Consultative Group on International Agricultural Research

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Study Paper Number 21

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The Impact of Agricultural Research in Tropical Africa

A Study of the Collaboration between the International and National Research Systems

Hans E. Jahnke, Dieter Kirschke, and Johannes Lagemann

The Impact of Agricultural Research in Tropical Africa

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in collaboration with

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At its annual meeting in November 1983 the Consultative Group on International Agricultural Research (CGIAR) commissioned a wide-ranging impact study of the results of the activities of the international agricultural research organizations under its sponsorship. An Advisory Committee was appointed to oversee the study and to present the principal findings at the annual meetings of the CGIAR in October 1985. The impact study director was given responsibility for preparing the main report and commissioning a series of papers on particular research issues and on the work of the centers in selected countries. This paper is one of that series.

The judgments expressed herein are those of the author(s). They do not necessarily reflect the views of the World Bank, of affiliated organizations, including the CGIAR Secretariat, of the international agricultural research centers supported by the CGIAR, of the donors to the CGIAR, or of any individual acting on their behalf. Staff of many national and international organizations provided valued information, but neither they nor their institutions are responsible for the views expressed in this paper. Neither are the views necessarily consistent with those expressed in the main and summary reports, and they should not be attributed to the Advisory Committee or the study director.

This paper has been prepared and published informally in order to share the information with the least possible delay.

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ABSTRACT

The study of the achievements and potential of the international agricultural research centers (often referred to as the "CGIAR impact study") came about as a result of widespread interest in the centers and concerns about their effectiveness, especially in tropical Africa. The objective of this report is to examine in a general way the opportunities that exist for agricultural research to help resolve Africa's economic and agricultural crises. Particular attention is given to the roles that international centers have played in the past and must continue to play.

The report is divided into two parts. Part A contains general considerations and sets the framework for the impact assessment. It introduces the problems research is faced with on the African continent and examines the present state of international and national agricultural research activities. Part B presents a detailed impact assessment concentrating on the collaboration between the CGIAR system and the national systems and discusses research impacts on agricultural production. This part relies heavily on information from the nine case studies of countries in tropical Africa: Burkina Faso (I.F. Ouali), Cameroon (S.N. Lyonga), Ethiopia (A. Negewo, H. Shawel), Kenya (G. Ruigu), Malawi (K. Billing), Nigeria (D.E. Okoro, J.N. Onuoka), Senegal (D. Sène), Tanzania (B. Ndunguru), Zimbabwe (K. Billing). As will be evident, the country studies show that each country has individual problems of its own, and that generalizations are hazardous. In total, however, these studies offer a fairly comprehensive view of international agricultural research activities in tropical Africa. Considering the many "top down" reviews of the CGIAR system, these studies should be a useful source of information on future allocative decisions. This is one of the main reasons for the emphasis given to country studies in the overall impact study.

FOREWORD

This report is one of the results of the CGIAR's overall endeavor to understand better the impact of agricultural research, particularly the CG institutes, on the developing countries and their agricultural development. While the overall endeavor has worldwide dimensions, this report refers to tropical Africa alone. Originally it was to have consisted of the results of nine country studies only, to be coordinated by GFA, a German consulting firm. It was soon found that the heterogeneity of studies on one hand and the need to view the particular challenge of African agricultural development within a more general framework on the other, made it advisable to attempt to write an "overall report". It essentially consists of two parts: A - General Considerations (agricultural development in tropical Africa, the role of the CG system there, the national agricultural research system) and B - Country Perspectives, summarizing the results from the nine country studies in terms of impact of the IARS on NAR and of impact on agricultural production.

GFA wishes to express its appreciation for having been entrusted as a German consulting firm with the "tropical Africa" part of the CGIAR's endeavor to study the impact of agricultural research. A considerable number of persons have contributed to this study and to the report as presented here.

Prof. J. Anderson, overall Study Director, set us on the course, was continuously available for advice, and constituted for us and for our collaborators in many different countries over the study period of one year the rock in the sea. This also holds for Dorothy Marschak, assistant to Prof. Anderson, and his substitute, whenever he had to travel away from Washington.

The CG Secretariat was a manyfold and always forthcoming source of information and guidance. A particularly valuable form of assistance was provided by distributing the drafts of the country reports to the national authorities, to the IARCs, and to others, and by relating comments back to the authors. Much appreciated were Robert Herdt's extensive commentaries on various country studies.

The authors benefited from TAC's ongoing efforts to develop a rational base for the setting of research priorities. Chapter 3 on the CG activities in Africa builds to a considerable degree on TAC's work. Particular mention should be made of Dr. G. Camus, TAC Chairman, A. von der Osten, then Executive Secretary, and Mrs. P. Roberts-Pichette for authorization and implementation of the collaboration.

The FAO through its work with TAC on quantitative indicators for research priorities, its general data bank and its massive work on the AT 2000 study and on the AEZ project, has contributed in many ways. This includes concepts and approaches that go well beyond any particular piece of information or input. Prof. Bommer, Assistant Director General, authorized and made possible this cooperation in which Dr. D. Norse, Senior Policy and Planning Coordinator, and Mr. I. R. Loerbroks played a major role.

The IARCs provided a wealth of information, supplied comments on country reports, and the African centers in addition gave most valuable logistical support. Information offered and reactions provided by the centers were heterogeneous in character and volume. This was not seen as a disadvantage because in the end this present report does not aim to provide the IARS's view on research impact, but rather that of the recipients of the IARS results.

Finally, of the international organizations, the World Bank has to be mentioned as a general source of information and as a critical sounding board for many of the country study drafts. Of particular value for this report have been the bank's several recent analyses of the economic and agricultural situation of Sub-Saharan Africa.

For inclusion of at least some non-CG experience with research cooperation the French research system was selected because of its many decades of presence in Africa, its continued existence to the present day, and its centralized structure which makes the system easy to address. Prof. G. Vallaeys, research advisor in the Ministry of Foreign Affairs, authorized the French contribution. M. Dubreuil, in charge of international relations at CIRAD, provided active support through organizing and financing a country case study (Senegal), and a summary report prepared by Mr. P. Roche, on which Chapter 4.3 is based. Dr. G. Tacher was instrumental in maintaining the liaison and also in advising about the impact of veterinary research work.

None of the work would have been possible without the active and sympathetic support of the national authorities in the different countries studied. A name by name acknowledgement is contained in the country reports. It may, therefore, suffice to say that of the nine countries originally envisaged for case studies, each one provided the conditions necessary for execution and timely conclusion of the work. The countries and the respective authors of the country studies (in brackets) were: Burkina Faso (I.F. Ouali), Cameroon (S.N. Lyonga), Ethiopia (A. Negewo, H. Shawel), Kenya (G. Ruigu), Malawi (K. Billing), Nigeria (D.E. Okoro, J.N. Onvoka), Senegal (D. Sène), Tanzania (B. Ndunguru), Zimbabwe (K. Billing).

Mr. Gromotka organized the overall information flow, compiled most of the aggregate statistics for tropical Africa, and was responsible for much of the proofreading.

Finally, the heavy typing load - various drafts not only of this summary report, but also of the country reports - has to be mentioned. Mrs. U. Paul, Mrs. H. Jenner and Mrs. M. Gramann did an excellent job in mastering this load and in standing up against pressures of time and deadlines over months.

We thank all the collaborators and contributors mentioned and the many others who have gone unmentioned.

Hamburg, October 1985

H.E.J., D.K., J.L.

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ABBREVIATIONS AND ACRONYMS

AEZ	Agroecological Zones (FAO Research Project)
AFAA	Association of Faculties of Agriculture in Africa
AID	Agency for International Development
AT 2000	Agriculture: Toward 2000, FAO project
CEDRES	Centre d'Etudes, de Documentation, de Recherche Economique Sociale
CEEMAT	Centre d'Etude et d'Expérimentation du Machinisme Agricole Tropical
CFDT	French Cotton Development Organization
CG, CGIAR	Consultative Group(on International Agricultural Research)
CIAT	Centro Internacional de Agricultura Tropical, Cali, Colombia
CIMMYT	Centro Internacional de Mejoramiento de Maiz y Trigo, Mexico D.F., Mexico
CIP	Centro Internacional de la Papa, Lima, Peru
CIRAD	Centre de Cooperation Internationale en Recherche
CIRES	Centre Ivorien de Recherches Economiques et Sociales
CTFT	Le Centre Technique Forestier Tropical
DANIDA	Danish International Development Agency
EC	European Community
ETC	Ethiopian Science and Technology Commission
FAO	Food and Agriculture Organization of the United Nations
F.R. Germany	Federal Republic of Germany
GERDAT	Groupement d'Etudes et de Recherches pour le Développement de l'Agronomie Tropicale
GFA	Gesellschaft für Agrarprojekte in Übersee (German Company for Agricultural Projects Overseas)
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit

IADS	International Agricultural Development Service
IAR	International Agricultural Research
IARS, IARC	IAR System, IAR Center
IBPGR	International Board for Plant Genetic Resources, Rome, Italy
IBRD	International Bank for Reconstruction and Development (World Bank)
ICARDA	International Center for Agricultural Research in the Dry Areas, Aleppo, Syria
ICIPE	The International Center of Insect Physiology and Ecology
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics, Andhra Pradesh, India
ICS	Interlinked Computer System (of the FAO)
IDRC	International Development Research Center, Canada
IEMVT	L'Institut d'Elevage et de Médecine Véterinaire
IFAD	International Fund for Agricultural Development, Rome
IFARD	International Center for Agricultural Research in the Dry Areas, Aleppo, Syria
IFPRI	International Food Policy Research Institute, Washington D.C., U.S.A.
IIASA	International Institute for Applied Systems Analysis
IICA	Inter-American Institute for Agricultural Cooperation
IITA	International Institute of Tropical Agriculture, Ibadan, Nigeria
ILCA	International Livestock Center for Africa, Addis Ababa, Ethiopia
ILRAD	International Laboratory for Research on Animal Diseases, Nairobi, Kenya
IRAT	Institut de Recherches d'Agronomie Tropicales et des Cultures Vivrières
IRCC	Institut de Recherches du Café, du Cacao et d'autres Plantes Stimulantes, Paris

IRCT	Institut de Recherches du Coton et des Textiles Exotiques
IRFA	Institut de Recherches sur les Fruits et Agrumes
IRHO	Institut de Recherches sur les Huiles et Oleagineux
IRRI	International Rice Research Institute, Manila, Philippines
ISNAR	International Service for National Agricultural Research, The Hague, Netherlands
ISRA	Institut Sénégalais des Recherches Agricoles
KNCST	Kenya National Council for Science and Technology, Nairobi
NAR	National Agricultural Research
NARS, NARC	NAR System, NAR Center
ORSTOM	Office de la Recherche Scientifique et Technique d'Outre-Mer
PNAP	National Potato Improvement Program (of Ruanda)
PRAPA	Programme Régional d'Amélioration de la Culture des Pommes de Terre en Afrique Centrale
SADCC	Southern African Development Coordination Conference
TAC	Technical Advisory Committee (of the CGIAR)
U.K.	United Kingdom
UNDP	United Nations Development Program
UNFPA	United Nations Fund for Population Activities
US	United States of America
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
VSN	Volontaires du Service National
WARDA	West Africa Rice Development Association, Monrovia, Liberia

Chapter 1

INTRODUCTION

1.1 Background

This report is part of the effort presently undertaken by the Consultative Group to review the effectiveness of its system of IARCs. The concern about effectiveness has a number of - not necessarily consistent - motives among which are:

- the expanding belief that research successes like the so-called green revolution can be "made"; that research planning is just another form of investment planning;
- the realization at the same time that successes like the green revolution have come up against obstacles that make expansion and/or repetition not so easy;
- the concern by many that the green revolution itself has also had its negative effects;
- the greater squeeze on financial resources in recent years, which has led to the increased need of making choices and comparing alternative research plans in terms of their expected effect.

To these general considerations have to be added the particular concerns about Africa. Over the past two decades, Sub-Saharan Africa (Figure 1) has shown a poor performance in overall economic development and, particularly, in agricultural production and per capita food supply. The region has also undergone several crises in food supply, some of them resulting in outright catastrophes. While there has been encouraging progress in most developing regions, the aggregate picture of Sub-Saharan Africa is gloomy. But even at the low overall level of performance, there are marked differences among the countries, which appear worth pursuing for explanatory factors. Agricultural research as the preoccupation of this report can only be one of the factors, and possibly not even the most important one. Nevertheless, it may add another facet to the understanding of unsatisfactory agricultural performance in Sub-Saharan Africa and point to possibilities among others to improve performance in the future. It is in this sense, that the question of an impact of international agricultural research in Sub-Saharan Africa is of particular interest.

