for the countries for which information is available, a number of inconsistencies show up, but there is no clearly detectable pattern in these. Some countries appear to devote more resources to crops than their value seems to merit, while in others livestock or forestry receive disproportionate attention. The "other" category, which sometimes amounts to 25 to 35 percent of the total, also obscures the situation, since this often includes research in disciplines (soil science, water management or farming systems), which probably contribute more to the value of crops than anything else. Our main conclusion is that this subject merits further economic analysis, but it will need to be done at the country level.

In order to attempt to evaluate the geoclimatic distribution of research resources, it has been necessary to extrapolate scientist numbers from 1975 data to 1980 for a number of countries for which we do not have 1980 data. The extrapolation was based on the assumption that staff establishments for those countries would expand at approximately the same average growth rate as the other countries in the same income group for which we were able to compute actual growth rates from time series data. The projection of scientist numbers is considered a better measure of growth of a national system than expenditures, because staff determine the absorptive capacity of a country for funds -- as well as its capacity to perform research -- and staff numbers are not subject to the same "lumpiness" as the growth of funding. It is recognized, however, that shortage of operating funds may limit output even where numbers have increased.

Table 14: Distribution of Research Scientists among the Different Sectors of Agriculture in Selected Developing Countries

Region/Country	Year	Sector of Agriculture				
		Crops (percent)	Animal Husbandry (percent)	Forestry (percent)	Fisheries (percent)	Others (percent)
ASIA						
Bangladesh	1977/78	79.9	3.2	8.1	1.8	7.0
Indonesia	1974	66.3	11.1	11.7	10.9	--
	1979	54.6	8.0	10.1	9.7	17.6
Malaysia	1980	60.5	13.0	--	1.5	25.1
Nepal	1980	75.9	6.8	14.4	2.7	--
Pakistan	1977/78	81.9	13.7	2.9	1.5	--
Philippines	1974	37.0	10.0	10.0	6.0	37.0
	1978	45.0	7.0	13.0	9.0	26.0
Thailand	1974	69.6	12.2	12.8	5.4	--
	1979	86.5	8.9	0.9	3.7	--
NORTH AFRICA/MIDDLE EAST						
Yemen, AR	1977	90.3	--	--	--	9.7
Yemen PDR	1976	87.1	--	8.1	--	4.8
SUB-SAHARA AFRICA						
Sudan	1977	79.0	13.8	--	--	7.2
Ethiopia	1977	59.0	7.0	--	--	34.0
Kenya	1979/80	57.8	39.8	1.6	0.8	--
Nigeria	1977/78	63.6	16.7	12.1	7.6	--
	1980	57.9	23.3	8.6	10.2	--
Senegal	1975	58.0	23.2	2.9	15.9	--
	1980	56.0	23.0	2.0	19.0	--
Upper Volta	1975	61.7	11.5	--	--	26.8
Togo	1980	59.2	40.8	--	--	--
LATIN AMERICA						
Barbados	1980	72.2	27.8	--	--	--
Costa Rica	1980	96.0	--	--	--	4.0
Haiti	1980	75.7	18.9	--	--	5.4

Table 14: (page two) -- Distribution of Research Scientists among the Different Sectors of Agriculture in Selected Developing Countries

Region/Country	Year	Sector of Agriculture: Crops (percent)	Animal Husbandry (percent)	Forestry (percent)	Fisheries (percent)	Others (percent)
LATIN AMERICA (Continued)						
Jamaica	1980	76.7	10.0	--	--	13.3
Mexico (Total)	1974	82.5	13.4	4.4[a]	--	0.3
(INIA only)	1977	91.3	--	--	--	8.7
Nicaragua	1980	75.0	16.7	--	--	8.3
Panama	1980	64.3	--	--	--	35.7
Brazil (EMBRAPA)	1980	73.1	26.9	--	--	--
Colombia (ICA)	1980	53.2	31.2	--	--	15.6
Peru (INIA)	1980	85.2	1.0	7.6	--	6.2
(Universities)	1978	74.7	21.0	4.3	--	--
Uruguay (University)	1980	52.3	17.9	10.6	--	19.2
Venezuela	1980	72.9	27.1[b]	--	--	--

Sources of Basic Data:

ASIA

Bangladesh: Boyce 1980 (Table 5.3, p.78).
Indonesia: Boyce 1980; 1974 (Table 3.5, p.25); 1979 (Table 3.8, p. 32); the figures refer to the AARD.
Malaysia: Mustapha 1981 (Table 5, p.12); the figures refer to MARDI.
Nepal: Sharma 1981 (Table 3).
Pakistan: Ahmad 1981 (Table 7, p.18).
Philippines: Drilon et al. 1981.
Thailand: Isarangkura 1981 (Table 11).

NORTH AFRICA/MIDDLE EAST

MacNally, CGIAR Secretariat country files for Yemen AR and Yemen PDR.

SUB-SAHARA AFRICA

Ethiopia & Upper Volta: MacNally's country files.
Kenya: Wanjiati 1981 (Table IV).
Nigeria: 1977/78 - Idachaba 1980 (Table 14, p.29); 1980 - Green Revolution National Committee, "Report of Research Institutes Review Panel 1980/81", (Vol. I).
Senegal: FAO.

LATIN AMERICA

Pineiro & Trigo in all cases, except Brazil.
Brazil: Fonseca & Barros 1981 (Table 8).

a/ Includes fisheries.
b/ Refers to pastures.

The estimated number of scientists in 1980 is shown for 76 countries and 10 major geoclimatic regions in Table 15. Land use and basic foods of the diet in each of these regions tend to be dominated by one or two crops, and thus the adequacy of the research resources being allocated to those key crops can be inferred from this table, even if the results cannot be considered conclusive.

It appears probable that rice, the dominant food crop of Southeast and South Asia, and important in Western South America and West Africa, is receiving adequate attention overall, especially as it has one of the largest and oldest international agricultural research centers, IRRI, solely devoted to it; rice programs are located at three other internationally-supported centers; and in strong national programs in several countries.

Wheat and barley, with two international centres working on them, and their main centers of cultivation in regions with strong or at least adequate national research institutions -- South Asia, Near East Asia and North Africa, temperate East Africa, and South America -- may also be well served. The fact that wheat, barley and rice are all grown extensively in developed countries may be a further source of strength since there is already a large research base on which to draw.

Although the latter is also true of maize, and maize is also relatively well served by international or regional agricultural research programs (at CIMMYT, CIAT, IITA, CATIE, and in Southeast Asia), the national institutions are often weak in some regions where maize is a key crop in the diet. This applies especially to West, Eastern, and Southern Africa, and to Central America and the Caribbean. This, together with the great diversity of maize environments and local consumer preferences for different colors and textures of grain, may be a main reason for slower progress in expanding yields of maize in developing countries, despite the great succcess achieved with improved technology for this crop in North America.

Cassava, which is often grown in the same ecological areas as maize, has until recently received little research attention. It now figures prominently in the programs of IITA and CIAT and is receiving attention in several national programs. This is due to an interest in its potential for feed and energy production, as well as food.

Millet and sorghum, together with groundnuts and several species of grain legume, are the predominant food crops of the dry tropics, stretching from India across a broad belt of Central and West Africa, north of the wetter maize/cassava zone. Although several international and national programs are devoted to these crops, yields are still low; since the areas in which they are grown are subject to erratic rainfall and high risk of crop failure, these crops present research with a series of challenging problems. A number of African countries where they are important have relatively limited research resources.

Other geographical regions where limited resources seem to cause severe problems are islands in the Caribbean, Pacific, and Indian Oceans. These are mostly in the humid tropics, modified by oceanic

Table 15: 1980 Agricultural Research Expenditures and Scientist Numbers, Actual (51 countries) or Extrapolated (25 countries)

		Research Expenditure 000 1975 U.S. $	Number of Research Scientists	Population (Total) 1980 (000)	Percent of Total by Region	Percent of Total Expense By Region	Percent of Total Scientists By Region	Scientists Per 000 Total Population
ASIA	16	251,553	18,941	1,217,529	61.8	28.3	53.0	64.3
Temperate E. Asia	2	24,282	1,612	54,980	2.8	2.7	4.5	34.1
South Asian Sub-Continent	5	139,656	12,293	894,166	45.4	15.7	34.3	72.7
Indo Malaysian Humid Tropics	9	87,620	5,036	268,383	13.6	9.9	14.2	53.3
NORTH AFRICA/MIDDLE EAST	8	41,061	4,529	92,585	4.7	4.6	12.6	20.4
SUB-SAHARAN AFRICA	29	184,569	4,354	307,770	15.7	20.7	12.2	70.6
Semiarid Tropics	8	102,712	1,542	125,316	6.4	11.5	4.3	81.3
Lowland Humid Tropics	7	37,080	1,105	70,611	3.6	4.1	3.1	63.9
Eastern/Southern Africa	14	44,777	1,707	111,843	5.7	5.1	4.8	65.5
LATIN AMERICA	23	412,375	7,934	351,740	17.8	46.4	22.2	44.3
Central America/ Caribbean	13	63,288	1,899	108,019	5.5	7.2	5.3	56.9
Tropical South America	7	230,951	4,468	202,633	10.2	25.9	12.5	45.3
Temperate South America	3	118,136	1,567	41,088	2.1	13.3	4.4	26.2
TOTAL	76	889,563	35,758	1,969,624	100.0	100.0	100.0	55.1

influences, but they have an extraordinary diversity of crops, both annual and perennial, many of which have not been much researched or on which research has been allowed to run down, except where private organizations are involved (coconuts and bananas). The perennial crops do not come within the ambit of the International Agricultural Research Centers or any other major research organization, despite their great importance to this group of countries. Several islands, for example the Seychelles and Solomon Islands with coconuts and Mauritius with sugar, are almost one-crop agricultural economies. Such island communities are predominantly small, often geographically isolated, and many are newly independent. ISNAR has already been looking at the problems of the Pacific Islands, but there are some 40 island communities with this sort of problem, and how to meet their agricultural research needs most effectively merits comprehensive study.

6. EDUCATION AND TRAINING REQUIREMENTS FOR THE FUTURE

Based on the normative approach used in Working Paper No. 30, an attempt has been made to assess the magnitudes and costs of training scientists for agricultural research services in the 51 countries for which we have 1980 staff numbers. To meet their 1990 needs for scientists it is estimated that approximately 114,000 new entrants will have to be trained. (Table 16.) The assumptions on which this calculation is based are the following:

i. An average 3.5 percent growth of agricultural GDP between 1980 and 1990. This is somewhat lower than the 4 percent adopted in IFPRI's earlier paper and should be generally attainable. It is about the minimum required to keep production in line with demand for food.

ii. Research expenditures equivalent on average to 1 percent of agricultural GDP in all of the 51 countries by 1990.

iii. Expenditures per scientist as for 1980, in 1975 constant prices.

iv. An attrition rate of 20 percent in the 1980 scientist stock by 1990.

v. A dropout rate of 35 percent along the educational road to an M.Sc.

vi. An average cost per M.Sc. trained of $30,000. This is lower than the figure used in the earlier study, which was based on overseas training costs in the United States. With an enhanced Third World capability to train scientists to Master's level in most disciplines, we feel that the bulk of the new stock will be trained in their own or other Third World countries by 1990 at considerable savings. For example, annual costs of training in India and Nepal averaged $3,000 for graduates in 1978, and $2,000 for a research technician. Although they will have risen somewhat since, and are probably a good deal more in some other Third World countries where living costs are higher, a total of $30,000 for a five-year period is probably not unreasonable. Also, education in an environment closer to working realities may improve the ultimate relevance of the research.