1.2 Aim and Scope

The aim of the report is to enhance the understanding of ways in which agricultural research may contribute to improved agricultural (food) production performance in Sub-Saharan Africa. At the same time it is attempting to answer the question of past and potential impact of the IARCs in that region. Given the critical position of Africa, it is necessary to elaborate on many particularities of e.g. the transformation of research results into practice, the IARCs' activities and their resource allocation in Africa and the relative role of the IARS in the overall efforts. It is also

Source: Map projection FAO (1978);
regional subdivision by H.E. Jahnke.

Figure 1 Regions of Tropical Africa

Tropical Africa comprises 45 Sub-Saharan countries:

1. Angola
2. Benin
3. Botswana
4. Burkina Faso
5. Burundi
6. Cameroon
7. Cape Verde
8. Central African Republic
9. Chad
10. Comores
11. Congo
12. Cote d'Ivoire
13. Djibouti
14. Equatorial Guinea
15. Ethiopia
16. Gabon
17. Gambia
18. Ghana
19. Guinea
20. Guinea-Bissau
21. Kenya
22. Lesotho
23. Liberia
24. Madagascar
25. Malawi
26. Mali
27. Mauritania
28. Mauritius
29. Mozambique
30. Niger
31. Nigeria
32. Principe and Sao Tome
33. Rwanda
34. Senegal
35. Seychelles
36. Sierra Leone
37. Somalia
38. Sudan
39. Swaziland
40. Tanzania
41. Togo
42. Uganda
43. Zaire
44. Zambia
45. Zimbabwe

necessary to detect differences in perceptions of what the IARCs should be doing between tropical Africa and other regions.

The concept of "perceptions" is a particularly challenging one. While everybody would agree on the importance of obtaining African viewpoints on the topic, it also involves complications. First, it necessitates a country-by-country approach. This means that nationals collect opinions about impact in their own country. It is, however, quite open to discussion, whether such national views are comparable among each other.

Second, a considerable degree of subjectivity has to be accepted, even if within one country one would attempt to get as broad a spectrum of opinions as possible. As a practical consequence, the detailed country studies could only be carried out for a sample of countries, nine out of more than 40, as it were.

Furthermore, since these country studies had to be carried out by nationals with a good knowledge of the IARS, it has to be accepted that the acquisition of that particular knowledge may be connected to particular experiences with one or several centers reflected in judgements and interpretations.

Finally, it had to be attempted to generalize from the findings of the different country studies and to bring them into the framework of the available aggregate information for tropical Africa. To what extent such generalizations ares legitimate cannot really be determined by any statistical methods but is more a matter of judgement.

1.3 Approach

Apart from the introductory Chapter and the Concluding Remarks, the report is divided into two parts, one containing general considerations (Chapters 2, 3 and 4), the other the country perspectives (Chapters 5 and 6).

Chapter 2 of Part A sets the stage by bringing together the information on the current status and the recent trends of agricultural development and food production in tropical Africa. Beside the illustration of poor performance and low productivity, the chapter also addresses itself to general constraints and potentials and to the agricultural production structure in tropical Africa. A final section is devoted to development perspectives with a particular view to the role of research and here again to the potential role of the IARS.

Chapter 3 deals with the actual role of the CG system in tropical Africa. Following a description of the guiding principles and of the evolution of the system in general, its involvement in tropical Africa is examined in more detail, including the resource allocation by type of activity, region, etc. The chapter ends with a discussion of the problems of assessing the impact as opposed to simply describing its involvement. It concludes that "impact assessment" should at least be given two meanings:

- assessing the impact of IAR on the NARS and
- assessing the impact of research in general on agricultural production.

It is recognized that there remain problems of establishing cause-effect linkages and of arriving at operational measuring devices.

As a preparation for the first part of impact assessment, Chapter 4 examines in more detail the NARSs of tropical Africa. This is also in recognition of the fact that, as a rule, the IARS has to work through a NARS in order to have an impact. Differently put, the impact of the IARS can only be as strong as the NARS is. Of course, to assess the strength of a NARS either is not a straightforward task. Neither staff nor budget figures are clear indicators. In addition, the NARSs also interact with bilateral groupings, e.g. the French-based research system. It is then not clear what can be considered a NARS.

Chapter 5 constitutes the first step of the actual impact assessment, namely the assessment of the impact the CG system has through collaboration on the NAR. Such collaboration consists of the provision of biological materials, of research ideas and techniques and of the enhancement of human capital through training courses, etc. The chapter also deals with the limitations of such collaboration and with some of the inbuilt problems. Like the following chapter, the findings are largely those from the nine country studies.

Chapter 6 represents the summary of the nine country studies, as far as the impact of research on agricultural production in tropical Africa is concerned. The examination for impact starts with production and income effects, but also gets into other impact areas like equity issues. Reasons for success and failures are sought, and particular attention is paid to the role of agricultural policies and to the role of the NARSs in actually realizing production impacts.

The conclusions finally are not presented as a monolithic block, but rather in form of a series of tentative concluding remarks. Interpretation and extrapolation have to be carried out with caution for several reasons:

- Established and relatively reliable statistics on agricultural production normally refer to aggregates whose link to research is complex and almost impossible to quantify. The country studies as the main source of new information are therefore difficult to give a statistical significance.

- The case studies have only been carried out in nine countries out of more than 40 in tropical Africa.

- The new information from the country studies relates not only to hard and proven facts, but to a considerable extent to perceptions of nationals involved in the collaboration with the IARS and therefore contains a measure of subjectivity whose importance is difficult to assess.

Yet there is also justification for a more positive, more optimistic interpretation. New and useful information has been gained that can usefully be integrated into future strategies for agricultural research and development.

Chapter 2

AGRICULTURAL DEVELOPMENT IN TROPICAL AFRICA

2.1 The Crisis in African Agriculture

Tropical Africa in the mid 1980s is in a deep socio-economic and agrarian crisis, which is for the time being the endpoint of long run unfavorable trend over the past two decades. It is particularly striking to compare the present situation to that of the sixties, the post-independence period for most African countries, which was buoyant with optimistic plans for growth and development.

The growth rate of the gross domestic product (GDP) indicates the serious change of economic conditions. Whereas Sub-Saharan Africa's GDP grew at an average of 3.8 percent p.a. from 1960 to 1970, it has fallen to an average of 3.0 percent p.a. between 1970 and 1982 and is still falling every year. At the same time the annual population growth rate accelerated from 2.4 percent (1960-70) to 2.8 percent (1970-82) globally the highest population growth rate and is still further rising. Subsequently, the average annual growth rate of per capita income has been very low, declining from 1.4 percent (1960-70) to 0.4 percent (1970-81) - (Table 2.1).

In tropical Africa 70 to 90 percent of the population is rural and earns its living from agriculture, the main economic sector, although its share of GDP has been declining steadily. Given the low overall economic growth rate this often implies an absolute decline in agricultural production or at least a decline in per caput production. This in turn is often synonymous with real income losses for the poorest. Thus tropical Africa's agrarian crisis is reflecting the overall economic crisis. Moreover tropical Africa has slowly lost its ability to feed itself. It is the only region in which a large agricultural trade surplus has turned into a net deficit over the last two decades. This adverse shift in the food trade position is largely explained by West Africa's shift from an exporter to a net food importer between the early 1960s and the mid 1970s. Since then especially the sluggish agricultural performance of Nigeria, as a key country, has aggravated the regional food deficit.

Tropical Africa's per capita food production has been declining for about 15 years and so has self-sufficiency. As production statistics, particularly for tropical Africa's subsistence production, are highly tentative, principal problems in estimating average growth rates in agriculture arise. Nevertheless, the growth rate of food production in the 1970s has not only been below the growth rate of total population but also below that of rural population. Even though the ratio of rural population to total population declined slowly to 78 percent (1982), the absolute size of rural population to feed is still growing rapidly. With the pattern of fast growth of population and slow growth of food production, the latter is loosing the race (Table 2.1, Figure 2).

Table 2.1 Socio-economic and Agricultural Sector Indicators in Selected Countries of Tropical Africa

		Zimbabwe	Malawi	Tanzania	Kenya	Ethiopia	Cameroon	Nigeria	Burkina Faso	Senegal	Sub-Saharan Africa	Year
GDP (a)	mio US $	5900	1320	4530	5340	4010	7370	71720	1000	2510	-	1982
GDP per capita	US $	738	189	227	297	122	819	788	143	418	-	1982
GDP growth rate	percent	2.2	5.1	4.0	5.5	2.2	7.0	3.8	3.4(k)	2.9	3.0 w	70-82
Population (c)	millions	8	7	20	18	33	9	91	7	6	380 t	mid82
Pop.-growth rate (b)	percent	3.2	3.0	3.4	4.0	2.0	3.0	2.6	2.0	2.7	2.8 w	70-82
Rural pop./ total pop.	percent	76	90	87	85	85	63	79	89	66	78 w	1982
Primary commodity share of export (d)	percent	-	93 (1)	76 (1)	52 (1)	91	64 (1)	-	85	29	-	1981
Income ToT (1970 = 100)	percent	-	125 (m)	63	218	-	92 (m)	58	246	105	-	1979
Food share of merchandise imports (e)	percent	-	8	13 (1)	8 (1)	9	9 (1)	-	25	28	-	1981
Food aid (f)	1000 ton.	0	2.0	254	115	177.8	10.5	1.4	82.4	77.1	2169 t	1982
Food aid per capita	kg	0	0.3	13.1	6.3	5.5	1.2	0	12.7	12.8	5.8 w	1982
Agric.GDP share	percent	15	37(n)	52	33	49	27	22	41	22	33 w	1982
Agric. GDP growth rate (b)	percent	1.8	4.1	2.8	4.1	0.9	3.4	-0.6	1.4(k)	2.3	2.1 m	70-82
Agr. production growth rate per capita (b)	percent	-1.0	0.5	-2.3	-1.2	-0.5	-1.0	-0.2	0.5	-1.4	-1.1 w	70-82
Daily calorie supply per capita (g)	calories	2025	2138	1985 (1)	2056 (1)	1758 (1)	2439 (1)	2361 (1)	2008 (1)	2434	2156 w	1981
As percent of requirement (h)	percent	90	94	83 (1)	88 (1)	76 (1)	102 (1)	91 (1)	95 (1)	101	90 w	1981

Agr. GDP per capita of agr. pop. (i)	US $	194	90(n)	154	129	77	281	373	70	126	-	1982
Agr. GDP per capita of agr. active pop.(j)	US $	599	204	383	345	188	616	1003	133	309	-	1982

w = weighted average t = total m = medium value

a) GDP measures the total final output of goods and services produced by an economy; for many countries, GDP by industrial origin is measured at factor cost, for other countries within complete national accounts series at future cost, market price series were used.

b) Average annual growth rate in percent.

c) Based on data from UN Population Division and results of recent population censuses.

d) Other than fuels, minerals, metals.

e) Merchandise imports, CIF, in current dollars, do not include trade in services.

f) Thousands of metric tonnes, grain equivalent.

g) Average annual growth rate of total production per capita.

h) Refers to calories needed to sustain a person at normal levels of activity and health, FAO estimates.

i) Agricultural population is defined as all persons depending for their livelihood on agriculture.

j) Economically active population in agriculture includes all persons engaged principally in agriucIture, forestry, hunting or fishing.

k) For 1970-81, not 1970-82;

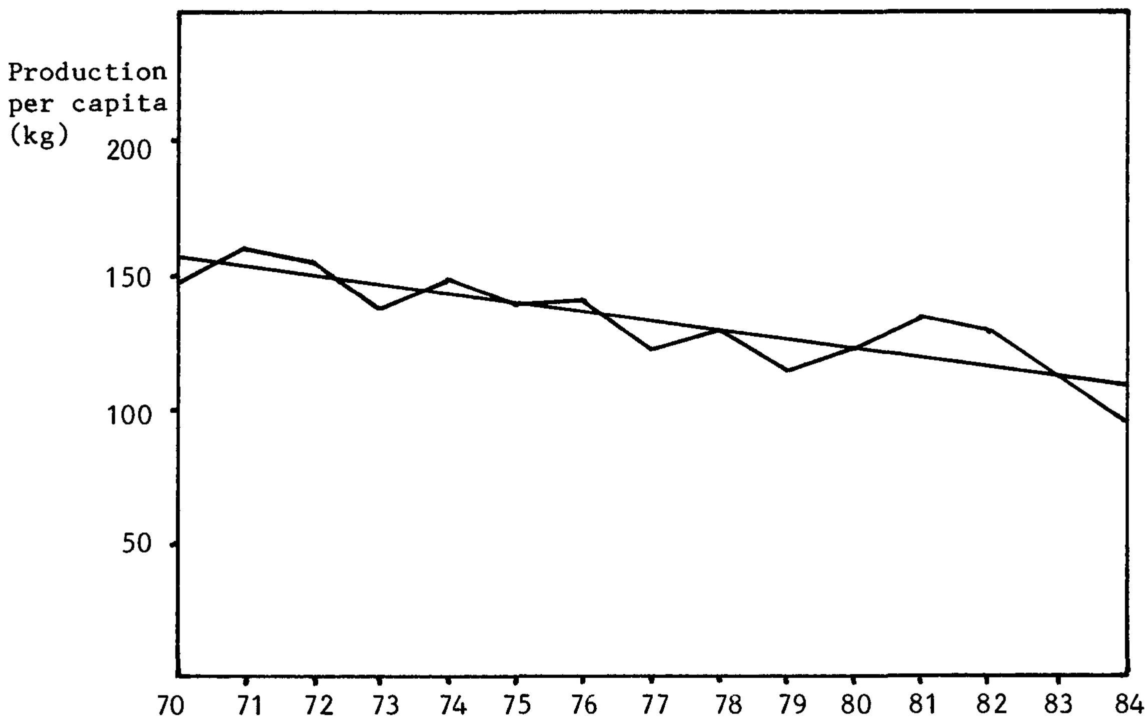
l) 1980, not 1981;

m) 1978, not 1979;

n) 1980, not 1982.

Source: 1. World Bank, Toward Sustained Development in Sub-Saharan Africa: A Joint Program of Action. Statistical Annex. Washington, 1984.
2. FAO Production Yearbook 1982. Rome, 1984.

Although food production rose by 2 percent p.a. 1980-82, faster than 1970-81, per capita output in 1983 was 11 percent below the 1980 level. Partly caused by the recent droughts this poor performance more than offsets all the very modest gains of the 1970s. Countries with large agricultural potentials, like Tanzania, Sudan, Zambia and Nigeria suffered the sharpest falls in per capita food production. Most seriously affected are 24 countries with food emergencies in the last two seasons, where food production declined by 15 percent between 1981 and 1983. For these countries even the trend line of food grain production per capita has already fallen below the critical line put by FAO at 140 kg.



Source: World Bank Analysis; FAO data, except that 1984 data are a projection using USAID, USDA, and FAO data.

Figure 2 Grain Production per Capita in 24 Drought-affected African Countries, 1970-1984

This long-run dramatic trend is valid for tropical Africa as a whole. The continued decline in per capita food production, especially of rural population, leaves roughly 100 million people malnourished in 1984.

The extreme differences in yield levels of important staple goods, e.g. sorghum, cassava or maize, indicate the regionally poor performance as well as the large agricultural potentials under different country-specific agro-ecological, socio-economic, and political conditions (see Annex Table 2.1).

As a consequence of regional nutritional deficits, imports of food grains have been rising for the last 20 years since independence at about 9 percent p.a. In the 1970s with declining export earnings and rising debt service obligations, and thus sinking import capacity, many countries lost their ability to import food on commercial terms and required imports on a concessional basis. Subsequently, food aid imports gained importance, changing their character as emergency measure for environmental hazards into a structural feature of many countries' balance of payments. In this sense the low rate of growth in food production may as well be an effect rather than a cause of rising cereals' imports.

The long-run stagnation in the production of food and export crops has resulted in a declining share in world trade. As tropical Africa's economies are open, they are heavily dependent on agricultural exports. For most crops the fall in world market shares started in the 1970s and continued in the 1980s.

Extra revenues of the commodity booms in the early 1970s allowed an increase in spending on both investment and consumption. Foreign borrowing was eased because of increasing creditworthiness. Many politically prestigious projects were planned without regard for their likely rate of return. After the commodity booms, when the import capacity declined significantly, governments were reluctant to reduce their spending, and had to borrow at rising interest rates. Instead of developing new export opportunities, commodity concentration of exports has increased over the last decade.

The poor economic and agricultural performance sets the stage for agricultural research. Agricultural production is a crucial determinant of overall economic growth and therefore has to be in the focus of research activities. Agricultural research efforts are needed to change past trends of poor agricultural performance, aiming at country-specific patterns of production constraints and potentials to end the pervasive poverty in tropical Africa.

2.2 Constraints and Potentials

Africa's agricultural crisis is the outcome of several deep-rooted internal and external problems, due to country-specific patterns of political, structural and technical constraints.

An important though often exaggerated constraint on agricultural production is the physical environment of Sub-Saharan Africa. Many of the soils are low in fertility and poor in structure. Tropical heat bakes the fragile soil, enervates the seed and withers the plants. Pest, diseases and weeds affect the physical growth of the crop. The unreliability of rainfall, either too little or too much and at the wrong time, causes moisture stress during the growing periods and affects yield formation and quality. The effects of recent droughts draw international attention to the arid zones. On the other hand, excessive rainfall as well causes difficulties of workability, reduced soil fertility, and produce handling and thus yield disadvantages.

It would be simplistic, however, to accept the physical environment as a sufficient explanation for poor agricultural productivity. The diversity of the environment alone (see Annex Table 2.2) would suggest that generalization about an environmental handicap is difficult to uphold. Besides there are also generalizable advantages like the high photosynthetic potential of the tropics. A comparison with comparable other tropical regions indicates that paths to sustainable development exist for practically all ecological zones though solutions often have neither been simple nor been adopted rapidly.

While tropical Africa as a whole is not densely populated in comparison with many Asian situations there are areas, particularly in the drier parts, where environmental problems are compounded by population pressure. This has resulted in regional overcultivation and overgrazing, reinforcing erosion and deforestation, thus increasing the vulnerability of semiarid regions. Smallholders are forced to shorten fallows and to cultivate less productive areas. Moreover, best agricultural land is permanently withdrawn from food production for urban and industrial use. Both, climate and human activity then cause the erosion of natural resources, particularly desertification, reducing the carrying capacity of land in terms of sustainable yield of fire-wood often below that in terms of crop production.

A historical constraint is the enduring legacy of viewing agriculture as a second rate subject, which has well continued into the post-independence period. The paradigm of the development sciences of the time of course was to use agriculture for maximum enhancement of growth elsewhere (Th. Schultz published his "Transforming Traditional Agriculture" only in 1964).

The following paragraphs summarize the World Bank's assessments of agricultural development in Africa: Only a small share of the budget was allocated to agriculture, and moreover, the exports were heavily taxed. Due to the lack of skilled and educated people colonial agricultural institutions were perpetuated, relying on a small number of elite and expatriate specialists. Political leaders largely accepted the legacy of state control in agriculture and increased the size of state bureaucracy, thus increasing institutional rivalries and management deficiencies. A further source of slow agricultural growth has been wars and civil strife caused by disputes with neighbors or disunity among domestic tribal and ethnic groups.

Over the last two decades there has been a consistent bias against agriculture in pricing, taxing, exchange-rate and investment policies. Two strategic pricing variables, exchange-rates and food prices, were repressing domestic agricultural incentives, holding back agriculture and absorbing administration capacity. Official exchange rates generally were too high, opening the countries among other things for food imports.

Internal terms of trade of export crops were turned against agriculture. In the interest of urban consumers official food prices were kept too low. This distorted agricultural incentives towards producing a reliable food surplus. On the one hand export commodities were taxed heavily to generate revenue, on the other hand there has been no consistent and sustained investment in rural infrastructure to generate agricultural production. Without road maintenance, existing transport conditions worsened, causing high recurrent costs, which governments now cannot afford any more.

Input supplies and services were insufficient and access to them most uneven, due to the sparseness and unreliability of the parastatal or private marketing and transport systems or the support services. Social services like educational and health facilities in rural areas were neglected and preventive treatment downplayed, causing widespread sickness and disease, thus undermining human physical and intellectual development.

Moreover, poor project selection and misallocation of investment, overprotection of industry and overexpansion of the public sector have resulted in poor returns on investment. Distorted incentives and inefficient institutions are central to tropical Africa's poor return on investment and therefore to its critical economic performance. For more than 20 years of independence there has been a fundamental misunderstanding among political leaders, foreign advisors and donors about the importance of agriculture, causing the erosion of the countryside.

New constraints emerged of the world economic recession of the early 1980s. Tropical Africa's small export-oriented economies were confronted with slow growth in trade of primary products, adverse terms of trade and higher energy prices, causing severe foreign exchange constraints and increasing the dependence on foreign aid from industrial nations. High debt service obligations and shortfalls in export revenues have reduced tropical Africa's capacity to absorb counterpart and follow-up recurrent costs. On the other hand ready availability of foreign aid and donors' agreement to pay recurrent cost will allow postponement of the inevitable steps of reducing the constraints to a smallholder road to development. Increased cereal imports reinforce the dependency and take pressure off governments to change domestic policy priorities towards agriculture and agricultural research.

Remedies are obviously not easy to come up with. For the purpose of this report two starting points appear to be of particular relevance: (1) As 80 years of colonial rule and 20 years of independence did not change persistence of smallholders as the dominant type of production unit, their performance still is the key to agricultural development in tropical Africa; and (2) Th. Schultz's double-thesis of 1964 that effective agricultural development through smallholders is possible but requires technical innovations.

The slow development of new technologies in agriculture because of only a small pool of adequately educated and trained manpower, and the urgent need for food security made imported technology a central premise in African research strategies. As it is impossible to fund research effort on every commodity in every country, international technology transfer has become a central link in the global agricultural research system. But in tropical Africa the direct technology transfer as yield-increasing biological, chemical and irrigation technology has not proven to be as successful as expected.

In many countries there is a gap between technology transfer in theory and practice due to domestic administrative, managerial and scientific capacity constraints. Most donors have seriously underestimated the variability in African agriculture and the indigenous scientific capacity required to achieve the full potential of technology transfer. It has to be realized that this continent is more split-up than any other. The average country's population is not more than 6 million, for a total of 340 million in tropical Africa. The political and administrative variety of as many as 45 Sub-saharan countries imposes a handicap on the development and regional spread of innovations. Fiscal shortages, foreign exchange constraints and manpower bottlenecks have increased absorptive capacity constraints.

From the smallholders' point of view yield increasing technology to make use of his production potential is not available. Primarily his traditional local seed lacks the genetic potential to invest in expensive inputs. Even if he has access to fertilizers and other inputs, he lacks both cash and credit to buy them. Furthermore he does not have the information to use them to advantage or the equipment to apply them. Supposed he manages to produce a surplus, he lacks access to markets at prices that will repay his investment. In technology terms, tropical Africa lacked the combination of inputs that made the success of the green revolution elsewhere, e.g. plant breeding, irrigation, transport, marketing, as necessary conditions.

Besides all internal and external constraints, the present situation of dominant crops' average yields remaining low is also an outcome of scale and effectiveness of agricultural research efforts. It is the specific feature of constraints which substantiates the importance of agricultural research in tropical Africa; e.g. limited research has been done on the trade-off between yield increase and drought-resistance to improve rainfed agriculture under African conditions.

The differences in average yield levels, particularly of cereals, roots and tubers, indicate the agricultural potential of tropical Africa. In terms of agro-climatic suitability productivity gains of staple foods are possible and urgently needed (see Annex Table 2.3.).

In terms of population growth the FAO computation of the potential population supporting capacities shows the great effect of climatic and soil endowment on the population supporting capacity. The regional ratio of projected population to projected potentials for the year 2000 with low level of inputs is for Africa 1.5, whereas the country results show, that 48 percent of Africa's potential cannot meet the food needs of their populations at this level of inputs. This means at low level of inputs 23 African countries will be unable to meet the food needs of their projected populations from their own land resources.