The total cumulative cost of university training for the new entrants is estimated at about $3.4 billion. However, this does not include retraining or upgrading of the 20,000 lower-level graduates currently in research services. Nor does it cover the costs of raising the numbers of technicians to give better support to those currently in service, or training additional technicians for the much larger number of new scientists who will be in service by 1990. Training two research technicians per researcher for each new scientist and one extra for each existing scientist implies around 110,000; allowing for attrition and dropouts totalling 50 percent of

Table 16: Estimated Requirements for Trained Scientists and Training Costs, 1990 (51 countries)

	Agric. GDP 1980	Agric. GDP 1990 1/	Agric. Res Expend. 1980	Agric. Res Expend. 1990 2/	Expend. Per Scientist 1980	No. of Research Scientists 1980	No. of Research Scientists 1990 3/	Number Requiring Training 1990 4/	Est. Dropout During Education 5/	Total Training Requirement 1990	Total Training Cost 6/
	(millions)		(1975 $)	(thousands)							
ASIA	74,517	105,069	246,238	1,050,690	13,464	18,289	82,031	67,400	23,590	90,900	2,729,700
Temperate E. Asia	8,193	11,552	18,962	115,520	19,752	960	5,849	5,081	1,778	6,859	205,770
South Asia Subcontinent	44,178	62,290	139,656	622,900	11,361	12,293	52,387	42,553	14,894	57,447	1,723,410
Indo-Malaysian Humid Tropics	22,146	31,225	87,620	312,250	17,399	5,036	23,795	19,766	6,918	26,684	800,520
NORTH AFRICA/MIDDLE EAST	1,707	2,404	5,587	24,040	21,324	262	1,191	981	343	1,324	39,720
Mediterranean Climatic Region	1,707	2,404	5,587	24,040	21,324	262	1,191	981	343	1,324	39,720
SUB-SAHARAN AFRICA	25,863	36,467	149,905	364,670	50,473	2,970	9,052	6,676	2,337	9,013	270,390
Semiarid Tropics	13,546	19,100	95,593	191,000	68,232	1,401	2,823	1,702	596	2,298	68,940
Lowland Humid Tropics	8,946	12,612	29,635	126,120	38,189	776	4,439	3,818	1,336	5,154	154,620
Eastern and Southern Africa	3,371	4,752	24,677	47,520	31,119	793	1,790	1,156	405	1,561	46,830
LATIN AMERICA	44,180	62,294	411,721	622,940	52,422	7,854	15,361	9,078	3,177	12,255	367,650
Central America/ Caribbean	11,599	16,355	62,634	163,550	34,433	1,819	5,316	3,861	1,351	5,212	156,360
Tropical South America	24,652	34,760	230,951	347,600	51,690	4,468	8,116	4,542	1,590	6,132	183,690
Temperate South America	7,929	11,180	118,136	111,800	75,390	1,567	1,929	675	236	911	27,330
TOTAL ALL REGIONS	146,268	206,238	813,451	2,062,380	27,692	29,375	107,635	84,135	29,447	113,582	3,407,460

1/ Based on an annual compound growth of 3.5 percent 1980-90.

2/ Assuming research expenditures reach 1 percent of agricultural GDP by 1990.

3/ Based on 1980 costs and 1 percent 1990 agricultural GDP.

4/ 1990 scientist numbers less 80 percent of 1980 scientists still in service by 1990.

5/ Assessed at 35 percent of total entering university.

6/ $30,000 per scientist, assuming majority trained in Third World.

this number we estimate that some 165,000 will have to enter the training system. At an average cost of $3,000 per trainee (which may be conservative), the cumulative total will be almost $500 million.

Thus an overall education and training cost of around $4 billion can be envisaged if a 1990 research expenditure of 1 percent of agricultural GDP is to be sustained. This will not be easy, and suggests that any higher expenditure target is not likely to be feasible. Not only will these direct costs have to be met, but additional capital expenditure on educational institutions and equipment may prove necessary.

There is some tendency in current development theory to down-play higher education. This is partly the result of studies which indicate better rates of return to investment in primary or vocational education; and partly due to a feeling that university education encourages elitism and does not directly benefit the poor.

Yet it is unrealistic to hope for high rates of return to investment in research, or for such investment to lead to new technology more appropriate to the poor or resource-poor areas, if low priority is given to support for the appropriate educational facilities. It seems likely that the progress being achieved now in countries such as India is due in large measure to the fact that investment in higher level scientific and conceptual skills was made in the past and is still being made. Although India now has the capacity to produce over 2,000 agricultural and veterinary post-graduates a year, it would require an annual output of roughly 5,500 to meet 1990 requirements for agricultural research alone if research expenditures were to reach 1 percent of agricultural GDP by that year. This would strain its capacity to meet its own needs, quite apart from its ability to help other Third World countries. Thus there should be no complacency over education and training needs despite encouraging progress in some countries.

Pineiro and Trigo (1980) have noted a tendency to cut back on educational expenditures for agricultural sciences in certain South American countries; while some donors have also reduced support to overseas graduate training in their countries. The levelling-off of the growth of the CGIAR System may also reduce training and retraining opportunities. There are some bright spots in the current climate of retrenchment; for example, the initiative of Australia in establishing a consortium of its universities to assist the development of higher agricultural education in Asia; the work of IDRC in Canada; the evolution of SAREC in Sweden; and the inception of ICRA in the Netherlands with support from six other countries. Much is hoped for from the U.N. initiative with Technical Cooperation among Developed Countries (TCDC). Our analysis indicates that all these efforts and more will be needed if lack of trained staff is not to be a continuing constraint on the expansion of national agricultural research systems.

In view of the critical importance of the supply of trained scientific staff and assistants, further study of the input-output relationships and potential training capabilities of institutions in both developed and developing countries deserves high priority.

This is a subject we have not been able to address adequately so far.

Demand for graduates is a further important aspect of the same subject. Information on the current nature and disciplinary breakdown of scientific staff is available for a few countries, principally in Asia and Latin America, but it is not often related to vacancies or needs. There is evidence from these reports of particular weaknesses in management sciences, social sciences and economics, agricultural engineering, animal husbandry (not veterinary science), pasture management, post-harvest technology, and some aspects of resource management (agro-climatology, irrigation, and water management). Some sciences appear to be less popular with students, although it is not clear why. However, this is a field which merits much deeper study.

7. EXTERNAL ASSISTANCE TO AGRICULTURAL RESEARCH

PROBLEMS OF DEFINITION

Agricultural research is difficult to define precisely, and it is interpreted in different ways in both national and international statistics. For purposes of this study we have included all activities designed to develop new knowledge or obtain new information through experimentation and analysis (whether in technical, social, or policy fields) or to adapt existing knowledge to a different environment. "Agriculture" is defined here as comprising crops, livestock, forestry, fisheries, the management of the environment for their production, and post-harvest technology.

The difficulties of definition are especially apparent in attempts to identify the contribution of external assistance to national research programs. No two donors classify their assistance in exactly the same way. The following are among the major problems of identification.

* Research and extension, research and education, and research extension and education are often listed together in a total package of program assistance to national institutions; it is not possible to disentangle them from published statistics.
* Research is frequently only a component of a large project, and this component cannot easily be separated from the total cost. Projects may be described in a way which makes it hard to decide whether they involve research or not.
* The expenditure on a project is often presented as a "life-of-project" commitment, and disbursements in a given year cannot be identified.
* Capital and recurrent expenditures are rarely differentiated. This makes it questionable to assume that annual expenditures can be obtained from a 5-year or "life-of-project" total by averaging, since the pattern is likely to be uneven where large capital elements are involved because of the characteristic "lumpiness" of capital investment. Nevertheless, we have done this in the case of certain donors, with an appropriate indication in the footnotes.
* For a variety of different reasons, it has been hard to avoid double counting in many instances.
* Records are particularly weak on inputs and output of scientific education and training programs. This is partly because of the large number of students who have passed through such programs and partly because follow-up on their subsequent careers in their own countries has rarely been systematically attempted. How many took up a permanent career in agricultural research is not usually recorded.

The problems in grasping the entirety of external support to national agricultural research and technology delivery systems are formidable. Three of the donors to whom we wrote for information expressed a wish to have their data recorded and presented systematically but admitted that they were unable to devote the resources to screen their own records to supply it to us.

Despite these difficulties, it has seemed to us worthwhile to try to determine whether external aid to agricultural research, as defined above, has increased or declined during the past decade; whether there are still important gaps in the spectrum of aid to agricultural research and scientific education for the Third World countries; whether assistance is being distributed in a way which meets national needs; what, if any, problems it involves for recipient countries; and how these might be resolved or ameliorated.

We will now try to examine these questions, bearing in mind the imperfections, limitations and inconsistencies of the data on which our conclusions are based.

HOW HAS THE TOTALITY OF DONOR SUPPORT TO RESEARCH MOVED IN THE 1970s?

In their analysis of national and international agricultural research and extension programs published in 1975, Boyce and Evenson concluded that there had been a significant decline in bilateral and multinational aid to research programs in the developing countries in the late 1960s and early 1970s. They state that the level of aid (in 1971 prices) was about $55 million in 1959, rising to $80 to $100 million by 1965, then declining to $60 to $70 million by 1971. Of this they estimated that United States, British, and French aid to research totalled about $40 million. Some increase followed in the early 1970s, primarily due to increased FAO support of research.

However, Evenson states in a subsequent paper (Chicago 1978): "The decline in technical and entrepreneurial assistance to national program development has been substantial since the late 1960s." He attributes this partly to retrenchment consequent to political factors in developing countries and also in part to the establishment of the international agricultural research system: "The Consultative Group virtually acquired property rights to funding for agricultural research during the centers' expansion period."

It seems doubtful whether this last contention is correct. Although donors were enthusiastic about building up the CG system in the early 1970s, there was also a growing recognition of the need for parallel strengthening of national institutions, which led to strong resolutions in support of increasing expenditures on research and scientific training and expanding international assistance to national systems at both the 1974 World Food Conference and the 1975 FAO General Conference. A further outcome was the establishment by the CGIAR itself of the International Service for National Agricultural Research (ISNAR) in 1979, with the objective of helping to build national systems.

In its Working Paper No. 30, tabled for information at the 1978 Centers Week meeting, IFPRI expressed the opinion that expenditures on national research systems had in fact risen rather than stagnated during the 1970s, and our more recent analysis tends to support this. Table 17 shows that, in constant 1975 dollars, donor funding to national research institutions averaged about $364 million a year during the period 1976-80, rising steadily each year in real terms to about $460 million by 1979, after which there are signs of levelling-off. Total disbursements for research over the quinquennium have therefore exceeded $2.0 billion when the cumulative 1976-80 funding for the CGIAR institutions of nearly $400 million is added. Donor contributions to national programs alone in 1975 appear to have been about four times those estimated by Boyce and Evenson for 1971, and overall external support for agricultural research in the Third World, including international and regional institutions, is probably higher in real terms by a factor of six than it was in 1971 -- approximately $540 million in 1980 compared to $80 million in 1971.

The 1980 aid total alone is higher than IFPRI's estimate of total national research expenditures by 65 developing countries in 1975. Moreover, the aid estimate in Table 17 does not include assistance from OPEC, Saudi Arabian, or other Arab funds, nor any aid given by Eastern Bloc countries.

This increase in real terms seems to have resulted from the recognition by an increasing number of donors of the central role that improved agricultural technology must play in an effort to achieve faster economic growth, improved nutrition, employment, and income distribution in the poorer countries. This has been reflected in three developments:

* A substantial increase in priority to funding national agricultural research by some large, traditional donors;
* Awakened interest in supporting agricultural research by newer donors;
* Increasing contributions from certain international and regional funding organizations, in particular the Development Banks (which entered the scene significantly in the early 1970s), and more recently established funds such as IFAD.