The results represent only a "first approximation" of the overall physical situation, but do indicate the massive extent of the problem and some possible solutions. The food deficit situation in 16 of the critical countries could be overcome by raising the level of inputs to an intermediate level or by food inputs from bordering countries (see Annex Table 2.4.).

Intermediate input levels comprise the use of improved hand tools and/or draught implements, some fertilizer and pesticide application, some simple soil conservation measures lessening productivity losses from land degradation and cultivation of a combination of the presently grown mixture of crops and the most calorie-protein productive crops. Appropriate and realistic input levels are crucial for agricultural research and adoption focussing on the massive potential of the smallholder sector.

2.3 Production Structure and Self-Sufficiency

The persistence of most and the worsening of some of the disparities in agricultural performance within countries and between countries is partly due to the diversity of agro-climatic zones and the complexity of tropical Africa. It is evident that better agricultural performance is highly country-specific. Nevertheless, there are obviously similarities in the importance of commodities, especially in cereals and other food crops.

The production patterns in tropical Africa show the relative importance of roots, pulses, millet and sorghum, compared to all developing countries. Subsequently these traditional African subsistence crops provide the main daily calorie supply (see Annex Table 2.5). Whereas wheat and rice, which are the most crucial part of food (aid) imports, amounting to 82 percent of 1982 gross cereals imports, are generally less important in domestic production and consumption.

As the relative importance of commodities varies from country to country and from low-value crops to higher-value crops the overall self-sufficiency ratio, i.e. the extent to which demand in a country is met by domestic production, is a revealing measure of tropical Africa's weak agricultural performance (Tables 2.2 and 2.3).

Table 2.2 Value of Production in Selected Countries of Tropical Africa by Commodity, 1981, in Percent of Total Value

	Zim-babwe	Malawi	Tan-zania	Kenya	Ethiopia	Cameroon	Nigeria	Burkina Faso	Senegal	Africa (b)	All (c) developing countries
Wheat	2.8	0.0	0.5	1.9	3.5	0.0	0.0	0.0	0.0	1.8	5.4
Rice	0.0	1.3	2.3	0.5	0.0	1.0	3.9	1.5	4.5	3.7	18.6
Maize	33.9	29.0	4.7	16.5	6.3	5.0	2.8	3.0	1.1	5.2	4.3
Barley	0.3	0.0	0.0	0.6	4.6	0.0	0.0	0.0	0.0	1.1	0.8
Millets and other cereals	3.5	2.3	2.1	2.4	10.7	3.6	11.3	31.5	14.3	5.7	2.6
Roots	0.6	2.8	23.9	7.3	6.2	18.4	37.0	2.6	0.6	20.7	6.5
Sugar	6.7	5.8	1.6	6.5	1.3	0.9	0.3	2.0	2.1	2.1	5.0
Pulses	0.9	11.0	4.0	5.1	10.7	3.4	4.6	15.2	1.6	4.5	3.3
Vegetables	2.5	5.7	9.7	4.9	4.4	6.1	8.9	3.2	2.8	6.8	7.9
Bananas	0.6	0.5	9.3	2.6	0.4	10.5	3.7	0.0	0.1	5.6	2.4
Citrus fruit	0.9	0.0	0.3	0.3	0.2	0.0	0.0	0.0	0.8	1.5	1.9
Fruit	0.0	5.7	4.6	2.4	1.0	2.5	2.7	2.8	1.7	3.9	5.4
Vegetable oils	10.8	9.7	3.8	1.3	3.0	8.4	6.7	9.1	51.0	7.2	6.6
Cocoa	0.0	0.0	0.1	0.0	0.0	12.2	3.1	0.0	0.0	3.7	0.8
Beef	12.0	2.0	7.9	14.3	11.5	4.7	3.4	10.7	6.9	6.0	5.2
Mutton	0.5	0.4	1.5	2.5	6.5	1.3	2.5	2.9	1.8	2.6	1.3
Pig meat	1.3	1.7	0.4	0.4	0.1	3.4	1.0	1.7	1.8	1.1	2.5
Poultry	1.0	1.4	1.0	2.1	3.1	1.1	3.7	3.0	1.6	2.5	2.4
Milk	3.5	1.0	8.2	11.1	7.9	0.7	1.0	2.7	4.4	4.4	7.2
Eggs	0.9	1.4	1.8	1.1	3.0	0.6	2.4	1.6	0.8	1.6	1.9

Cereals (d)	40.4	32.7	9.6	22.0	25.1	9.7	17.9	36.1	19.9	17.4	31.7
Other food crops (e)	23.0	41.2	57.3	30.4	27.3	62.2	66.9	35.0	60.7	55.7	39.7
Non-food crops (f)	17.5	18.2	12.4	16.2	15.5	16.3	1.1	6.4	2.1	8.8	8.2
Livestock (g)	19.1	8.0	20.6	31.4	32.1	11.8	14.0	22.6	17.3	18.2	20.4
Total (h)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

(a) According to FAO's AT 2000 project data. Prices used correspond to 1974-76 world export unit values in US $.

(b) Including 37 major countries.

(c) Including 90 countries and 98 percent of total population in developing countries with the exception of China.

(d) Wheat to millets and other cereals.

(e) Roots to cocoa.

(f) Coffee, tea, tobacco, cotton, jute and hard fibers, rubber, and fodder crops.

(g) Beef to eggs.

(h) Cereals, other food crops, non-food crops, and livestock.

Source: FAO, AT 2000 data files (Table 1.1: Historical Time Series of Production, and Table 2.1: Supply Utilization Accounts).

Table 2.3 Trends for Self-Sufficiency (a) in Selected Countries of Tropical Africa by Commodity (b), Annual Rate of Change, 1975-81, in Percent

	Zim-babwe	Malawi	Tan-zania	Kenya	Ethiopia	Cameroon	Nigeria	Burkina Faso	Senegal	Africa (c)	All (d) developing countries
Wheat	3.2	-10.9	7.5	-2.4	-3.6	0	-20.6	0	0	-6.7	0.2
Rice	7.0	1.0	3.6	-5.1	0	-1.9	-8.4	-4.5	-12.0	-5.2	0.2
Maize	-9.3	-0.5	0.8	-3.3	-0.2	0	-2.9	-0.7	1.0	-2.8	-1.2
Barley	24.6	0	1.5	2.8	0	0	0	0	0	-2.1	-1.8
Millets	0.5	0.3	0.5	0	0	-0.3	0	-0.2	-0.3	0	0.2
Roots	-0.3	-0.8	0	0	0	0	0	0	-1.6	0	0.9
Sugar	-1.3	13.5	-4.0	3.8	-0.3	5.6	-20.6	5.3	19.5	-3.0	-1.4
Pulses	-2.3	0.2	0	-0.5	-2.5	0	0	-0.3	0	-1.0	-0.3
Vegetables	0	0	0	0.5	-0.2	-0.3	-0.9	-0.3	1.1	-0.3	0.0
Bananas	0	0	0	0.2	-3.0	-0.5	0	0	3.7	-0.2	-0.3
Citrus fruit	-4.0	0.5	-0.2	0.5	-0.5	0	0	0	3.3	0.7	4.1
Fruit	0	0.2	0	0.1	-0.2	-0.6	-0.2	0.7	2.6	-1.0	0.0
Vegetable oils	-0.8	-1.4	-0.3	-11.9	-7.3	-1.4	-5.6	-2.6	-10.1	-4.6	-1.6
Cocoa (k)	-	-	0	-	-	0	0	0	-	5.2	-4.0
Beef	-6.9	0.7	-0.3	-1.0	-0.7	-1.4	-3.1	-0.9	-0.9	-1.4	-0.3
Mutton	0.2	0.3	0	0	-0.2	0	-0.2	-3.1	-0.4	-0.3	-1.1
Pig meat	-1.3	0	0.2	-1.7	0.3	-0.2	-0.2	0	0	-0.5	-0.2
Poultry	-0.7	0	0	0	0	-0.3	-1.4	0	-0.2	-0.5	-0.5
Milk	-0.7	-4.0	0.4	-2.2	-1.2	-4.5	-6.7	-14.3	-2.4	-2.7	-1.3
Eggs	-0.2	0	0	-0.2	-0.2	0	0	0.2	-0.2	-1.2	-0.3

Cereals (e)	-6.0	-0.5	2.0	-3.0	-0.7	-1.5	-4.0	-0.9	-5.4	-3.2	-0.2
Other food crops (f)	-0.7	1.0	0	-0.8	-2.1	-0.1	-2.1	-0.6	-8.6	-1.3	-0.3
Non-food crops (g)	0	-4.6	-3.3	-14.3	2.0	-10.1	-5.1	6.5	-4.2	-3.3	-1.7
Livestock (h)	-4.1	-0.5	0	-1.2	-0.5	-1.1	-1.9	-4.2	-1.2	-1.5	-0.7
Total (i)	-1.2	-0.1	0.3	-1.3	-0.6	-0.8	-2.6	-1.0	-7.7	-2.0	-0.3

(a) Production/demand.

(b) According to FAO s AT 2000 project data. Prices used correspond to 1974-76 world export unit values in US $.

(c) Including 37 major countries.

(d) Including 90 countries and 98 percent of total population in developing countries with the exception of China.

(e) Wheat to millets and other cereals.

(f) Roots to cocoa.

(g) Coffee, tea, tobacco, cotton, jute and hard fibers, rubber, and fodder crops.

(h) Beef to eggs.

(i) Cereals, other food crops, non-food crops, and livestock.

(k) = not available.

Source: FAO, AT 2000 data files (Table 1.5 Historical Time Series of Self-sufficiency Ratio).

The overall trends for self-sufficiency in tropical Africa are negative. Production of major staples like millet, sorghum and roots seems to have been able to satisfy increasing demand until 1981. The negative trends in wheat and rice indicate changing consumption patterns towards cheap imported food.

The first wave of green revolution passed tropical Africa and did not stop the overall trend of deterioration in food production. It did not even entail the means to mobilize Africa's resources to gain back its historical position of self-sufficiency in staple goods. High-yielding varieties successful only at a high level of inputs, were facing the chronic lack of complementary inputs. Traditional African subsistence crops, such as millet, sorghum, root crops and legumes were neglected by agricultural research. Dominant crops in the larger length of growing periodic zones (more than 270 days p.a.) of the warm tropics and subtropics are cassava and in sub-humid areas maize. Rainfed millet and sorghum, which are most widely grown (80 percent of cultivated land) in arid areas have not been improved genetically to increase food production on a broad base.

One may conclude that successes in plant breeding and other fields of biological technology in the past have neither fitted fully with Africa's production and consumption pattern nor corresponded to the major deficiency of making complementary inputs available. There is also the recognition that the specificities of drought, pressure of disease and pest as well as other factors require highly adapted research rather than transfer of results. While one would wish to remedy all this as quickly as possible it is more realistic to assume that the research task ahead is a long-term one.

2.4 Development Perspectives and the Role of Research

Long-term reforms towards a growth-oriented rural development strategy will have to surmount the local mixtures of basic constraints and policy failings. Structural imbalances, human capital, agricultural research and extension have to be handled as a package because corrections in one area may bring no benefit unless improvements in connected areas are made, thus reform is a long term affair, and tropical Africa's production problems cannot be solved in the short run, bearing in mind the political, socio-economic and agro-ecological diversity. But the continuation of past performance and present trends leads to alarming results that will soon confront the world even more squarely than today unless major changes are made. In this setting agricultural research will be increasingly important in the allocation of scarce public resources. Rising opportunity costs stress the responsibility for availability and increases of appropriate inputs, and thus production changes.

The FAO study "Agriculture: Toward 2000" (FAO, 1981 a, b) examines food and agricultural prospects and alternative future possibilities. Three major scenarios are based on accumulated information and insight by FAO over many years about food and agricultural demand and production, constraints and potentials.

Starting with the past performance of the food and agricultural sector, the trend scenario describes possible outcomes of the continuation of present trends, as observable in tropical Africa. Stagnant or declining per capita production levels increase the dependence on food imports and food aid. Because of limited gains in per capita calorie supply the numbers of undernourished will rise dramatically. Declining agricultural self-sufficiency will be worsened by growing environmental dangers to the productive base.

Both Scenarios A and B are quantified explorations of future demands for food and agricultural products and the possibilities of meeting them from changed domestic production under the assumptions of the study.. Both scenarios are based on quantitative assessments of natural resources and input requirements and on proposals of country and subject matter specialists, and thus are normative guidelines. Fundamental differences in Scenarios A and B are the different overall economic (Gross Domestic Product) growth rates used to project demand, for Africa 5.9 percent, and 5.4 percent p.a. from 1980 to 2000 respectively, and the different agricultural production projections, for Africa 4.3 percent, and 3.4 percent p.a. from 1980 to 2000 respectively. The medium growth Scenario B implies modest improvements over trends and avoids the worst outcomes of the trend scenario. The optimistic Scenario A is more ambitious and assumes high production growth rates, thus doubling per capita incomes and improving self-sufficiency by the year 2000. Given the demographic trend of rapidly increasing population, trend production performance (2.6 percent p.a. from 1980 to 2000) would not provide the necessary food supplies. On the other hand, annual growth in agricultural output can rarely be sustained over long periods at more than around 3-4 percent p.a., because of agro-ecological, institutional and demand constraints particularly in tropical Africa. Subsequently only the Scenario B production growth of 3.4 percent p.a., which implies almost a doubling of the African 1.8 percent p.a. past performance from 1961/65 to 1980, will be described in the following. Taking into account the recent droughts and harvest shortfalls even this projection has become highly optimistic. African countries are assumed to reach production growth rates commodity by commodity which are between those of past trends and those of Scenario A. With a non-agricultural gross domestic product required to rise at 6.2 percent p.a. this projection means a tremendous challenge both for agriculture and for the non-agricultural sectors (Table 2.4).

Despite all production advances, Scenario B projects a further decline of the African self-sufficiency ratio for cereals (to 70 percent in 2000). Exports of tropical products rise sizeably but imports are still expanding faster although much less so than in the 1960s and 1970s. If trends persist, African agricultural exports are projected to cover no more than half of the agricultural imports by the year 2000. Facing the lack of resources to finance large food imports, additional food will be an indispensable component of any attempt to reduce undernutrition. On the other hand further large imports of cheap food or food aid are compromising the economic incentives of farmers, and are widening the income disparities, thus supporting the rural-urban migration.

Table 2.4 Production Change under FAO's AT 2000 Scenario B in Selected Countries of Tropical Africa by Commodity (a), Annual Rate of Change 1975-2000, in Percent

	Zimbabwe	Malawi	Tanzania	Kenya	Ethiopia	Cameroon	Nigeria	Burkina Faso	Senegal	Africa (b)	All (c) developing countries
Wheat	3.4	0.0	8.5	3.1	3.0	-	2.1	0.0	0.0	2.4	2.6
Rice	5.5	7.1	6.0	5.5	0.0	4.1	7.1	2.8	4.5	4.1	2.6
Maize	2.7	2.5	3.5	2.4	2.5	3.1	3.8	2.8	5.2	2.8	3.1
Barley	2.8	0.0	2.6	5.7	2.8	0.0	0.0	0.0	0.0	2.2	2.1
Millets and other cereals	1.1	5.1	3.2	3.2	2.5	1.8	2.3	2.4	1.3	2.3	2.6
Roots	2.9	3.3	4.1	4.0	2.8	2.2	3.0	2.8	2.7	3.0	2.8
Sugar	3.9	4.1	5.8	6.2	4.1	5.3	6.9	4.7	9.2	4.3	3.4
Pulses	3.2	2.2	3.4	2.2	2.3	2.9	2.7	2.4	1.5	2.6	2.5
Vegetables	2.9	5.0	3.1	4.6	3.3	3.2	4.6	3.1	4.3	4.0	3.7
Bananas	3.4	4.6	2.9	4.4	3.1	1.6	2.5	0.0	5.4	2.4	2.8
Citrus fruit	4.1	4.5	3.8	6.8	3.0	0.0	0.0	0.0	3.9	3.6	3.6
Fruit	-	4.2	3.4	6.1	3.3	3.5	4.7	2.9	5.5	3.3	3.5
Vegetable oils	2.8	4.2	3.4	3.9	1.7	3.4	1.1	3.2	0.5	2.5	3.5
Cocoa	0.0	0.0	6.8	0.0	0.0	1.6	0.6	0.0	0.0	1.4	2.2
Beef	2.1	4.1	2.2	2.2	1.1	4.4	3.0	2.0	4.3	2.5	3.0
Mutton	2.4	4.0	1.9	2.8	1.0	3.0	3.1	3.2	4.0	3.0	2.7
Pig meat	3.4	4.8	6.7	6.0	3.1	3.8	6.2	3.6	4.8	4.5	4.1
Poultry	2.7	6.7	5.5	6.7	2.4	4.6	8.3	3.5	4.9	6.0	5.6
Milk	1.2	5.1	3.1	2.5	1.5	3.9	3.4	2.4	2.6	2.9	3.1
Eggs	2.1	5.6	4.0	6.5	1.3	3.9	6.3	3.6	4.6	4.7	4.8

Cereals (d)	2.6	3.1	4.3	2.7	2.6	2.7	3.4	2.5	2.6	2.9	2.6
Other food crops (e)	3.5	3.7	3.6	4.3	2.6	2.4	3.2	3.3	1.1	3.0	3.3
Non-food crops (f)	1.6	4.0	3.0	3.5	3.0	2.2	2.2	5.8	6.1	2.8	2.6
Livestock (g)	2.1	5.2	2.9	3.2	1.3	4.1	5.2	2.7	4.1	3.5	3.6
Total (h)	2.4	3.7	3.5	3.5	2.3	2.6	3.4	3.0	2.0	3.0	3.1

(a) According to FAO's AT 2000 project data. Prices used correspond to 1974-76 world export unit values in US $.

(b) Including 37 major countries.

(c) Including 90 countries and 98 percent of total population in developing countries with the exception of China.

(d) Wheat to millets and other cereals.

(e) Roots to cocoa.

(f) Coffee, tea, tobacco, cotton, jute and hard fibers, rubber, and fodder crops.

(g) Beef to eggs.

(h) Cereals, other food crops, and livestock.

Source: FAO, AT 2000 data files (Tables 2.1 and 2.5: Supply Utilization Accounts).

Although it avoids the worst outcome of persistent trends the modestly ambitious Scenario B projects deteriorating socio-economic conditions in Africa: Production and calorie supplies rise but the number of seriously undernourished rises too, cereal self-sufficiency declines, and static rural incomes leave the largest part of population at an increasing disadvantage.

The development strategy for food and agriculture implied is a "more of what we already know"-strategy (FAO). It demands higher priority to food and agriculture within the range of policies. A major aim must be the abolition of hunger, and higher priority to agriculture includes an improved distribution of food production, resources and output.

Scenario B is built around an 80 percent rise in agricultural output depending on a massive increase in inputs and widespread modernization in technology and techniques, i.e. a further regional crop and location-specific green revolution (see Annex Table 2.6). In the past, output expansion occurred mainly through area expansion, particularly in the low-income countries. Land-abundant countries have higher incomes than those where land is more scarce. Only middle-income countries were able to achieve yield increases as well.

In Scenario B three main sources contribute to increased crop production with the following relative shares:

- arable land growth	+ 27 percent
- increased yields	+ 51 percent
- increased cropping intensity	+ 22 percent
	100 percent of changes

Cropping intensity is the ratio of harvested area over arable land and indicates the number of times a hectare of arable land is harvested in a year on the average.

Yield increases which make for half of the total changes in crop production can be differentiated into three different situations:

- high-yielding varieties will only be successful with optimal moisture, plant nutrient and plant protection;
- under less favorable natural conditions moderate yield increases with less inputs should be aimed at;
- on the subsistence farming level limited increases but greater stability of yields should be the strategy.

Any country-specific strategy consists of combinations of these three situations and thus will influence the priorities in agricultural research. In the short-run the efficiency in the use of resources rather than their availability will be a major challenge for agricultural research.

Governments, IAR institutions and donor agencies have to gain consensus on the short and longer run development priorities. The food production problem cannot be solved in less than a decade, and probably it will take longer. This is basically so because it takes time to build political support for an agricultural-led development strategy, a fundamental redirection in agricultural policy, and the restructuring of agrarian institutions. Then at least a decade of expenditures in agricultural research is needed to develop and/or adapt appropriate technology. Subsequently, long-term development programs have to ensure adoption and implementation.

The scenarios described show that considerable improvements are possible over the existing trend and that these improvements do not depend on miracle breakthroughs but rather on the application of existing technology. However, there is still a need for research of the adaptive kind, applying existing technologies to the needs of small countries and the diversity of agro-climatic zones. The patterns of basic constraints and policy failures vary from country to country. Location-specific agricultural research should rely to the largest extent possible on agronomic practices, already applied in traditional production systems. Upgrading measures and innovations should be introduced very gradually, including feedback systems to consult small-scale farmers about their needs and their performance, to build up confidence in the soundness of outside advice. All innovations must stand the test of a 'worst case scenario', i.e. the extremely limited ability of smallholders to take risks (World Bank).

In summary then, when one talks about the development perspectives of tropical Africa and the role of research, one may retain the following points:

- to achieve significant improvements over the present and over future trends tremendous efforts are necessary; no quick and easy results can be expected;

- efforts can certainly not be limited to research only but must also be directed at complementary services and at the overall policy framework;

- "research" does not imply the search for the miracle breakthrough (although it may); more often than not it seems to be the adaptation of known principles and existing technology to local conditions.

Especially the last point leads to the all-pervasive question of collaboration between IAR for more basic research, applicable in principle to larger regions and NAR adapting technology to specific circumstances.

Chapter 3

THE ROLE OF THE CG SYSTEM IN TROPICAL AFRICA

To assess the impact of international agricultural research (IAR) in tropical Africa, it is necessary, first of all, to identify the link between the CG system and tropical Africa. Its extent and its different aspects help to reveal the principal role of the CG system and its impact potential. This is the starting point for assessing actual impacts and it helps to reveal possible constraints. A second prerequisite for impact assessment is to have a clear notion of the kind of impacts which are relevant, and how they can be identified and measured. This points to some general problems of impact assessment in IAR.

3.1 Guiding Principles and Evolution

The CG system represents one of the components of an emerging global agricultural research system. It can perform effectively only if it concentrates on a limited number of research problems for which it has a comparative advantage. Following the Second Review of the CGIAR, this comparative advantage is widely seen in generating new technology, i.e. to concentrate on applied research. Upstream research functions like basic and strategic research designed to generate new understanding and the solution to specific research problems, respectively, should be left to research institutions in developed countries whereas NAR in developing countries should take care of adaptive research. From the CG system point of view, such downstream research should be designed to adjust technology to the specific needs of a particular set of environmental conditions.

Such a division of labor in the global agricultural research system poses some problems as far as tropical Africa is concerned. NAR on this continent is often too weak to take over technologies from IARCs and carry out adaptive research on the national level. The question, then, is whether international agricultural research should fill this downstream gap itself or whether one should concentrate on strengthening NAR in tropical Africa.

There is no single answer to this problem. IARCs have felt a responsibility to go downstream, in particular in tropical Africa. Some of the centers have created regional centers, many of them have developed regional programs. In many cases these activities include adaptive research to a certain extent. Equally, farming systems research often has an "adaptive" component. On the other hand, ISNAR within the system and other international and national development agencies have helped to strengthen NAR in tropical Africa.

The past development demonstrates that there may well be a conflict between a concentration on the system's comparative advantage and particular research needs in tropical Africa. This conflict is not likely to diminish, but to increase over time. As developing countries develop their own research infrastructure on a global scale, adaptive research may gradually lose its importance within the system. As TAC noted in 1979 in its Priority Paper: "As their national research capabilities improve, the developing countries increasingly see the role of international research as being a complementary one to supplement research activities, which they consider as their responsibility to carry out".

What may be true on a global scale, however, may not be relevant in tropical Africa. NAR on this continent will for a considerable time to come not be able to cover adaptive research needs. From a global point of view, therefore, the system may well move upstream - from the viewpoint of tropical Africa, however, such a development is likely to reduce potential impacts of international agricultural research for this continent.

Closely related to the notion of comparative advantage is the idea of the global nature of the system. The original centers were created with a narrow commodity mandate that placed upon them global responsibilities for one or for a very small number of crops. Some of the subsequent centers, then, had a regional mandate including a number of crops with considerable importance to that region, but secondary importance from a world perspective. Furthermore, the regional nature of the mandates was interpreted as requiring a much greater emphasis on farming systems research, adaptive research and agronomic practices related to site-specific problems.