Despite the substantial accretions to research support since 1970, the apparent downturn in the level of contributions of a number of donors since 1978 or 1979 is disturbing. Among 12 donors for which we have year-by-year data for the period 1976-80, 8 show decreased levels of funding in 1980 compared to 1979, and 4 were lower in 1979 than in 1978. There has also been a marked levelling off in support for the CGIAR institutes in the last three years which almost amounts to a no-growth situation in real terms.* In view of the stress laid on the need for strong support to

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*See Table 9.5. Report of the CGIAR Review Committee, September 1981.

Table 17: External Funding for Agricultural Research by Region, 1976-80 1/ (Constant 1975 U.S. 000 Dollars Deflated from 1981 IMF Yearbook)

	Africa		Asia		Latin America		Near East		Total		Total	5-Year Average
	1976	1980	1976	1980	1976	1980	1976	1980	1976	1980	1976-80	
Australia	--	--	9,570	7,650	--	--	--	300	8,570	7,650	43,650	8,730
Belgium 2/	n.a.	5,552	n.a.	1,568	n.a.	392	n.a.	653	n.a.	8,165	(8,165)	(1,633)
Canada	11,877	6,932	7,612	4,463	5,541	5,111	1,102	1,653	26,132	18,159	109,781	21,956
Denmark	--	59	173	270	--	8	--	--	173	337	1,037	207
Finland	11	5	--	--	--	--	--	--	11	5	36	7
France	30,589	42,090	76	77	1,495	2,628	--	--	32,160	44,795	178,344	35,669
Japan	32	297	3,694	5,597	144	2,106	19	98	3,889	8,098	45,289	9,058
Netherlands 3/	2,824	5,289	1,930	1,380	2,252	1,183	572	986	7,578	8,838	49,534	9,907
New Zealand	--	--	1,119	205	--	--	--	--	1,119	205	2,191	439
Norway	52	1,918	--	93	--	--	--	--	52	2,011	6,895	1,379
Sweden	608	1,737	--	882	325	664	54	309	987	3,592	13,074	2,615
Switzerland 3,4/	567	234	302	351	491	1,092	--	--	1,360	1,677	9,422	1,884
W. Germany 4,5/	4,827	4,827	5,001	5,001	2,217	2,217	2,838	2,838	14,883	14,883	83,812	16,762
United Kingdom 4/	978	302	17	135	539	557	119	17	1,653	1,011	11,230	2,246
United States 4/	5,800	72,000	6,000	17,000	6,200	25,000	6,000	20,000	24,000	134,000	370,000	74,000
Total Bilateral	58,165	141,242	35,494	44,672	19,204	40,958	10,704	26,854	123,567	253,426	932,460	186,492
EEC	n.a.	8,700	n.a.	100	n.a.	400	n.a.	2,260	n.a.	11,460	n.a.	n.a.
IBRD	2,660	18,500	29,800	58,200	440	29,300	100	6,000	33,000	112,000	400,000	80,000
IDB 5/	--	--	--	--	20,100	20,100	--	--	20,100	20,150	100,500	20,100
UNDP/FAO 4,5,6/	n.a.	23,300	n.a.	21,000	n.a.	17,300	n.a.	19,200	66,000	93,000	350,000	70,000
Total Multilateral	2,660	50,500	29,800	79,300	20,540	67,100	100	27,460	119,100	236,610	850,500	170,100
Total Bilateral and Multilateral	60,825	191,742	65,294	123,972	39,744	108,058	10,804	54,314	242,667	490,036	1,782,960	356,592
CGIAR System	--	--	--	--	--	--	--	--	60,800	92,300	411,742	82,348
Overall Total	60,825	191,742	65,294	123,972	39,744	108,058	10,804	54,314	303,467	582,336	2,194,702	438,940

1/ Does not include base costs of technical assistance organizations of donor countries or agencies.
2/ Data provided for 1980 only.
3/ Includes contribution to core budgets of CGIAR.
4/ Includes some global projects not identified by region.
5/ Five year total pro rated by year.
6/ UNDP data for regions apply only to FAO; additional allowance for non-FAO projects included in 1976 and 1980 UNDP totals.

Sources of Data: Country reports to FAO and/or IFPRI; World Bank, UNDP, FAO data supplied to IFPRI, IDB data supplied to IFPRI, Bilateral Agency Reports, Marches Tropicaux (France).

agricultural research in the Third World at two summit meetings, these trends are disappointing.

In the case of support to national systems one reason for a lower level of funding could be the coincidental termination of a number of large loans or grants coming more or less simultaneously. However, looking at the situation overall it seems more likely that it is the result of changing political and economic circumstances in some major donor countries. Another possibility, which we hope is not the case but cannot be discounted, is some loss of confidence in investment in research as a means of accelerating agricultural growth because of expectations of major benefits which have not yet been fulfilled.

In any case, a secular decline in external support for agricultural research in the Third World would represent a serious situation in view of the critical food deficits still facing many countries, and the need for accelerated agricultural growth as a means of stimulating employment and income. Financial stability and long-term commitment by Third World governments is frequently stressed as a necessity for success in research by development economists and other political analysts. At a time when many developing countries appear to be making such commitments on an increasing scale, it would be a great pity if donors start to reduce theirs.

THE GEOGRAPHICAL BALANCE OF AID TO AGRICULTURAL RESEARCH

In looking at the distribution of financial assistance to agricultural research, it is pertinent to consider whether the resources are going to the most needy countries. Annex 3 shows that virtually all Third World countries are receiving some external assistance for agricultural research, and most are being helped by two or more donors. Of the total estimated foreign funding to national systems of about $1.8 billion for the 1976-80 quinquennium, African countries have received the largest share -- over $500 million. Loans and grants to Asian countries exceeded $450 million; those to Latin America amounted to $335 million; and the countries of the Mediterranean-Near East region received the least -- about $240 million. The latter may have obtained additional money from the various Arab and OPEC donors. However, although we do not have records of all these, representatives of some of the larger funds have informed us that they have not funded national agricultural research.

Within these overall regional totals the pattern of support varies greatly. Although sub-Saharan countries of Africa have received the largest amount in aggregate, the region contains both the largest number of countries of any developing region (48) and the most really poor countries (30) -- with a 1979 GNP per capita of $500 or less. While a few countries (Mali, Zaire, Senegal, Ivory Coast, Ethiopia, Malawi, Tanzania, and Kenya) appear to have received more than $15 million each in aggregate, a high proportion of funding has been relatively small and project-oriented. Program funds adequate to build national research systems have been provided

to only a few countries (Senegal, Tanzania, Ghana, Ethiopia, Mali, Lesotho, Burundi, and Upper Volta).

By contrast, South and Southeast Asia, which contain a much smaller number of countries (about 10), have received large sums in aid, a high proportion of which have gone towards building national research and extension systems (in Bangladesh, India, Indonesia, Thailand, Malaysia, Pakistan, the Republic of Korea, and Sri Lanka). Several Asian countries now appear to be in a postion of self-sustaining growth as a result of these loans and their own efforts.

The same holds true for many South American countries and for Mexico in Central America. Mexico, Bolivia, Brazil, Colombia, Peru, Ecuador, and Jamaica all seem to have received over $10 million for aid to research.

Regions which now appear to have a special need for assistance are the Pacific Islands; the Caribbean and to a lesser extent Central America; and Southern Africa (Botswana, Lesotho, Malawi, Madagascar, Mozambique, Swaziland, and Zambia). These are not necessarily the poorest regions in absolute terms, but they contain a high proportion of small, newly independent countries, which have few trained people and which may have difficulty in sustaining viable national research systems. The Sahelian countries of West Africa also face serious difficulties because of their relatively low population density, poor communications, poverty, and difficult climate, although considerable sums of money as well as strong technical assistance have been channeled to their support in recent years. While this has built good research programs in some countries, the extreme shortage of trained local scientists means that there is still heavy dependence on expatriate scientists, and viable national systems have not yet been developed.

The donor community as a whole has attempted to use many different approaches in efforts to meet the needs of the developing countries for assistance in the development of their national research programs. In all it appears that identified multi- and bilateral donors are supporting more than 1,000 projects involving elements of research in national, regional, and other supranational programs which embrace practically all of the developing countries. FAO reports 277 such projects, the World Bank 359; while France, West Germany, the United Kingdom and the United States each have one or more projects in 35-50 countries, plus technical assistance staff in a number of others. At least five other donor agencies support projects in between 10 and 20 countries. Some of these projects appear to contribute significantly to the strengthening of national research institutions -- in other words to long-term program development -- others are more short-term and operationally oriented.

Although it is not always easy to judge this from project descriptions, we estimate that about 50 countries are getting help which could contribute directly to building their national institutions; there are about 100 such projects varying greatly in size and the amount of external funding. This covers information from eleven major donor agencies (Australia, Belgium, France, Sweden, Switzerland, West Germany, the United Kingdom, the United

States, FAO/UNDP, the World Bank, and the IDB). For some of these, for example FAO and UNDP, our list is incomplete; while a number of additional donors have supplied financial data aggregated by country or region but not by project. Because of the different time horizons it is not possible to arrive at an aggregate estimate of their costs or to break out individual years. However, a pro-rated estimate for 1980 indicates an expenditure of about $120 million.

In a recent paper a distinguished development economist has described as "anarchic" the situation with respect to the global bilateral and multilateral systems of support for national agricultural research systems, extension services, and rural development programs. This would probably not be too strong a word. Due to a proliferation of donors in the last decade and the large number of projects involved, it is difficult to get a clear picture of the levels and directions of support for research. There appears to be some truth in his assertion that there is competition among and between assistance agencies and recipients which blunts the effectiveness of aid.* He suggests a program support approach among donors (perhaps on a consortium basis), and there are situations where this approach has been successfully linked to a formula for parallel growth of domestic support to research and extension. If this idea were to be followed, it might avoid the type of situation where donor-sponsored projects of low level priority siphon off national resources from more important objectives, and donor support could be linked in a more rational fashion to the growth of national capacity to absorb it. At present money frequently outruns the ability of national systems to use it effectively, especially if it is provided mainly for capital investment. A program approach at the national level would not preclude projects being funded within the framework of the program which visibly bore donors' emblems, but projects would be geared to an overall set of national goals and a time horizon. This would allow other potential bearers of assistance to know what was going on and enable duplication and competition to be minimized.

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*Six or seven donors to various aspects of research in one country is quite common, and in some it runs into double figures.

8. FURTHER ISSUES FOR RESEARCH

Several topics of interest can be identified from the large number of reports and data reviewed but which could not be tackled adequately in the current IFPRI/ISNAR study; these topics may require improved information based on case studies. They can be grouped under four broad headings: resource allocation, research organization and management, human resource development, and research information systems, although there is clearly some overlapping between these categories and they cannot be treated as watertight compartments. Some topics apply primarily to national agricultural research systems, others to international research; several have relevance to both national and international research.

RESOURCE ALLOCATION TO AGRICULTURAL RESEARCH

i) How can optimal rates of investment in research be determined ex ante?

As a result of numerous ex post studies on high rates of return to investment in agricultural research, it is widely accepted that most countries (developed and developing) are under-spending on research. Furthermore, it is often stated that low-income countries are not spending enough money on research and ought to be spending much more because this is what developed countries do.

However, there is little evidence (see the first paragraph on page 20) to guide countries with limited overall resources as to what levels of expenditure can be justified in a given set of local circumstances and what returns might justify more expenditures at the margin. Has this lack of precise direct evidence acted as a disincentive to expanded investment in research, or is the failure to invest more due to the often modest performance of national systems?

The same basic issue may have to be faced increasingly over time in deciding optimal levels of investment in international research. The latter cannot be overlooked in any wider analysis of research priorities, especially if it competes for donor support with national research.

ii) What are the main factors influencing returns to research?

Apart from the quality of the research itself, numerous exogenous factors determine the nature and magnitude of returns to national research investments, i.e., incentive policies, the availability of production shifters, the adequacy of supporting services (seed, extension, credit), etc. To what extent can failure to achieve measurable returns to research be attributed to external factors and to what extent is it due to poor choices of research topic or failure in the conduct of research? An important issue in

attempting such an assessment is how to measure output from research. This difficult question may not be answerable in precise terms, particularly over a limited time span.

iii) How can allocative mechanisms be improved to take account of the dynamics of social and economic change in determining research priorities?

Many of the criteria applied to determining research priorities are relatively static. However, work by Per Pinstrup-Andersen (Minnesota 1981) has shown how priorities could change for research on food commodities on certain assumptions of growth in incomes and changes in income distribution. Other trends such as urbanization, industrialization, population growth, compulsory schooling, etc., also play an important role in change. Can these various factors be built into dynamic models, i.e., to develop an early warning system of the need for changes in research and production priorities?

RESEARCH ORGANIZATION AND MANAGEMENT

iv) How have historical influences affected the evolution and efficiency of national systems?

Since independence, research and development systems in less developed countries have been influenced by the British, French, United States, and World Bank approaches. Some countries have developed modifications of these systems; some have evolved innovations of their own. Can models of organizations which have been particularly successful in the conduct of cost-effective and efficient research, and in training and utilizing scientific staff, be derived from cross-country comparisons of these different experiences?

v) What is the optimal size and reasonable degree of dispersion of a research system?

Agricultural research systems vary greatly in their organization: some are highly centralized, others seem to be excessively fragmented. Even allowing for the need to cover local situations adequately, studies by FAO and others in the early 1970s suggest that many Third World systems were too dispersed to be effective. Our analysis indicates that this is still a problem in a number of countries. Can the tradeoff be calculated between the gains in economies of scale and critical mass from concentrating staff and the loss of regional focus from concentration? Is this a particular problem for smaller countries?

A related question is how to ensure continued high level disciplinary inputs into multi-disciplinary (commodity) programs. A good balance needs to be established within individual programs and institutes, and between institutes over the system as a whole, including those involved in more basic scientific research and universities. There seems, however, to have been little critical examination of these important organizational issues.

vi) How can the dialogue between policy-makers and research directors be improved?

While there is a growing recognition of the need to ensure the relevance of research programs to production situations, little

attention appears to have been paid to the role which good research systems can have in providing advice to policy-makers and in making the requirements of the systems known effectively to non-technical staffs in planning and finance ministries. There is evidence that weaknesses in this area may effect the extent of resources allocated to research. What are the mechanisms by which better understanding can be developed?

In the case of international research, how can means be devised to establish channels by which national needs and priorities (demand for research) are made known both to the managers of the CGIAR and to the individual center directors?

HUMAN RESOURCES FOR RESEARCH

vii) What is the optimum division of labor in the conduct of research?

This is an extremely important issue which also involves delicate questions of competitive financial resource allocation; finding the correct balance may determine the degree of success achieved in the overall conduct of research. The actors on the scene include the international agricultural research centers, regional institutions, national publicly funded research stations, and universities in both developing and industrialized countries, and the private sector. Perhaps the most important aspects are:

(a) What are the complementarities between work at different institutions, and what should be the optimum division of labor between international/regional and national research systems? and

(b) What is the future role of the private sector in research?

The first of these has already been the subject of considerable discussion; the second has been less studied, at least with respect to developing countries.

Most national research is still supported primarily from public budgets, although cesses on producers or exporters play an important role in some commodity research. Work by Pineiro, Trigo, and others suggests that the private sector is playing an increasingly important role in agricultural research in Latin America, with consequences which may be both good (relieving pressure on national public systems to do everything) and bad (siphoning off trained staff and doing little training itself, picking out the plums and leaving the more difficult or unrewarding areas of research to the public sector).

It would be valuable to be able to identify and quantify the contribution which the private sector is making to research in the different regions -- to identify trends and draw inferences for the future. This could have important implications both for ISNAR, which is likely to be involved in the planning, programming, and promoting of public sector research, and the international agricultural research centers, which may increasingly find themselves dependent on collaboration with the private sector -- if the Latin American trends become more general.

viii) What are the scientific and technical manpower constraints, and how can they best be alleviated?

What are the constraints imposed by the national educational and technical training systems on the development of well-staffed national research organizations? Where are the main educational bottlenecks? Are donor (or national government) policies towards investment in education and educational institutions at different levels reinforcing or alleviating those bottlenecks? What more, if anything, could the international centers be doing to fill the gaps?

ix) How can staff attrition in public sector research and training be reduced?

Wastage of human resources starts in the educational system and continues during employment after staff are trained. There is considerable divergence of opinion as to the scale, pattern, and causes of attrition and the measures required to reduce it. Since the extent of losses has an important bearing on the numbers of people who have to be trained, as well as on the capacity of existing trained staff to supervise further in-service training of new graduates, further studies of their losses and their causes seems to merit high priority.

RESEARCH INFORMATION SERVICES

x) How can data on national systems best be collected, tabulated, and kept up-to-date?

The present study has revealed that the need to maintain a continuum of information on national systems is still not widely recognized. A continuous update of key data on national systems would be invaluable for donors and technical assistance agencies, for the international agricultural research centers, and for national policy-makers and research directors who could use the information as an intelligence base comparing their approaches and resource allocations with those of other countries. Thus to develop a sound and workable system of country classification and categorization would provide an indispensible tool of global importance for helping to build national research capabilities.

It would also be useful to develop means of classifying countries according to their research needs and priorities. Various possibilities exist, including income group, agroclimatic zone, commodity concentration, growth rates of agricultural product, food deficits, etc.

Our experience in this project suggests that most Third World countries and many donors do not maintain adequate and comprehensive records of research. The matter has urgency.

FAO has been developing a Current Agricultural Research Information System (CARIS) since 1975 and has published three Directories of Institutions, Scientists and Programs. There are a number of gaps in the reporting, possibly because of the depth of information requested. Designing a system which provides an adequate basis of knowledge without making too heavy demands on research managers is not an easy task.

As a basis for maintaining up-to-date information it has been suggested by ISNAR that a loose-leaf system be adopted, with a constant format for recording data for each individual country (Annex 6).

Annex 1-A

ASIA: Data on Research Expenditures and Numbers of Research Scientists in Selected Countries, 1970-80

i) Constructed Time Series

(Expenditures in thousand 1975 constant U.S. dollars)

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Bangladesh											
Expenditures (000 $)	1,224	1,330	1,436	1,365	1,515	6,784	6,106	9,767	10,068	16,865	17,385
Scientists (Nos.)	138	150	162	175	190	635	571	914	951	1,593	1,642
India											
Expenditures	79,911	100,818	114,789	103,650	97,020	60,334	74,310	83,077	99,744	10[illegible],880	101,098
Scientists	5,805	5,850	5,895	6,166	6,450	6,623	6,716	6,811	6,907	7,004	7,103
Indonesia											
Expenditures	6,469	7,271	8,177	9,189	15,169	22,449	32,065	34,608	33,595	24,776	29,056
Scientists	371	417	469	527	592	664	779	914	1,072	1,256	1,473
Korea, Republic											
Expenditures	14,564	15,282	15,053	15,494	15,948	16,415	16,895	17,390	17,898	18,423	18,962
Scientists	734	774	762	784	807	831	855	880	906	933	960
Malaysia											
Expenditures	11,528	12,752	17,957	21,253	26,069	28,006	20,033	24,658	27,250	27,434	29,023
Scientists	133	147	207	245	317	498	573	605	690	777	822
Nepal											
Expenditures	1,377	1,371	1,425	1,412	1,484	1,616	1,726	1,778	2,200	1,726	1,827
Scientists	170	169	176	175	184	200	214	220	217	214	226
Philippines											
Expenditures	10,111	9,724	9,680	9,637	8,655	9,488	10,401	11,171	11,537	9,018	8,769
Scientists	880	846	972	1,117	1,038	1,137	1,245	1,337	1,381	1,079	1,050
Sri Lanka											
Expenditures	3,713	3,590	3,472	3.357	3,246	3,254	3,443	3,290	2,309	2,323	2,836
Scientists	109	105	150	161	156	202	213	287	343	346	422

Annex 1-A
Asia (page 2)

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Thailand											
Expenditures	9,346	9,706	10,084	10,463	10,860	15,065	14,526	16,703	16,135	14,256	15,203
Scientists	494	513	533	553	574	595	1,280	1,320	1,341	1,430	1,525

ii) Countries for which time-series could not be constructed

Fiji											
Expenditures								893	820	1,361	1,534
Scientists					54		23	44		22	
Pakistan											
Expenditures						20,000	20,831	19,947	18,919	17,677	16,510
Scientists											
Papua/New Guinea											
Expenditures									1,676	1,661	3,300
Scientists											110
Solomon Islands											
Expenditures								206	189	196	333
Scientists										8	
Tonga											
Expenditures											286
Scientists											8
West Samoa											
Expenditures											116
Scientists											8

Annex 1-B

NORTH AFRICA/MIDDLE EAST: Data on Research Expenditures and Numbers of Research Scientists in Selected Countries, 1970-80.

1) Constructed Time Series

(Expenditures in thousand 1975 constant U.S. dollars)

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Cyprus											
Expenditures (000 $)	501	598	695	558	617	676	822	1,045	1,193	1,385	1,575
Scientists (Nos.)	31	37	43	42	52	57	52	52	53	54	55
Jordan											
Expenditures	250	279	335	508	557	490	491	568	644	586	555
Scientists	21	23	28	42	40	35	35	38	40	38	35
Syria											
Expenditures	1,387	1,529	1,588	1,668	1,731	1,628	2,452	2,653	2,653	3,075	3,457
Scientists	69	76	79	83	86	81	122	132	132	153	172

ii) Countries for which Time Series could not be constructed (1980 data extrapolated where asterisked.)

Egypt											
Expenditures		13,630		13,015	11,092	13,888					19,748*
Scientists	1,780	750*			800		1,967				2,724*
Iraq											
Expenditures						1,302					2,630 *
Scientists						75	133				164 *
Libya											
Expenditures						1,389					2,806*
Scientists	15			12		75	112	100			138*
Morocco											
Expenditures		3,723			3,461						5,869*
Scientists	55	60			65	200	495				686*
Tunisia											
Expenditures						2,847					4,421*
Scientists	95					164	206				285*

Annex 1-C

AFRICA: Data on Research Expenditures and Numbers of Research Scientists in Selected African Countries, 1970-80

i) Constructed Time Series

(Expenditures in thousand 1975 constant U.S. dollars)

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
A. West Africa											
Ghana											
Expenditures		3,723			3,246	3,963	7,854	8,524	6,396	6,457	6,594
Scientists					304	300	300	301	341	344	352
Nigeria											
Expenditures	21,158	21,277	21,390	21,516	21,638	58,325	90,392	100,175	79,332	73,243	79,634
Scientists	302	300	304	298	300	491	761	843	917	997	1,084
Senegal											
Expenditures	3,532	3,723	3,914	4,115	4,327	3,949	5,718	5,288	5,612	6,198	6,399
Scientists	51	53	56	59	62	57	82	85	93	99	105
Zaire											
Expenditures	4,890	5,379	4,766	5,163	5,626	4,633	5,505	3,888	3,771	2,765	3,330
Scientists	60	66	72	78	85	70	83	113	110	81	97
B. East Africa											
Burundi											
Expenditures	582	665	693	603	626	649	1,869	2,178	2,165	2,325	2,358
Scientists	21	24	25	26	27	28	25	22	26	40	41
Kenya											
Expenditures	1,520	773	5,066	7,375	8,869	785	8,287	12,279	13,608	13,903	14,204
Scientists	207	210	213	233	280	321	333	299	371	306	400
Madagascar											
Expenditures	4,548	4,189	3,653	3,803	4,003	3,657	3,563	3,470	3,376	3,282	3,188
Scientists	76	70	73	76	80	78	76	76	72	70	68

Annex 1-C (page 2) -- AFRICAN Research Expenditures and Numbers of Scientists

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Sudan											
Expenditures	4,505	5,419	4,941	5,281	4,972	6,317	7,320	7,486	8,298	9,154	9,560
Scientists	121	128	139	149	140	178	162	166	184	203	212
Tanzania											
Expenditures	3,329	4,388	6,564	5,820	6,492	7,074	5,506	4,860	4,847	4,878	4,715
Scientists	90	100	112	130	145	158	184	194	200	256	256
Zambia											
Expenditures	4,882	4,833	4,785	4,737	4,690	4,644	4,710	3,644	4,191	3,859	3,400
Scientists	82	81	80	80	79	78	79	104	118	109	96

ii) Countries for which time-series could not be constructed (1980 data extrapolated where asterisked.)