Hence, there are two different perspectives and possible evolutionary paths for the CG system. From the viewpoint of tropical Africa, obviously, the regional approach is most advantageous. It allows addressing the specific problems and constraints to agricultural production on this continent which differ considerably from those elsewhere. Within the CG system it is accepted that regionalization is perfectly compatible with the concept of global crop improvement mandates. In many cases, a regional focus, to ensure specific requirements of new technologies, is an essential condition for final success. Nevertheless, there is a widespread view that the system should gradually strengthen its global perspective. One argument to support this view is related to the system's comparative advantage in a global research system as discussed above. The other argument refers to the organization and governance and, thus, to the efficiency of the system. In this respect the following comment from the Second CGIAR Review is worth mentioning: "It is recognized that international agricultural research requires long-term funding, must concentrate on well-defined problems of high priority and must not be influenced by national policies that are unrelated to global needs. These principles are particularly appropriate for the international centers, which were inaugurated specifically to help in alleviating problems of world hunger and poverty."

It is difficult to foresee in which direction the system will actually develop. A strengthening of the global view would probably reduce the potential impact of international agricultural research in tropical Africa, due to two facts. First, the heterogeneity of agriculture on this continent is extremely pronounced and does not allow widespread application of global research results, as may be the case with rice research for Asia. Second, the use of global research results is bound to the translation in NARSs which is particularly restricted in tropical Africa. Centers seem to be well aware of the specific problems of tropical Africa. Recently the directors agreed that a concerted attack should be made on these problems through commodity-oriented networks linking IARCs and NARSs or universities with common problems (News from CGIAR, March 1985). The directors pointed to the young history of research on food commodities in general, and in tropical Africa in particular. They also mentioned the great diversity of African ecologies and the many logistical and economic problems for agricultural production on this continent. New technologies are strongly demanded throughout tropical Africa, but they have to be easily applicable and adaptable to the specific production environments.

Basically, the guiding principles of action and the evolution of the CG system derive from its original objectives: through research and research-related activities the CG system is to contribute to:

- increasing the amount, quality and stability of food supplies in developing countries and meeting the total world food needs;

- meeting the requirements of international cooperation of the less advantaged groups in developing countries; and

- achieve an overall improvement in the welfare of the less advantaged sectors of society in developing countries through the design of technologies that will improve the efficiency in the utilization of resources at their disposal.

According to this description of CG system goals, the basic importance of efficiency and equity considerations for the system is obvious. There is no regional perspective in the description of CG system goals, but, obviously, the equity aspect is of major relevance for tropical Africa as the poorest continent in the developing world. For equity reasons alone, the CG system would have to devote a relatively large share of its resources to tropical Africa. The question is, whether such an allocation of resources reduces the overall return, thus, implying efficiency losses of the system as a whole. The issue of a trade-off between efficiency and equity appears to be particularly relevant for tropical Africa. It is not obvious how this conflict between CG goals will be handled in the future and which goal will finally dominate. It is certain, that tropical Africa will be interested to see the CG system stress equity. It is rather beyond the scope of this study to judge the advantageousness of decision for the system as a whole intending to benefit all developing countries with maximum efficiency.

A final aspect refers to the kind and type of research activities of the CG system. The CG system, in principle, is an incomplete system. It is incomplete in at least two respects:

- its coverage of research areas, and

- its coverage of research functions in the overall process of research and technology generation.

In the past the system has mostly concentrated on commodity-oriented research integrating some aspects of component research. These activities do not cover all different aspects of developing countries' food production. Emphasis, instead, has been given to selectivity and concentration of effort on those activities tackling key constraints to sustained progress in food production in the developing world. In dealing with these problems the system has used the center of excellence approach and, thus, attempted to bring in a systematic manner, the most advanced knowledge and the best expertise available to developing countries.

This approach will certainly result in high returns on the global scale if the selected research results can be used on the national level by integrating them into national research programs. Again, a workable NARS is necessary to translate results of IARCs and ensure their success. Following the discussion above, it may be argued that selectivity and concentration may hamper the effectiveness of international agricultural research in tropical Africa.

It may be stated, therefore, that main guiding principles and perspectives of the CG system may have to be judged differently from a global point of view, and from the point of view of tropical Africa. The particularities of this continent demand a specific orientation of the CG system, which may mean a deviation from its original scope. The particularities of tropical Africa, on the other hand, certainly also reflect national policy failures. This can hardly be remedied by a reallocation of international research resources. This is another facet of the question whether the IARCs should really devote more resources to tropical Africa to the detriment of the global perspective.

3.2 Engagement in Tropical Africa

The CG system has a global perspective by nature, but many of its activities are more or less directed specifically towards tropical Africa. In this section, the relevance and breadth of such Africa-oriented IARC activities are discussed. Equally, some preliminary remarks on the impact of these activities are presented.

All IARCs are basically considered to operate under the rubric of a formal mandate, which comprises the set of purposes or objectives given to the centers at the time of their creation. These formal mandates are then elaborated into actual center programs and activities which may be interpreted as operational mandates. These operational mandates may vary over time; CIP, e.g. has a formal worldwide mandate for potatoes and other root crops. It has decided, however, to concentrate efforts on potatoes alone.

The operational mandates of IARCs provide a first impression of the relevance of center activities for tropical Africa (Pineiro and Moscardi, 1984; Herdt, 1984):

CIAT	- cassava, field bean
CIMMYT	- wheat, maize, barley, triticale
CIP	- potato
IBPGR	- plant genetic resources
ICARDA	- faba bean
ICRISAT	- chickpea, pigeon pea, millet, sorghum, groundnut; farming systems in the semiarid tropics

IFPRI	-	food policy
IITA	-	rice, maize, cassava, sweet potato, yam, cocoyam, soybean, cowpea; farming systems in humid and subhumid tropics
ILCA	-	livestock production systems
ILRAD	-	trypanosomiasis, theileriosis
IRRI	-	rice
ISNAR	-	national agricultural research
WARDA	-	rice

Hence, all activities of all IARCs can be related to tropical Africa. The extent of such a relationship, of course, differs. Whereas the activities of the Africa-based centers, ILCA, ILRAD, IITA and WARDA, are practically restricted to this continent, the other centers either have a rather long history of engagement in tropical Africa or are on the way to strengthening regional programs. Following review recommendations, e.g. ICRISAT has intensified research efforts for tropical Africa. CIMMYT and CIP already have rather accentuated regional research programs and even CIAT and IRRI have some links to tropical Africa, though their efforts concentrate more on Latin America and Asia respectively.

In more detail the center activities in tropical Africa present themselves in the following way (News from CGIAR, Vol. 5, No. 1 (March 1985)):

IITA - The International Institute of Tropical Agriculture, located in Ibadan, Nigeria, was the first center established on the African continent (1967). Within the CGIAR system, IITA has worldwide responsibility for the improvement of cowpea, yam, cocoyam and sweet potato, and regional (Africa) responsibility for cassava, rice, maize and soybean. Currently, IITA is developing ways to improve regional farming systems through more productive and ecologically sound alternatives to traditional systems of bush fallow and livestock cultivation. IITA and ILCA developed alley-cropping, a form of agroforestry, in which arable crops are grown between perennial tree crops with multiple uses such as fodder, wood fuel and green manure. IITA has been strongly identified with the research center for important food crops of the humid tropical areas of Africa.

ILCA - The International Livestock Center for Africa was established in 1974 in Addis Ababa, Ethiopia, to assist national efforts in tropical Africa. These efforts include carrying out research and development on improved livestock production and marketing systems, training regional livestock specialists and gathering documentation useful to the African livestock industry. ILCA is focusing on systems analysis and management approaches and techniques in four ecological zones - arid, subhumid, humid and highlands - rather than individual commodities. ILCA's Humid Zone Program is based at IITA where the two centers are cooperating on research for farming systems in which animals play an important role.

ILRAD - The International Laboratory for Research on Animal Disease was also established in 1974 and is located in Nairobi, Kenya. ILRAD is assisting in the development of effective controls for two major African livestock diseases - trypanosomiasis and theileriosis (East Coast fever) - which seriously impede livestock production in vast areas of a number of countries in Africa. ILRAD's emphasis is to identify and exploit disease control methods that rely on the immunological responses of the host animals. It is working with other institutions to pool animal disease and production skills toward solving these problems. ILRAD and ILCA are working with the International Center for Insect Physiology and Ecology (ICIPE) and other organizations in a trypanotolerance network.

WARDA - The West Africa Rice Development Association, located in Monrovia, Liberia, was established in 1971, as a regional organization to promote self-sufficiency in rice production in 15 countries of West Africa. WARDA, in cooperation with IRRI, is developing improved rice varieties adapted to the region's agroclimatic and social conditions, and is developing improved farming systems that are appropriate to these regional conditions. WARDA's program concentrates on four systems of rice production - mangrove swamp rice (saline conditions), irrigated rice, upland (rainfed) rice and deep water rice.

Other center programs

Eight other centers have staff stationed in Africa, engaged in a variety of activities in cooperation with national research institutions, and ISNAR is working on a country-by-country basis in assessing national agricultural research programs.

CIAT - The International Center for Tropical Agriculture, headquartered in Colombia, has responsibility for the world germplasm collection of cassava and, in cooperation with IITA, is involved in supplying germplasm for cassava improvement programs in Africa. Six CIAT staff are working in East Africa on problems of bean production.

CIMMYT - The International Maize and Wheat Improvement Center, located in Mexico, has several ongoing programs in Africa. The maize program has activities in Ghana, Tanzania and Zaire and has a collaborative component with IITA. The wheat program is particularly active in East Africa with staff members assigned to cover 17 countries. From 1971 to 1983, there were 187 participants from tropical Africa in the maize in-service training course, and from 1966 to 1983, 96 trainees participated in the wheat in-service training course.

IBPGR - The International Board for Plant Genetic Resources, located in Rome and responsible for promoting an international network of genetic resource centers, has sponsored several collecting missions in various African countries, notably in West Africa and has assisted in the establishment of several national genebanks in African countries.

ICRISAT - The International Crops Research Institute for the semiarid tropics, headquartered in Hyderabad, India, is responsible for sorghum, millet and groundnut, major crops in many parts of Africa. The ICRISAT Sahelian Center, located near Niamey, Niger, was established to aid development of varieties of these crops adapted to the difficult Sahel environment. From 1974-1983, ICRISAT provided in-service training to 364 African researchers.

CIP - The International Potato Center, based in Peru, has several staff members posted in Africa to assist potato research in Rwanda and Burundi. CIP also cooperates with a country network, PRAPA (Program Regional d'Amelioration de la Culture de Pomme de Terre en Afrique Centrale), which was established in 1982 to carry out research and training activities.

IRRI - The International Rice Research Institute, headquartered in the Philippines provides through its International Rice Testing Program advanced rice materials to WARDA and other interested institutions. IRRI recently established an outreach program for rice production in Egypt and expects to begin one in Madagascar.

ICARDA - The International Center for Agricultural Research in the Dry Areas, located in Syria, has a program for faba beans in Egypt, the Sudan, and most recently Ethiopia. A research team is stationed in Tunisia to work on barley and legume improvement with North African national research institutions.

IFPRI - The International Food Policy Research Institute, located in Washington D.C., works on policy issues related to food and agricultural production and trade. IFPRI is currently devoting approximately 35 percent of its research to Africa projects.

ISNAR - The International Service for National Agricultural Research, located in The Hague (Netherlands), assists developing countries to improve their national agricultural research capability. To date ISNAR has completed assessments of the national systems in Burkina Faso, Ivory Coast, Kenya, Madagascar, Malawi, Rwanda and Somalia.

Taking it all together, the commitment of the CG system towards tropical Africa is considerable. This conclusion can also be supported by some quantitative information. Table 3.1 shows that a relatively large share of IARC staff is located in tropical Africa, particularly in West Africa. Moreover, it is worth noting how widespread the programs of IARCs are, in general, and, in particular, in tropical Africa. In West Africa, e.g., 99 of the 206 scientists in 1982-83 are not located in the respective IARC host countries. This shows the importance of outreach programs and activities in this region.

The center activities in tropical Africa usually reflect their basic philosophy in research and research-related activities. IITA stresses the multicrop approach and farming systems research. ILCA similarly follows a farming systems approach with particular reference on livestock production. The other centers concentrate on commodity-specific research programs as they do in other continents though all of them emphasize a farming systems viewpoint in their work. Up to now there is no answer to the question whether concentration of research efforts on specific commodities or a broader approach is more successful, in general, and, in particular, in tropical Africa.

The extent of CG system activities in tropical Africa gives rise to high expectations, but they are not met by reality. There is a widespread perception that the impact of international agricultural research in tropical Africa falls short of expectations. It is also argued that such a judgement needs to be qualified in many respects and that it may be misleading to apply the same yardstick for impact identification in tropical Africa as on other continents.

Table 3.1 Number of IARC Senior Staff, Visiting Scientists and Staff on Deputation by Location in Different Countries, 1983 (a)

	CIAT	CIMMYT	CIP	IBPGR	ICARDA	ICRISAT	IFPRI	IITA	ILCA	ILRAD	ISNAR	IRRI	WARDA	Total	Total outside IARC host country
Latin America	80	48	49	1		2		3			1	1		185	29
East/South Africa		4	4	1		4		2	41	30				86	22
Burundi			1											1	1
Botswana									1					1	1
Ethiopia								1	27					28	1
ILCA Field Sites									7					7	
Kenya		3	1	1		1			6	30				42	12
Malawi						1								1	1
Rwanda			2											2	2
Sudan						2								2	2
Tanzania		1						1						2	2
West/Central Africa		3		1		21		100	12			1	68	206	99
Cameroon								12						12	12
Gambia													2	2	2
Ghana		1						2					2	5	5
Guinea													2	2	2
Ivory Coast													1	1	1
Liberia								1					34	35	1
Mali						2			4				6	12	12
Nigeria		2				4		73	7			1		87	14
Niger						7			1				2	10	10
Senegal						1							9	10	10
Sierra Leone													9	9	9
Burkina Faso				1		7		5					1	14	14
Zaire								7						7	7

North Africa/ Near East		1	2	1	46	2						1		53	11
Asia	1	9	7	2		50	1					89		159	70
Other Countries		1		9			30				27			67	
Total	81	66	62	15	46	79	31	105	53	30	28	92	68	756	231

(a) 1983 for ILCA, ISNAR, CIAT, IBPGR, ILRAD, IFPRI, and ICRISAT; 1982 for others.

Source: CG Secretariat.

First of all, the African centers and programs are relatively young to already yield the same results as research efforts in other continents of the developing world. There is a widespread hope that relevant technologies for African farmers are in the pipeline and will be ready for use in the not too distant future.

Second, it is obvious that international research cannot be blamed for the poor performance of African agriculture. Research is only one factor in the national attempts to change the unfavorable socio-economic environment and promote development. National agricultural research, in many cases, is too weak to make use of research results on the international level and the on-farm adoption of new technologies is restricted due to the lack of inputs, infrastructure, incentives, extension systems, etc.

A third point is that research, to have an effect on agricultural development, may have to have more intangible effects first. This is clearly true for the CG system in tropical Africa. Its commodity-oriented research activities may not yet have resulted in significantly increased production but, in addition, to training and communication activities, may have helped to initiate and foster the awareness, necessary for the development process.

There is a further and more critical aspect. Some claim that center activities in the past did not really reflect the particular research needs of the continent. It is argued, that activities were not related to real constraints and did not adequately take into account the problems of site-specificity, which is crucial to this heterogenous continent.

It is beyond the scope of this study to judge the relative importance of these arguments trying to explain the modest impact of IAR in tropical Africa. The question is how the system will react to the perception of its activities in tropical Africa, which is largely one of disappointment. There are several options:

- the system may continue its activities as before, bringing forth the technologies that are now in the pipeline, and hoping that better conditions will allow adoption in the future,

- the system may adjust its activities to take care of the adoption problem more directly, or

- the system may reduce its activities in tropical Africa, concentrating on its global task and regarding the African problem rather as one of policy adjustment and general development assistance than of research.

Again, a recommendation cannot be expected from this study, but some of the implications of the various options can be briefly traced.

A reduction of CG activities in tropical Africa would be in line with the original idea of the CGIAR emphasizing the global perspective and the concept of widespread adaptability of (genetic) research results. The efficiency goal of increased food production on a global scale would dominate.

On the other hand, an increased adaptation of CG activities to solving specific African problems would reflect increased importance of regional equity considerations. It would also mean that the CG system would have to devote relatively more resources to activities like training, policy research, farming systems research and strengthening of NARSs. Relatively fewer resources, on the other hand, would be given to the classical research (genetic improvement, component research). Equally, increased engagement in downstream activities would be needed, strengthening, in particular, the NARSs. In general, the CG system would move towards a cooperation with other agencies engaged in the development process. Emphasis would remain on research and research-related activities, but interaction with other international and national agencies of technical assistance would become much more important. Such a development might be in conflict with the original scope and with the concept of comparative advantage of the CG system. It is a question, therefore, whether the CG system should extend its activities towards those areas, which originally were beyond its scope and conception. But the CG system is an open system, free to choose, accentuate and change its priorities for different activities over time. It is up to the international donor community to decide, which way the system should actually go facing the particular problems of tropical Africa.

3.3 Regional Priorities and Resource Allocation

For allocating resources within the CG system priority choices have to be made. The question is how much money should be spent on the different CG activities, and to which regions the money should be allocated. Such priority choices clearly reflect the system's interpretation of research needs in developing countries and research potentials. With respect to specific regions like tropical Africa, several problems arise when the allocation of resources in IAR is considered :

- a basic problem is to identify regional needs and, thus, determine research priorities from a regional point of view,
- second, a possible divergence between a global and regional perspective has to be faced, and,
- the problem of weighting different regional needs has to be solved.

Priority setting within the CG system requires availability and interpretation of priority indicators. In principle, such indicators should trace out the relationship between expenditures for different research activities and CG goals. Due to the complexity of this relationship, there is a multitude of indicators giving partial information about this relationship. It is the task of TAC to appropriately interpret and use this information and guide priority setting within the system by its collective judgement.

Hence, the problem of priority setting is inherently complex, and it is beyond the scope of the study to consider all the different aspects mentioned for identifying priorities for tropical Africa. For commodity-oriented research, however, TAC bases its discussion on the value of production and the contribution to the diet of different commodities. According to TAC, this provides a quantitative startingpoint for the discussion, and it is straightforward to equally use these indicators to roughly identify priorities for tropical Africa.

In Table 3.2, priority rankings of food commodity groups and individual food commodities are listed for four regions of tropical Africa. The ranking is based on the value of production share on the left part of the table and on the combined calories and protein share in the diet on the right side. The latter part of the table is based on an arithmetic average of calories and protein shares in the diet. It is not pretended that equal weights are appropriate; that part of the table is merely supposed to present a rough, but integrated view of nutritional aspects for priority setting. Considering the country groupings, they are based on probably different regional needs and the consideration of agro-ecological zones. Practically, the study follows a grouping widely used within FAO and TAC (1).

Overall, the table demonstrates the great diversity of production and consumption in tropical Africa. According to the value of production share yams, e.g. should be given high priority in research resource allocation in humid and semiarid West Africa. Its importance, however, is modest in Equatorial Africa and can be neglected in East/South Africa. Sweet potato is another example. It has an outstanding and moderate contribution to the value of production in Equatorial and East/South Africa, respectively, whereas it can be neglected in humid and semiarid West Africa. There are several more examples that point to such an accentuated diversity in tropical Africa. As a consequence, it is of little help to speak of priorities for tropical Africa as a whole. It is necessary, instead, to take a more detailed view, which is in contradiction with the more global perspective chosen by the system. The conflict also holds true if commodity aggregates or calories/protein shares in the diet are considered. In the latter case cereals generally gain, and livestock and livestock products loose in importance, but fundamental differences remain between the regions. The following commodities have a share of more than 10 percent in the value of production:

(1) The following countries are considered in aggregates :
East/South Africa: Angola, Botswana, Kenya, Lesotho, Malawi, Mozambique, Swaziland, Tanzania, Zambia, Zimbabwe;
Equatorial Africa: Burundi, Central African Republic, Cameroon, Congo, Gabon, Madagascar, Rwanda, Uganda, Zaire;
Humid West Africa: Benin, Ghana, Guinea, Ivory Coast, Liberia, Sierra Leone, Togo;
Semiarid West Africa: Chad, Gambia, Guinea-Bissau, Mali, Mauritania, Niger, Nigeria, Senegal, Burkina Faso.

Table 3.2 Priority Ranking of Food Commodity Groups and Individual Food Commodities (a) in Descending Order (b) in Tropical Africa, 1979/81

According to value of production shares			
East/South Africa	Equatorial Africa	Humid West Africa	Semi-arid West Africa
Commodity groups			
-Livestock and livestock products	-Roots, tubers and starchy foods	-Roots, tubers and starchy foods	-Roots, tubers and starchy foods
-Cereals	-Livestock and livestock products	-Cereals	-Livestock and livestock products
-Roots, tubers and starchy foods	-Cereals	-Livestock and livestock products	-Cereals
-Vegetables	-Pulses	-Vegetables	-Pulses
-Pulses	-Vegetables	-Oilseeds	-Vegetables
-Oilseeds	-Oilseeds	-Pulses	-Oilseeds
Individual commodities (c)			
-Beef	-Plantain/banana	-Yam	-Yam
-Maize	-Sweet potato	-Rice	-Millet
-Milk	-Rice	-Plantain/banana	-Beef
-Plantain/banana	-Beef	-Cocoyam	-Cocoyam
-Cassava	-Cassava	-Oilpalm	-Groundnut
-Sweet potato	-Yam	-Maize	-Sorghum
-Groundnut	-Fieldbean	-Groundnut	-Sheep and goats
-Rice	-Maize	-Beef	-Cowpea
-Fieldbean	-Groundnut	-Cassava	-Milk
-Sheep and goats	-Millet		-Rice
-Potato	-Milk		-Oilpalm
-Sorghum	-Oilpalm		-Cassava
-Millet	-Potato		-Maize
-Wheat			-Plantain/banana

(Table continued on following page)

Table 3.2 (cont.)

According to calories/protein shares in the diet			
East/South Africa	Equatorial Africa	Humid West Africa	Semi-arid West Africa
	Commodity groups		
-Cereals	-Roots, tubers and starchy foods	-Cereals	-Cereals
-Roots, tubers and starchy foods	-Cereals	-Roots, tubers and starchy foods	-Roots, tubers and starchy foods
-Livestock and livestock products	-Pulses	-Livestock and livestock products	-Livestock and livestock products
-Pulses	-Livestock and livestock products	-Pulses	-Pulses
-Vegetables	-Vegetables	-Oilseeds	-Oilseeds
-Oilseeds	-Oilseeds	-Vegetables	-Vegetables
	Individual commodities		
-Maize	-Cassava	-Rice	-Millet
-Cassava	-Rice	-Maize	-Sorghum
-Wheat	-Maize	-Cassava	-Yam
-Beef	-Fieldbean	-Yam	-Rice
-Milk	-Groundnut	-Wheat	-Maize
-Sorghum	-Plantain/banana	-Plantain/banana	-Cassava
-Rice	-Millet	-Oilpalm	-Wheat
-Fieldbean	-Beef	-Groundnut	-Cowpea
-Millet	-Sweet potato	-Cocoyam	-Beef
-Groundnut	-Wheat	-Millet	-Groundnut
-Plantain/Banana	-Milk	-Beef	-Oilpalm
	-Sorghum	-Milk	-Milk
	-Oilpalm	-Sorghum	-Cocoyam
			-Sheep and goats

(a) This table is based on the value of production share and the calories/protein share in the diet as main priority indicators. It refers to the developing countries of FAO's AT 2000 study.

(b) According to the value of production share and the combined calories and protein share in the diet respectively.

(c) Commodities with a share of less than 1 percent are neglected.

Source: FAO, AT 2000 and ICS data files; FAO, The State of Food and Agriculture 1981, FAO Agriculture Series, No. 14, Rome 1982.

- in East / South Africa : beef, maize,
- in Equatorial Africa : plantain / banana, sweet potato
- in Humid West Africa : yam, and rice
- in Semiarid West Africa : yam, millet.