A. West Africa

Benin											
Expenditures		1,157	1,131		973	1,215					1,728*
Scientists	16	16	16		16	17					21*
Cameroon											
Expenditures		1,729			1,947						3,301*
Scientists	64	72			96						156*
Chad											
Expenditures		665			649						990*
Scientists	25	26			30						40*
Gambia											
Expenditures		29	30		27	53					75*
Scientists	5	5	4		5	10					13*
Liberia											
Expenditures		160			160	441					685*
Scientists	16	14	19		16	19	30				45*

Annex 1- C (page 3) -- AFRICAN Research Expenditures and Numbers of Scientists

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Mali											
Expenditures		2,261	2,448		2,488	2,630					3,740*
Scientists	18	25	30		35	37					47*
Mauritania											
Expenditures			656			597					849*
Scientists	6		4			4					6*
Niger											
Expenditures						819					1,165*
Scientists						16	9				20*
Sierra Leone											
Expenditures		319			324						495*
Scientists	17	30	33		46			46			58*
Togo											
Expenditures	1,058	605	529	362	506	687	940	892	1,289	1,415	1,236
Scientists	14	8	7	10	14	19	26	31	37	42	49
Upper Volta											
Expenditures	288	419			379		226				300*
Scientists	9	10			11	33	12				15*
B. East/Southern Africa											
Botswana											
Expenditures		439	355	377	356						543*
Scientists			37		30			46			57*
Somalia											
Expenditures						339					482*
Scientists	9					9	24	22			28*

Annex 1-C (page 4) -- AFRICAN Research Expenditures and Numbers of Scientists

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Ethiopia											
Expenditures		1,932			1,947						2,980*
Scientists	42	52			65	40	133	110			161*
Lesotho											
Expenditures		172			184						281*
Scientists	3	7			10						13*
Malawi											
Expenditures		1,596			1,947						2,980
Scientists	46	57	18		208						276*
Rwanda											
Expenditures		487			432	288					661*
Scientists	10	16			18	12	23				28*
Uganda											
Expenditures		4,388			3,787	3,408					4,846*
Scientists	86	80	67	72			48				58*
Zimbabwe											
Expenditures		2,899			4,327						7,337*
Scientists	136	172	174	174	180						293*

Annex 1-D

LATIN AMERICA: Data on Research Expenditures and Numbers of Research Scientists in Selected Countries, 1970-80.

i) Constructed Time Series (Expenditures in thousands 1975 constant U.S. dollars)

A. Central America/ Caribbean	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Barbados											
Expenditures (000 $)	584	623	545	467	419	370	364	364	421	569	501
Scientists (Nos.)	15	16	14	12	12	12	13	13	15	18	23
Costa Rica											
Expenditures	1,199	1,556	1,144	1,110	822	1,550	1,140	1,212	1,133	1,354	1,360
Scientists	47	61	68	66	71	77	56	60	56	67	75
El Salvador											
Expenditures	469	798	634	800	1,028	800	3,140	3,160	3,673	3,546	3,249
Scientists	46	55	52	56	72	56	77	78	91	88	116
Guatemala											
Expenditures			1,911	1,579	2,331	2,380	2,294	2,669	2,841	3,427	3,485
Scientists			50	41	61	63	61	71	100	121	123
Honduras											
Expenditures	1,032	1,064	932	946	973	460	390	549	658	607	639
Scientists	65	67	69	70	72	80	68	52	62	57	60
Jamaica											
Expenditures	699	740	1,143	1,237	1,183	1,367	1,219	1,071	765	459	504
Scientists	52	55	85	92	88	102	94	85	61	36	40
Mexico											
Expenditures	2,472	3,353	5,265	8,747	9,345	13,875	15,993	13,329	36,048	40,860	46,359
Scientists	551	540	711	936	1,000	770	888	740	839	951	1,079
Nicaragua											
Expenditures	1,027	1,064	1,101	916	973	1,119	1,210	1,331	1,118	1,212	1,306
Scientists	28	29	31	33	34	37	40	44	54	59	63

Annex 1-D (page 2) -- LATIN AMERICA Expenditures and Research Scientists

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Panama											
Expenditures	1,176	1,437	1,698	1,649	1,600	1,218	836	957	946	1,838	2,090
Scientists	36	44	52	51	49	38	26	29	29	56	64
B. South America											
Argentina											
Expenditures	40,019	42,553	44,148	30,492	31,916	33,398	41,983	38,050	52,153	72,981	108,648
Scientists	853	907	941	964	1,009	1,040	926	970	961	919	1,064
Bolivia											
Expenditures	1,594	1,568	1,254	1,281	1,307	1,241	1,176	2,062	2,301	2,104	1,834
Scientists	61	60	48	49	50	48	45	57	74	82	114
Brazil											
Expenditures	36,992	39,894	42,312	67,797	76,419	142,000	165,406	181,899	173,267	177,910	160,026
Scientists	1,530	1,650	1,750	1,473	1,660	1,974	2,529	2,496	2,554	2,757	2,957
Chile											
Expenditures	8,384	9,309	9,527	5,446	5,842	5,325	5,690	6,771	6,370	6,592	6,762
Scientists	154	171	175	179	192	175	187	265	285	284	281
Colombia											
Expenditures	21,402	24,492	24,297	25,718	22,016	23,004	24,419	24,564	31,981	30,321	25,194
Scientists					517		392			321	333
Ecuador											
Expenditures	3,475	3,862	5,032	5,486	5,041	5,153	5,264	5,143	4,471	5,127	4,204
Scientists	54	94	123	158	200	204	209	204	294	337	276
Paraguay											
Expenditures	371	439	495	564	649	598	567	631	685	838	2,025
Scientists	22	26	29	33	38	35	33	48	54	57	63

Annex 1D (page 3)--LATIN AMERICA Expenditures and Research Scientists

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Peru											
Expenditures	6,317	6,649	7,092	7,572	7,303	10,189	9,980	4,491	3,211	4,564	5,821
Scientists	171	180	192	205	220	253	248	264	240	259	269
Uruguay											
Expenditures	1,241	1,330	1,419	1,752	1,947	2,434	1,912	2,211	1,951	2,578	2,726
Scientists	70	75	80	90	100	125	156	180	159	210	222
Venezuela											
Expenditures	9,301	10,106	12,744	8,509	8,656	8,925	20,322	23,349	23,690	20,414	25,586
Scientists	208	226	285	348	354	365	286	329	333	287	360

ii) Countries for which time-series could not be constructed

Dominican Republic											
Expenditures								2,467	2,294	1,729	1,643
Scientists		12					40		52	67	99
Guyana											
Expenditures				650	578	1,000	1,067	1,268	1,042	1,455	1,586
Scientists	23		23	25	27	28	27	27			35
Haiti											
Expenditures							199	232	204		235
Scientists	22	23				38					37
Trinidad											
Expenditures			907							397	419
Scientists	37	39		39					39		43

Annex 2-A

Research Expenditures in 41 Developing Countries Grouped by Per Capita GNP Level, and Growthrates 1970-80 (Constant 1975 000 U.S. Dollars)

	(Constructed Time Series)											Growth Rates of Expenditure 1970-1980 % Per Annum
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	
LOW INCOME:	84,552	96,114	112,960	108,314	107,114	126,610	133,686	156,930	157,287	172,714	168,136	7.29
Asia												
Bangladesh	1,224	1,330	1,436	1,365	1,515	6,784	6,106	9,767	10,068	16,865	17,385	36.96
India	54,274	64,682	76,501	69,658	65,448	80,005	83,703	101,754	99,744	107,880	101.098	6.53
Nepal	1,377	1,371	1,425	1,412	1,484	1,616	1,726	1,778	2,200	1,726	1,827	3.94
Sri Lanka	3,713	3,590	3,472	3,357	3,246	3,254	3,443	3,290	2,309	2,323	2,836	-3.83
Sub-Sahara Africa												
Burundi	582	665	693	603	626	649	1,869	2,178	2,165	2,325	2,358	18.94
Kenya	1,520	773	5,066	7,375	8,369	7,985	8,287	12,279	13,608	13,903	14,204	27.41
Madagascar	4,548	4,189	3,653	3,803	4,003	3,657	3,563	3,470	3,376	3,282	3,188	-2.95
Senegal	3,532	3,723	3,914	4,115	4,327	3,949	5,718	5,288	5,612	6,198	6,399	6.45
Sudan	4,505	5,419	4,941	5,281	4,972	6,317	7,320	7,486	8,298	9,154	9,560	8.03
Tanzania	3,329	4,388	6,564	5,820	6,492	7,074	5,506	4,860	4,847	4,878	4,715	0.66
Togo	1,058	605	529	362	506	687	940	892	1,289	1,415	1,236	8.79
Zaire	4,890	5,379	4,766	5,163	5,626	4,633	5,505	3,888	3,771	2,765	3,330	-5.20
MIDDLE INCOME:	115,782	124,045	131,812	140,085	148,121	202,821	241,624	257,241	245,039	226,875	242,581	9.20
Asia												
Indonesia	6,469	7,271	8,177	9,189	15,169	22,449	32,065	34,608	33,695	24,776	29,056	20.01
Korea, Rep.	14,564	15,282	15,053	15,494	15,948	16,415	16,895	17,390	17,898	18,423	18,962	2.65
Malaysia	11,528	12,752	17,957	21,253	26,069	28,006	20,033	24,658	27,250	27,434	29,023	8.49
Philippines	10,111	9,724	9,680	9,637	8,655	9,488	10,401	11,171	11,537	9,018	8,769	0.48
Thailand	9,346	9,706	10,084	10,463	10,860	15,065	14,526	16,703	16,135	14,256	15,203	6.19
N. Africa/Middle East												
Jordan	250	279	335	508	557	490	491	568	644	586	555	8.54
Syria	1,387	1,529	1,588	1,668	1,731	1,628	2,452	2,653	2,653	3,075	3,457	9.69

Annex 2-A (page two) -- Research Expenditures in 41 Developing Countries by Per Capita GNP Level, and Growthrates 1970-80

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	Growth Rate 1970-1980
Sub-Saharan Africa												
Nigeria	21,158	21,277	21,396	21,516	21,638	58,325	90,392	100,175	79,332	73,243	79,634	19.95
Zambia	4,882	4,833	4,785	4,737	4,690	4,644	4,710	3,644	4,191	3,859	3,400	-3.24
Latin America												
Bolivia	1,594	1,568	1,254	1,281	1,307	1,241	1,176	2,062	2,301	2,104	1,834	4.22
Colombia	21,402	24,492	24,297	25,718	22,016	23,004	24,419	24,564	31,981	30,321	31,455	3.34
Ecuador	1,711	2,979	3,898	5,007	5,041	5,153	5,264	5,143	4,471	5,127	4,204	6.74
El Salvador	469	798	634	800	1,028	800	3,140	3,160	3,673	3,546	3,249	25.26
Guatemala	**1,465	**1,599	1,911	1,579	2,331	2,380	2,294	2,669	2,841	3,427	3,485	*9.12
Honduras	1,032	1,064	932	946	973	460	390	549	658	607	639	-6.75
Jamaica	699	740	1,143	1,237	1,183	1,367	1,219	1,071	765	459	504	-4.45
Nicaragua	1,027	1,064	1,101	916	973	1,110	1,210	1,331	1,118	1,212	1,306	2.52
Paraguay	371	439	495	564	649	598	567	631	685	838	2,025	11.66
Peru	6,317	6,649	7,092	7,572	7,303	10,189	9,980	4,491	3,211	4,564	5,821	-4.46
HIGH INCOME:	101,869	110,759	119,461	126,517	137,583	209,771	254,468	269,187	297,172	326,481	355,633	15.06
N. Africa/Middle East												
Cyprus	501	598	695	558	617	676	822	1,045	1,193	1,385	1,575	11.78
Latin America												
Argentina	40,019	42,553	44,148	30,492	31,916	33,398	41,983	38,050	52,153	72,981	108,648	7.90
Barbados	584	623	545	467	419	370	364	364	421	569	501	-2.29
Brazil	36,992	39,894	42,312	67,797	76,419	142,000	165,406	181,899	173,267	177,910	160,026	20.24
Chile	8,384	9,309	9,527	5,446	5,842	5,325	5,690	6,771	6,370	6,592	6,762	-2.91
Costa Rica	1,199	1,556	1,144	1,100	822	1,550	1,140	1,212	1,133	1,354	1,360	0.52
Mexico	2,472	3,353	5,265	8,747	9,345	13,875	15,993	13,329	36,048	40,860	46,359	33.54
Panama	1,176	1,437	1,698	1,649	1,600	1,218	836	957	946	1,838	2,090	11.41
Uruguay	1,241	1,330	1,419	1,752	1,947	2,434	1,912	2,211	1,951	2,578	2,726	7.53
Venezuela	9,301	10,106	12,744	8,509	8,656	8,925	20,322	23,349	23,690	20,414	25,586	12.14

** Trend estimate from data in year 1972-1980.

* Growth rate 1972-1980.

Annex 2-B -- Research Expenditures in 41 Developing Countries Grouped According to Agricultural GDP Growth, 1970-80.

(Constructed Time Series)
(Constant 1975 000 U.S. dollars)

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	Growth Rates of Expenditure 1970-1980 % Per Annum
SLOW GROWTH:	44,826	45,860	45,899	46,874	47,186	93,531	126,603	135,477	114,927	118,172	126,954	14.46
Asia												
Bangladesh	1,244	1,330	1,436	1,365	1,515	6,784	6,106	9,767	10,068	16,865	17,385	36.96
Nepal	1,377	1,371	1,425	1,412	1,484	1,616	1,726	1,778	2,200	1,726	1,827	6.53
N. Africa/Middle East												
Cyprus	501	598	695	558	617	676	822	1,045	1,193	1,385	1,575	11.78
Sub-Sahara Africa												
Burundi	582	665	693	603	626	649	1,869	2,178	2,165	2,325	2,358	18.94
Madagascar	4,548	4,189	3,653	3,803	4,003	3,657	3,563	3,470	3,376	3,282	3,188	-2.95
Nigeria	21,158	21,277	21,396	21,516	21,638	58,325	90,392	100,175	79,332	73,243	79,634	19.95
Sudan	4,505	5,419	4,941	5,281	4,972	6,317	7,320	7,486	8,298	9,154	9,560	8.03
Togo	1,058	605	529	362	506	687	940	892	1,289	1,415	1,236	8.79
Latin America												
Barbados	584	623	545	467	419	370	364	364	421	569	501	-2.29
Honduras	1,032	1,064	932	946	973	460	390	549	658	607	639	-6.75
Jamaica	699	740	1,143	1,237	1,183	1,367	1,219	1,071	765	459	504	-4.45
Peru	6,317	6,649	7,092	7,572	7,303	10,189	9,980	4,491	3,211	4,564	5,821	-4.46
Uruguay	1,241	1,330	1,419	1,752	1,947	2,434	1,912	2,211	1,951	2,578	2,726	7.53
MEDIUM GROWTH:	130,779	147,596	164,684	140,077	138,219	157,627	186,465	199,404	234,028	264,412	304,718	8.15
Asia												
India	54,274	64,682	76,501	69,658	65,448	80,005	83,703	101,754	99,744	107,880	101,098	6.53
Sri Lanka	3,713	3,590	3,472	3,357	3,246	3,254	3,443	3,290	2,309	2,323	2,836	-3.83

Annex 2B (page two) -- Research Expenditures in 41 Developing Countries Grouped According to Agricultural GDP Growth, 1970-80.

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	Growth Rate 1970-1980
Sub-Sahara Africa												
Zaire	4,890	5,379	4,766	5,163	5,626	4,633	5,505	3,888	3,771	2,765	3,300	-5.20
Zambia	4,882	4,833	4,785	4,737	4,690	4,644	4,710	3,644	4,191	3,859	3,400	-3.24
Latin America												
Argentina	40,019	42,553	44,148	30,492	31,916	33,398	41,983	38,050	52,153	72,981	108,648	7.90
Chile	8,384	9,309	9,527	5,466	5,842	5,325	5,690	6,771	6,370	6,592	6,762	-2.91
Costa Rica	1,199	1,556	1,144	1,119	822	1,550	1,140	1,212	1,133	1,354	1,360	0.52
El Salvador	469	798	634	1,200	1,028	800	3,140	3,160	3,673	3,546	3,249	25.26
Mexico	2,472	3,353	5,265	8,747	9,345	13,875	15,993	13,329	36,048	40,860	46,359	33.54
Panama	1,176	1,437	1,698	1,649	1,600	1,218	836	957	946	1,838	2,090	11.41
Venezuela	9,301	10,106	12,744	8,509	8,656	8,925	20,322	23,349	23,690	20,414	25,586	12.14
RAPID GROWTH:	126,598	137,462	153,686	188,384	207,413	288,044	316,710	348,477	350,543	343,486	334,678	12.19
Asia												
Indonesia	6,469	7,271	8,177	9,189	15,169	22,449	32,065	34,608	33,695	24,776	29,056	20.01
Korea, Rep.	14,564	15,282	15,053	15,494	15,948	16,415	16,895	17,390	17,898	18,423	18,962	2.65
Malaysia	11,528	12,752	17,957	21,253	26,069	28,006	20,033	24,658	27,250	27,434	29,023	8.49
Philippines	10,111	9,724	9,680	9,637	8,655	9,488	10,401	11,171	11,537	9,018	8,769	0.48
Thailand	9,346	9,706	10,084	10,463	10,860	15,065	14,526	16,703	16,135	14,256	15,203	6.19
North Africa/ Middle East												
Jordan	250	279	335	508	557	490	491	568	644	586	555	8.54
Syria	1,387	1,529	1,588	1,668	1,731	1,628	2,452	2,653	2,653	3,075	3,457	9.69
Sub-Saharan Africa												
Kenya	1,520	773	5,066	7,375	8,869	7,985	8,287	12,279	13,608	13,903	14,204	27.41
Senegal	3,532	3,723	3,914	4,115	4,327	3,949	5,718	5,288	5,612	6,198	6,399	6.45
Tanzania	3,329	4,388	6,564	5,820	6,492	7,074	5,506	4,860	4,847	4,878	4,715	0.66

Annex 2-C -- Scientist Numbers and Growth Rates in 41 Developing Countries Grouped by Per Capita GNP Level, 1970-80

(Constructed Time Series)

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	Growth Rates of Scientists 1970-1980 % Per Annum
LOW INCOME:	6,861	6,933	7,080	7,438	7,813	8,569	8,685	9,216	9,511	10,237	10,621	4.81
Asia												
Bangladesh	138	150	162	175	190	635	571	914	951	1,593	1,642	33.22
India	5,805	5,850	5,895	6,166	6,450	6,623	6,716	6,811	6,907	7,004	7,103	2.25
Nepal	170	169	175	175	184	200	214	220	217	214	226	3.33
Sri Lanka	109	105	150	161	156	202	213	287	343	346	422	15.12
Sub-Sahara Africa												
Burundi	21	24	25	26	27	28	25	22	26	40	41	4.47
Kenya	207	210	213	233	280	321	333	299	371	289	400	6.48
Madagascar	76	70	73	76	80	78	76	74	72	70	68	-0.64
Senegal	51	53	56	59	62	57	82	85	93	99	105	8.17
Sudan	121	128	139	149	140	178	162	166	184	203	212	5.46
Tanzania	89	100	112	130	145	158	184	194	200	256	256	11.34
Togo	14	8	7	10	14	19	26	31	37	42	49	20.79
Zaire	60	66	72	78	85	70	83	113	110	81	97	4.85
MIDDLE INCOME:	4,117	4,357	4,683	5,070	5,185	5,828	6,996	7,458	7,953	8,176	8,770	8.49
Asia												
Indonesia	371	417	469	527	592	664	779	914	1,072	1,256	1,473	14.78
Korea, Rep.	734	774	762	784	807	831	855	880	906	933	960	2.67
Malaysia	133	147	207	245	317	498	573	605	690	777	822	21.90
Philippines	880	846	972	1,117	1,038	1,137	1,245	1,337	1,381	1,079	1,050	3.19
Thailand	494	513	533	553	574	595	1,280	1,320	1,341	1,430	1,525	14.66
N. Africa/Middle East												
Jordan	21	23	28	42	40	35	35	38	40	38	35	4.93
Syria	69	76	79	83	86	81	122	132	132	153	172	9.70
Sub-Sahara Africa												
Nigeria	300	302	304	298	300	491	761	843	917	997	1,084	17.27
Zambia	82	81	80	80	79	78	79	104	118	109	96	3.39

Annex 2-C (page two) -- Scientist Numbers and Growth Rates in 41 Developing Countries Grouped by Per Capita GNP Level, 1970-80.

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	Growth Rate 1970-1980
Latin America												
Bolivia	61	60	48	49	50	48	45	57	74	82	114	5.48
Colombia	502	575	570	604	517	540	392	394	339	321	333	-6.23
Ecuador	54	94	123	158	200	204	209	204	294	337	276	16.11
El Salvador	46	55	52	56	72	56	77	78	91	88	116	8.44
Guatemala	**32	**37	50	41	61	63	61	71	100	121	123	*14.18
Honduras	65	67	69	70	72	80	68	52	62	57	60	-1.82
Jamaica	52	55	85	92	88	102	94	85	61	36	40	-3.65
Nicaragua	28	29	31	33	34	37	40	44	54	59	63	8.82
Paraguay	22	26	29	33	38	35	33	36	41	44	53	7.13
Peru	171	180	192	205	220	253	248	264	240	259	375	6.26
HIGH INCOME:	3,495	3,727	4,119	4,166	4,499	4,633	5,119	5,134	5,274	5,603	6,180	5.38
N. Africa/Middle East												
Cyprus	31	37	43	47	52	57	52	52	53	54	55	4.85
Latin America												
Argentina	853	907	941	964	1,009	1,040	926	970	961	919	1,064	1.05
Barbados	15	16	14	12	12	12	13	13	15	18	23	2.82
Brazil	1,530	1,650	1,750	1,473	1,660	1,974	2,529	2,496	2,544	2,757	2,957	7.49
Chile	154	171	175	179	192	175	187	265	285	284	281	6.82
Costa Rica	47	61	68	66	71	77	56	60	56	67	75	1.56
Mexico	551	540	711	936	1,000	770	888	740	839	951	1,079	5.16
Panama	36	44	52	51	49	38	26	29	29	56	64	0.30
Uruguay	70	75	80	90	100	125	156	180	159	210	222	13.35
Venezuela	208	226	285	348	354	365	286	329	333	287	360	3.55
TOTAL:	14,473	15,017	15,882	16,674	17,497	19,030	20,800	21,808	22,738	24,016	25,571	6.10

** Estimate from data in year 1972-1980.

* Growth rate 1972-1980.

Annex 2-D -- Scientist Numbers and Growth Rates in 41 Developing Countries Grouped by Growth of GDP, 1970-80

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	Growth Rates of Scientists 1970-1980 % Per Annum
SLOW GROWTH:	1,244	1,281	1,369	1,425	1,479	2,258	2,466	2,916	2,994	3,793	4,097	14.19
Asia												
Bangladesh	138	150	162	175	190	635	571	914	951	1,593	1,642	33.22
Nepal	170	169	176	175	184	200	214	220	217	214	226	3.33
N. Africa/Middle East												
Cyprus	31	37	43	47	52	57	52	52	53	54	55	4.85
Sub-Sahara Africa												
Burundi	21	24	25	26	27	28	25	22	26	40	41	4.74
Madagascar	76	70	73	76	80	78	76	74	72	70	68	-0.64
Nigeria	300	302	304	298	300	491	761	843	917	997	1,084	17.27
Sudan	121	128	139	149	140	178	162	166	184	203	212	5.46
Togo	14	8	7	10	14	19	26	31	37	42	49	20.79
Latin America												
Barbados	15	16	14	12	12	12	13	13	15	18	23	2.82
Honduras	65	67	69	70	72	80	68	52	62	57	60	-1.82
Jamaica	52	55	85	92	88	102	94	85	61	36	40	-3.65
Peru	171	180	192	205	220	253	248	264	240	259	375	6.26
Uruguay	70	75	80	90	100	125	156	180	159	210	222	13.35
MEDIUM GROWTH:	7,951	8,106	8,481	9,085	9,517	9,494	9,537	9,786	10,072	10,192	10,757	2.85
Asia												
India	5,805	5,850	5,895	6,165	6,450	6,623	6,716	6,811	6,907	7,004	7,103	2.25
Sri Lanka	109	105	150	161	156	202	213	287	343	346	422	15.12
Sub-Sahara Africa												
Zaire	60	66	72	78	85	70	83	113	110	81	97	4.85
Zambia	82	81	80	80	79	78	79	104	118	109	96	3.39
Latin America												
Argentina	853	907	941	964	1,009	1,040	926	970	961	919	1,064	1.05
Chile	154	171	175	179	192	175	187	265	285	284	281	6.82

Annex 2-D (page two) -- Scientist Numbers and Growth Rates in 41 Developing Countries Grouped by Growth of GDP, 1970-80

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	Growth Rate 1970-1980
Latin America (Continued)												
Costa Rica	47	61	68	66	71	77	56	60	56	67	75	1.56
El Salvador	46	55	52	56	72	56	77	78	91	88	116	8.44
Mexico	551	540	711	936	1,000	770	988	740	839	951	1,079	5.16
Panama	36	44	52	51	49	38	26	29	29	56	64	0.30
Venezuela	208	226	285	348	354	365	286	329	333	287	360	3.55
RAPID GROWTH:	5,278	5,630	6,032	6,164	6,501	7,278	8,797	9,106	9,672	10,031	10,717	7.89
Asia												
Indonesia	371	417	469	527	592	664	779	914	1,072	1,256	1,473	14.78
Korea, Rep.	734	774	762	784	807	831	855	880	906	933	960	2.67
Malaysia	133	147	207	245	317	498	573	605	690	777	822	21.90
Philippines	880	846	972	1,117	1,038	1,137	1,245	1,337	1,381	1,079	1,050	3.19
Thailand	494	513	533	553	574	595	1,280	1,320	1,341	1,430	1,525	14.66
N. Africa/Middle East												
Jordan	21	23	28	42	40	35	35	38	40	38	35	4.93
Syria	69	76	79	82	86	81	122	132	132	153	172	9.70
Sub-Sahara Africa												
Kenya	207	210	213	233	280	321	333	299	371	289	400	6.48
Senegal	51	53	56	59	62	57	82	85	93	99	105	8.17
Tanzania	89	100	112	130	145	158	184	194	200	256	256	11.34
Latin America												
Bolivia	61	60	48	49	50	48	45	57	74	82	114	5.48
Brazil	1,530	1,650	1,750	1,473	1,660	1,974	2,529	2,496	2,544	2,757	2,957	7.49
Colombia	502	575	570	604	517	540	392	394	339	331	333	-5.23
Ecuador	54	94	123	158	200	204	209	204	294	337	276	16.11
Guatemala	**32	**37	50	41	61	63	61	71	100	121	123	*14.18
Nicaragua	28	29	31	33	34	37	40	44	54	59	63	8.82
Paraguay	22	26	29	33	38	35	33	36	41	44	53	7.13

** Estimate from data in year 1972-1980.

* Growth rate 1972-1980.

Annex 3: Donors to Agricultural Research 1975 - 81 1/

Region and Countries Benefitting	Donor Country or Agency												Magnitude of Funds Channeled to Recipient Country 2/					
Asia and Pacific 3/	Australia	Belgium	Canada	France	Germany (Fed Rep)	Scan-dinavia	Switz-erland	UK	USA	FAO/ UNDP	IBRD	Others 4/	over 40 m	20-40 mill	10-20 mill	5-10 mill	1-5 mill	under 1 mill
Bangladesh	+				+	+	+		+	+	+	+	✓					
Burma											+						✓	✓
Fiji	+							+										
India					+	++	+	+	+		+		✓					
Indonesia	+			+			+		+		+	++	✓					
Korea (Rep.)					+				+	+	+				✓			
Malaysia	+	+			+			+			+			✓				
Nepal	+		+		+		+		+	+	+	+				✓		
Nr Caledonia	+			+				+										✓
Papua/N. Guinea									+								✓	
Pakistan	+				+	+	+		+	+	+				✓			
Philippines	+				+			+	+	+	+	+			✓			
Polynesia																		
Solomon Islands	+							+										
Sri Lanka	+					+	+		+	+	+	+		✓				
Thailand	+				+			+	+	+	+	++		✓				
W. Samoa	+			+								+						✓
Regional	+			+	+	+			+	+	+							
Asia Total = mill $	66.7	2.5	NA	NA	30.6	2.0	3.2	0.5	88.6	84.0	191.7	1.0	464.8 Total					
NA/ME																		
Afghanistan											+	+						
Bahrain								+										✓
Cyprus					+			+			+							✓
Egypt					+				+		+	+	✓					✓
Jordan	+								+	+		+						
Malta								+									✓	
Morocco		+		+	+				+									✓
Saudi Arabia								+						✓				
Sudan			+					+	+	+	+	+						✓
Syria				+	+				+	+	+	+	✓					
Tunisia		+		+					+	+	+					✓		
Turkey					+					+	+					✓		
Yemen AR											+				✓			
Yemen PDR											+				✓			
Regional																		✓
NA/ME Total Mill $	1.6	1.3	NA	NA	17.3	-	-	0.4	99.0	38.5	62.5	17.5	238.1 Total					

1/ Identified donors from material supplied to IFPRI, either directly from donors or by FAO or the World Bank. This is not a complete list of donors.
2/ These are funds already committed. In some cases the bulk has been spent, and in some cases a substantial proportion remains to be spent in the future. In most cases the donors have indicated expenditures over a 3-5 year period rather than for a single year, and for this reason we have indicated an order of magnitude rather than a precise figure for 1980. Figures are in current dollars.
3/ To the best of our knowledge we have only indicated specific donor support to projects, and not simply donor technical assistance. The latter is particularly important in the case of some countries such as France, which has a large overseas research support establishment and lists technical staff in a considerably greater number of countries than actually received funds for project support. This also applies to U.N. agencies such as FAO. These are not indicated here.
4/ "Others" include private foundations. EEC, IFAD, and some countries which have indicated support for overseas research without actually stating a financial figure, e.g., Japan. Two crosses indicates more than one country or agency giving support

Annex 3: (Page 2) Donors to Agricultural Research 1975 - 81[1/]

Sub-Saharan Africa	Belgium	Canada	France	Germany (Fed Rep)	Scan-dinavia	Switz-erland	UK	USA	FAO/ UNDP	IBRD	Others	over 40 m	20-40 mill	10-20 mill	5-10 mill	1-5 mill	under 1 mill
	Donor Country or Agency																
Benin			+								+				✓		
Botswana		+			+		+	+	+		+					✓	
Burundi	+		+	+			+	+		+	+			✓			
Cameroon	+	+	+	+				+			+			✓			
Central African Rep.			+													✓	✓
Chad			+					+	+	+							
Congo			+	+						+						✓	
Ethiopia					+			+	+	+	+				✓		
Ghana		+		+			+		+	+	+				✓		
Guinea										+						✓	
Ivory Coast	+		+	+						+	+		✓				
Kenya	+	+		+	+	+	+	+	+	+				✓			
Lesotho							+	+							✓		
Liberia								+		+						✓	
Madagascar			+	+						+						✓	
Malawi							+	+		+	+			✓			
Mali											+						✓
Mauritania			+														✓
Mauritius			+				+										✓
Niger	+		+					+	+	+	+				✓		
Nigeria			+	+			+			+							✓
Rwanda	+		+	+		+		+		+				✓			
Senegal	+	+	+				+		+	+	+		✓				
Sierra Leone								+		+						✓	
Somalia					+			+	+	+					✓		
Swaziland		+					+	+								✓	
Tanzania		+		+	++	+		+	+	+	+				✓		
Togo			+	+						+	+			✓			
Upper Volta		+	+	+					+	+				✓			
Zaire	+	+	+							+	+			✓			
Zambia	+	+			+		+	+	+	+	+		✓				
Others			+					+		+							
Regional	+	+	+	+	+	+	+	+					✓		✓		
Africa Total Mill. $	10.5	NA	60.5	38.3	3.1	0.5	4.5	140.3	58.4	92.0	63.0	471.1 Total					

Annex 3: (Page 3) Donors to Agricultural Research 1975-81

	Donor Country or Agency											Magnitude of Funds Channeled to Recipient Country					
	Belgium	France	Germany	Sweden	Switzer-land	UK	USA	UNDP/ FAO	IBRD	IDB	Others	Over 40 Mill	20-40 Mill.	10-20 Mill.	5-10 Mill.	1-5 Mill.	Under 1 Mill.
Central America/ Caribbean																	
Costa Rica			+							+						✓	
Dominican Rep.							+									✓	
El Salvador							+									✓	
Guatemala							+									✓	
Haiti		+					+									✓	
Honduras					+		+	+	+	+				✓			
Jamaica						+	+			+	+			✓			
Mexico			+			+		+	+			✓					
Nicaragua				+		+			+								✓
Panama							+	+							✓		
Trinidad						+											✓
Regional				+		+	+	+		+	+		✓				
Central Amer./ Caribbean Total Mill $	--	1.2	0.8	2.0	1.1	16.9	59.2	n.a.	43.0	14.5	1.9	140.6 Total					
South America																	
Argentina			+					+								✓	
Bolivia					+		+		+	+					✓		
Brazil			+			+		+	+	+		✓					
Colombia			+				+			+							
Ecuador							+		+	+	+		✓				
Guyana							+		+								✓
Paraguay							+									✓	
Peru	+		+		+		+	+	+	+			✓				
Uruguay								+								✓	
Belize						+											✓
Regional		+			+	+	+			+							
South America Total Mill $	0.6	1.7	11.5	0.4	0.7	1.0	64.1	22.0	130.1	131.0	1.1	364.2 Total					

Annex 4 : Comparative Indicators: Countries with Data for 1980

	GNP Per Cap. 1978 (U.S. $) a/	Agric. GDP 1980 (000 $) b/	Agric. Growth-Rate 1970-1980 (percent)	Population 1980 (000)	Arable and Permanent Crop Area 1978 (000 hectares)
ASIA		74.517.349		1,200,522	253,110
(1) Temperate East Asia					
Korea, Republic	1,160	8,192,972	4.0	37,979	2,222
(2) South Asia Sub-Continent		43,480,281		879,289	199,936
Bangladesh	90	3,656,174	1.6	88,705	9,127
India	180	34,932,100	2.6	693,887	168,500
Nepal	120	913,578	1.4*	14,256	2,319
Pakistan	230	3,978,429	1.9	82,441	19,990
(3) Indo-Malaysian Humid Tropics		22,844,096		283,254	50,952
Fiji	1,440	174,933	6.6*	619	n.a.
Indonesia	360	6,657,183	4.0	151,894	16,368
Malaysia	1,090	3,578,629	5.0	13,640	6,480
Papua New Guinea	560	559,521	5.7	3.082	359
Philippines	510	5,428,844	4.9	50,996	8,100
Solomon Islands	430	n.a.	n.a.	221	n.a.
Sri Lanka	190	697,783	2.3	14,871	2,145
Thailand	490	5,747,203	5.6	47,674	17,500
Tonga	430	n.a.	n.a.	96	n.a.
Western Samoa	n.a.	n.a.	n.a.	161	n.a.

Annex 4 (page two): Comparative Indicators: Countries with Data for 1980

	GNP Per Cap. 1978 (U.S. $) a/	Agric. GDP 1980 (000 $) b/	Agric. Growth-Rate 1970-1980 (percent)	Population 1980 (000)	Arable and Permanent Crop Area 1978 (000 hectares)
NORTH AFRICA/MIDDLE EAST					
(4) Mediterranean Climatic Region		1,706,948		12,485	7,390
Cyprus	2,110	140,644	1.1*	651	432
Jordan	1,050	126,880	5.3*	3,190	1,370
Syria	930	1,439,424	7.2	8,644	5,588
SUB-SAHARAN AFRICA		23,489,544		197,018	60,923
(5) Semiarid Tropics		13,546,420		101,116	33,909
Nigeria	560	11,341,122	-1.5	77,082	23,990
Senegal	340	527,770	3.3	5,661	2,404
Sudan	320	1,677,528	0.9*	18,371	7,515
(6) Lowland Humid Tropics		6,572,194		51,411	13,269
Ghana	390	3,941,059	-1.2	11,679	2,720
Madagascar	250	827,630	-0.3	8,742	2,929
Togo	320	161,858	1.7	2,699	1,420
Zaire	210	1,641,647	1.9	28,291	6,200
Ivory Coast	1,040	2,373,800	3.4	8,200	9,160
(7) Eastern and Southern Africa		3,370,930		44,493	13,745
Burundi	140	289,904	1.7	4,512	1,277
Kenya	320	1,314,931	5.5	16,402	2,270
Tanzania	230	1,340,234	4.5	17,934	5,140
Zambia	480	425,861	3.1	5,645	5,058

Annex 4 (page 3) Comparative Indicators: Countries with Data for 1980

	GNP Per Cap. 1978 (U.S. $) a/	Agric. GDP 1980 (000 $) b/	Agric. Growth-Rate 1970-1980 (percent)	Population 1980 (000)	Arable and Permanent Crop Area 1978 (000 hectares)
LATIN AMERICA		44,536,354		345,640	136,973
(8) Central American/ Caribbean		11,955,087		101,919	31,931
Barbados	1,940	36,949	0.0	253	33
Costa Rica	1,540	562,713	2.5	2,213	490
Dominican Republic	910	839,259	3.3	5,946	1,230
El Salvador	600	646,965	2.7	4,801	680
Guatemala	910	n.a.	5.3	7,262	1,800
Guyana	550	85,721	1.0	884	379
Honduras	480	399,451	0.8	3,693	1,757
Jamaica	1,100	219,914	1.4	2,192	265
Mexico	1,290	8,283,762	2.1	69,994	23,200
Nicaragua	840	484,840	5.4	2,737	1,511
Panama	1,290	39,513	2.4	1,944	566
(9) Tropical South America		24,652,390		202,633	62,204
Bolivia	510	537,826	3.6	5,572	3,327
Brazil	1,570	13,869,680	5.3	126,377	40,720
Colombia	870	4,662,543	4.9	26,907	5,600
Ecuador	910	1,191,922	4.6	8,023	2,615
Paraguay	850	712,318	6.2	3,067	1,155
Peru	740	1,741,336	0.7	17,773	3,430
Venezuela	2,910	1,936,765	3.5	14,914	5,357

Annex 4 (page four) Comparative Indicators: Countries with Data for 1980

	GNP Per Cap. 1978 (U.S. $)a/	Agric. GDP 1980 (000 $) b/	Agric. Growth-Rate 1970-1980 (percent)	Population 1980 (000)	Arable and Permanent Crop Area 1978 (000 hectares)
(10) Temperate South America		7,928,877		41,088	42,838
Argentina	1,910	6,640,383	2.3	27,056	35,100
Chile	1,410	830,094	2.7	11,107	5,828
Uruguay	1,610	458,400	0.1	2,925	1,910
TOTALS ALL REGIONS		144,250,190		1,755,665	458,396

a/ Current dollars

b/ Constant 1975 dollars

* 1951-79 growth rate

Annex 5: Number of Extension Workers by Category and Distribution by Region, 1980. 1/

Developing Countries	Staff Numbers by Category: Support: Administrative	Support: Specialist	Field: Agents	Field: Assistants	Total Staff	Grads. as % of Tot. Staff (%)	Distribution of Tot. Staff by Region (%)	Grads as % of Tot. staff by Region (%)	Distribution of Total Agr. Pop. by Region (%)	Nos. Staff Per 1000 Agric. Pop	Nos. Grads. Per 1000 Agric. Pop.
ASIA											
Temperate E. Asia	2,218	3,540	6,137	13,578	25,473	18.5	11.4	8.1	2.5	1.20	0.223
South Asia	7,751	2,262	19,285	85,902	115,200	25.5	51.5	50.8	63.3	0.21	0.053
Humid Tropical Asia	4,263	2,065	11,328	19,151	36,807	15.4	16.4	9.8	8.8	0.48	0.073
Total Asia	14,232	7,867	36,750	118,631	177,480	20.9	79.3	68.7	74.6	0.27	0.061
NEAR EAST											
Mediterranean Zone	556	515	10,120	1,476	12,667	13.0	5.7	2.9	5.5	0.27	0.035
Semiarid Tropics	238	85	287	354	964	34.0	0.4	0.5	1.3	0.10	0.031
Total Near East/ North Africa	794	600	10,407	1,830	13,631	14.5	6.1	3.4	6.8	0.23	0.033
AFRICA											
Semiarid Tropics	152	333	2,310	401	3,196	11.2	1.4	0.6	1.1	0.34	0.038
Lowland Humid Tropics	123	330	3,721	533	4,707	16.2	2.1	1.3	1.1	0.48	0.079
Eastern/Southern Africa	416	525	1,084	4,010	6,035	16.6	2.7	1.7	4.6	0.15	0.025
Total Africa	691	1,188	7,115	4,944	13,938	15.3	5.2	3.6	6.8	0.24	0.036
LATIN AMERICA											
Central America	444	439	2,078	958	3,919	54.6	1.7	3.7	3.9	0.11	0.062
Caribbean Islands	43	127	449	101	720	16.0	0.3	0.2	0.8	0.10	0.016
Tropical S. America	639	1,821	9,321	1,739	13,520	81.6	6.0	19.1	6.6	0.23	0.191
Temperate S. America	209	114	462	60	845	83.0	0.4	1.2	0.5	0.21	0.178
Total Latin America	1,335	2,501	12,310	2,858	19,004	73.6	8.4	24.2	11.8	0.18	0.135
TOTAL THIRD WORLD	17,052	12,156	66,582	128,263	224,053	24.6	100.0	100.0	100.0	0.26	0.064
Industrialized Countries											
ASIA											
Japan	749	1,627	13,493	459	16,328	57.0	25.7	24.1	28.3	1.16	0.660
OCEANIA											
Australia/New Zealand	163	426	1,021	92	1,702	92.0	2.7	4.2	2.3	1.43	1.320
AFRICA											
South Africa	355	71	757	489	1,672	28.8	2.6	1.1	15.7	0.21	0.062
EUROPE											
14 Countries	2,369	3,418	11,239	1,434	18,460	44.2	29.3	21.2	40.6	0.91	0.404
NORTH AMERICA											
Canada and the U.S.	1,448	4,790	12,678	6,164	25,080	75.8	39.7	49.4	13.1	3.87	2.940
TOTAL INDUSTRIALIZED	5,084	10,332	39,188	8,638	63,242	61.0	100.0	100.0	100.0	1.27	0.775
TOTAL ALL REGIONS	22,136	22,488	105,770	136,901	287,295	33.3	100.0	100.0	100.0	0.31	0.105
PERCENT OF TOTAL IN DEVELOPING COUNTRIES	77.0	54.0	62.9	94.0	78.0	58.8	--	--	94.5	--	--

1/ Source of data: Swanson and Rassi 1981.

Annex 6

National Agricultural Research Systems

Resources used: checklist of information needed

MINIMUM: For each research unit in the public sector (including Universities) and in the private sector:
for current year and as many earlier years as possible:

1. Number of research workers by education level:

Ph.D.)		Crops (all aspects)
M. S./M. Vet)	or equivalent in	Animal Husbandry
B. S.)		Forestry
		Fisheries
		Socio-Economics

2. Support staff below B.S. level of education:
   Specify diploma, certificate, high school, with numbers in each category

3. Number of persons in training
   Expected B.S. output of local/regional institutions.
   Expected annual intake into agricultural research.
   Staff in training for M.S. in local institutions
   in overseas institutions
   Ph.D. in local institutions
   in overseas institutions

4. Agricultural research expenditures:
   Capital (buildings, land, and equipment, separately)

Salaries and wages)		Crops
Administration)	by sector in	Animal Husbandry
Operating costs)		Forestry
		Fisheries
		Socio-Economics

5. Extent of foreign assistance to agricultural research:
   Capital
   Incremental staff costs
   Incremental operating costs
   Training components

Please specify currency and whether in current terms or at a given reference date.

SUPPLEMENTARY:

1. Structure of research system, e.g., main, regional, sub-station, etc.
2. Institutional arrangements, e.g., Ministry, Research Council, University, autonomous group, Private Institutions.
3. Location and staffing of each unit. Scientists and support staff by discipline.
4. If several groups involved, specify salary scales in each group for:
   Ph.D)
   M.S.) level staff
   B.S.)
5. Total budget and breakdown for each unit.
6. How is budget formulated, disbursed: at what point(s) is control exercised?
7. Is the allocation of funds done on a systematic and regular basis with assured continuity?
8. Are supporting services adequately staffed at each unit. If not, give reasons: manpower, money, problems of location and/or management.
9. Agricultural research expenditure for major commodity or commodity groups.
10. For M.S. and Ph.D. staff - average years in post after qualifying at M.S. or Ph.D. level.

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Note: A supplementary bibliography classified by region and country is available from IFPRI upon request.