The following commodities account for more than 10 percent of the calorie/protein content of the diet :

- in East / South Africa : maize, cassava,
- in Equatorial Africa : cassava, rice,
- in Humid West Africa : rice, maize, cassava, and
- in Semiarid West Africa : millet, sorghum.

From an economic and a nutritional point of view these are clearly the outstanding commodities for CG support in tropical Africa. The question is, how these regional priorities fit into a global priority concept of IAR. For a comparison, Annex Table 3.1 gives the value of production shares and the calorie/protein shares in the diet for all world regions expressed as differences between regional and global figures. High absolute values illustrate relatively large divergences between regional and global priority setting. A positive sign means that a commodity or a commodity group is relatively more important for a region considered than for all developing countries whereas the opposite is true in case of a negative sign. Hence, the table reveals possible divergences between a global and regional priority perspective. A clear-cut result is that priority setting from a global view cannot catch the regional particularities in tropical Africa at all. For commodity groups, a global view would overrate the importance of cereals. With the exception of East/South Africa, it would also overemphasize livestock and livestock products and underrate the importance of roots, tubers and starchy foods. For individual commodities, the result is more differentiated. Taking into account economic, as well as nutritional considerations and neglecting deviations of less than 5 percentage points, a global view of priorities would overrate

- in East/South Africa : rice, wheat, other livestock (pig meat, eggs, poultry)
- in Equatorial Africa : rice, wheat, other livestock,
- in Humid West Africa : rice, wheat, sweet potato, other livestock, and
- in Semiarid West Africa: rice, wheat, sweet potato, other livestock.

On the other hand, a global view would undervalue

- in East/South Africa : maize, cassava, beef
- in Equatorial Africa : cassava, plantain/banana, field bean,
- in Humid West Africa : cassava, yam, and
- in Semiarid West Africa: sorghum, millet, yam.

Hence, in setting priorities among commodity-oriented research activities within the CG system fundamental divergences between a global and an African viewpoint have to be faced. The problem may even be greater if other research activities are considered. It has been argued in the previous section that, due to the particularities in tropical Africa, there is a special need for research-related CG system activities like training, policy research, farming systems research and activities to strengthen NARSs. This may also conflict with a global view of priorities.

The decisive question, therefore, is whether the CG system is willing to react to the specific research priorities of tropical Africa, thus, giving less emphasis to the global perspective. Actually, the conflicts will not always be that important in commodity-oriented research if a relatively large share of high priority commodities is produced in this continent. Should the system follow a global perspective in resource allocation in this case and link its expenditures to production figures, it would automatically meet the particular needs of tropical Africa to a considerable degree.

In Annex Table 3.2 the production of different commodities in tropical Africa is expressed as a share of overall production in all developing countries. The table shows that several high priority commodities of tropical Africa are actually produced to a large extent in tropical Africa. This is true, e.g., for cassava, plantain/banana, yam and millet. It is not true, however, for maize, sorghum, and beef. Furthermore, many of the commodities that are relatively low-valued in tropical Africa are produced outside this continent like, e.g., rice and wheat. A global perspective for priority setting, thus, means that a considerable part of commodity-oriented research resources is not devoted to tropical Africa. Annex Table 3.3, finally, illustrates the situation for the countries chosen for case studies.

There are several ways for the system to put more emphasis on African priorities:

- It could devote more money to research activities in tropical Africa than it would do following a global perspective. The question is, of course, by what yardstick one can determine the "right" distribution of CG system resources. The value of production in different regions could be used as well as nutritional or equity criteria.

- It could devote more money for research on commodities, specific to tropical Africa.

- It could adapt its expenditure structure to the specific priority structure of this continent.

- It could devote more resources to research-related activities with respect to this continent.

To follow one or more of these ways would obviously mean for the system to leave its global perspective and to engage in downstream activities. The question is whether such a development would be in line with the principle of comparative advantage of the system. Actually the centers have spent about one third of their resources in tropical Africa, and they have become increasingly engaged in activities on this continent. In Figure 3 expenditure shares of the CG system for several developing countries are compared to value of production shares and population shares. The regional distribution of CGS expenditures must necessarily be somewhat arbitrary in several cases, and, hence, the figures should not be overinterpreted. Nevertheless, they give a rough indication, that tropical Africa already receives a relatively large share of the system's resources as compared to a global point of view. Whether this allocation is sufficient and represents an appropriate answer to African needs, however, is open to question.

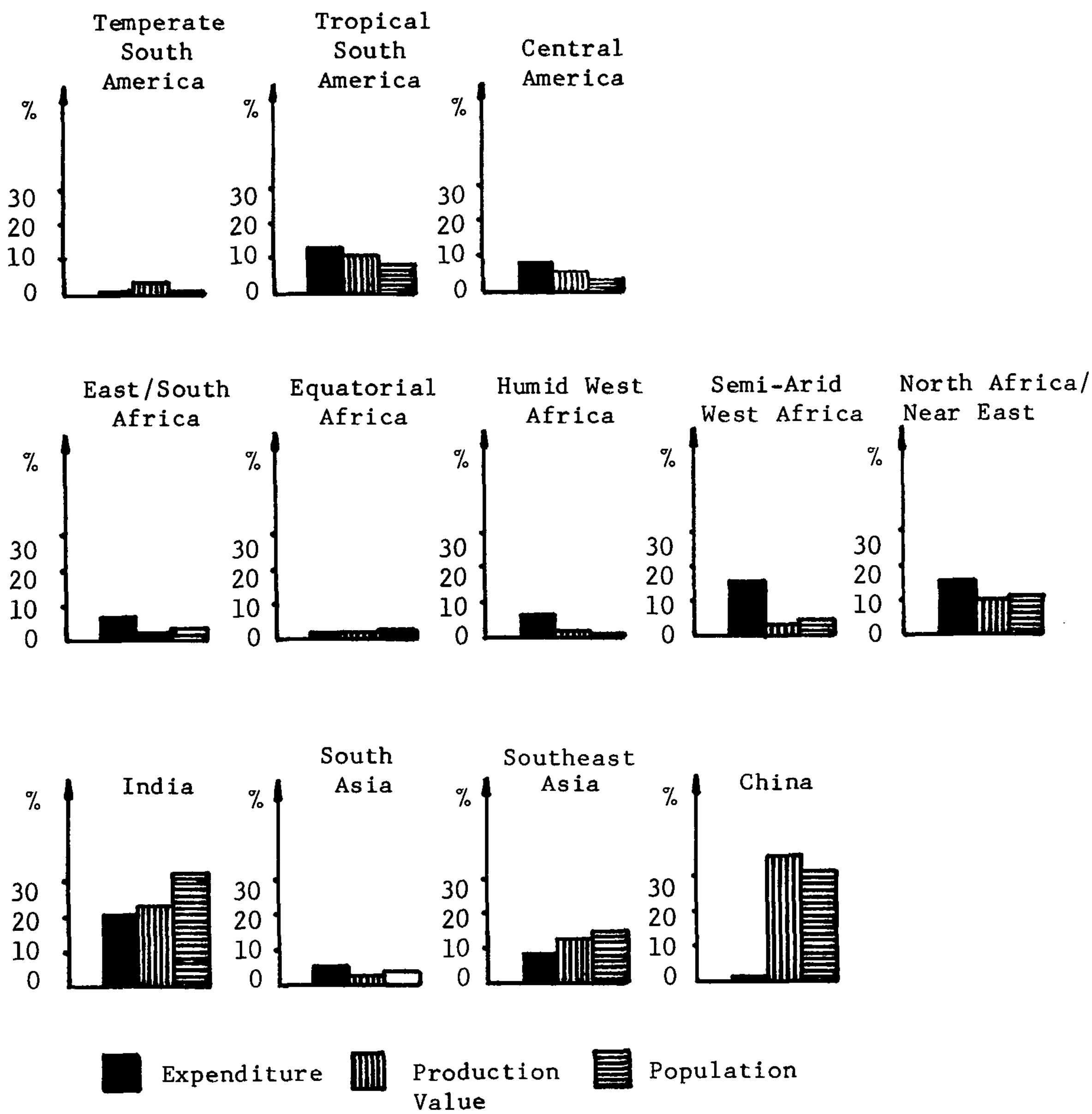
3.4 Problems of Impact Assessment

The discussion so far has concentrated on the links between IARS and tropical Africa assuming that such links will ultimately result in corresponding impacts. It is necessary, now, to operationalize the impact notion and specify different impact areas. It is the purpose of this section to indicate the kinds of impact to be identified, and the ways to measure and evaluate them.

Any impact assessment has to be operationalized by choosing appropriate criteria. Such criteria must be related to the IARS's goals and to specific IARC activities. It is suggested to identify criteria according to the way IARC activities may influence the development process, and, hence, the desired goal realization. This way may be characterized by the following steps:

- the generation and dissemination of knowledge and new technologies
- the effect on NAR and its efficiency,
- farm level effects of new technologies,
- aggregated input and output effects of technological changes,
- market and welfare effects of technological changes,
- distributional effects, and
- effects on other production-related goals and the socio-economic development.

For each step IARC activities may result in relevant impacts. There are, however, some general problems in assessing research impact. A first one is the existence of uncertainty and of time-lags. Research is a venture into the unknown and it is impossible to predict either an outcome with certainty, or the time at which this will occur. Any impact assessment, therefore, should not try to pretend certainty, but give information about the particular kind of uncertainty involved in the research process considered. Reference to historical impacts is insufficient and does not ensure comparable future impacts. Ex ante impact information, therefore, is an important feature of assessment in general and especially for those IARCs only recently installed.



Source: According to figures from TAC Secretariat, TAC Review of Priorities for the CGIAR System, First Draft, Rome, 1984. FAO, AT 2000 and ICS data files; FAO, The State of Food and Agriculture 1981, FAO Agriculture Series No. 14, Rome, 1982; World Bank, World Development Report, Washington, 1984.

Figure 3 CG System Expenditure for Commodity-oriented Research by Region, 1983, in Relation to Production Value and Population - all figures in percent of world total -

A second problem is that of causality. Impact assessment requires identifying a causal linkage between IARC activites and an impact indicator. This may be straightforward in some cases of purely adaptive research, but normally is more difficult to establish the links between cause and effect.

The third problem, finally, refers to the isolation of research effects. The actual performance of the development process is the result of a multiplicity of factors. IARC activities may enhance CG goal realization, but such a positive impact may be overlain by unfavorable external factors. A positive impact of research results, e.g., may be hampered by institutional arrangements, policies, credit shortages, tenure arrangements and other factors. Sorting out the partial impact of IARC activities on CG goal realization cannot be achieved by simply looking at time series data. Such data reflect the combined development of all factors affecting the variable considered. The task, instead, is to construct a hypothetical time series that would reflect the development without IARC activities, but, of course, this is easier said than done.

Efficient generation and dissemination of knowledge is at the heart of CG system activities. There are several indicators, which characterize the efficiency of research efforts, the relevance of research outputs and the dissemination process. Research productivity crucially depends on the efficient use of research resources. Indicators like quantity and quality of publications, the planning and monitoring of research programs, peer reviews, etc., may help to actually judge efficiency. Given the high scientific standards of the IARCs, the question of efficiency may not be a central issue within the CG system. It has to be noted, however, that overall research productivity is highest if centers stick closely to those activities where they have a comparative advantage in the global research system.

To measure research output, it is necessary to get a concise view of the different types of knowledge produced. Knowledge as such may be incorporated in new methodologies and procedures as well as in innovations. Methodologies and procedures represent knowledge that will indirectly favor the outcome of a production process. Systems research is a typical example in this respect. On the other hand, measurement should not only relate to the past, but look into the future. There are numerous indicators available that may help to assess a possible future impact of research on production. Progress made in recent years may give some hints, but pipeline considerations and the aspect of the ease of research will obviously get a larger weight. It will also be helpful to identify the major constraints to increased production concerning all levels of basic, strategic, applied, and adaptive research and to assess the nature of a particular problem and the time required for its solution.

Finally, to assess the knowledge dissemination process it is important to see a center's general position in a communication network. In this respect, existing communication channels between IARCs and NARCs, politicians, and people at the farm and processing level have to be identified. Equally, outreach and training activities are to be examined.

Closely related to the knowledge dissemination process is the possible effect of IARCs on NAR. International research influences production only in an indirect way. Its results are supposed to be adapted to location-specific needs and resources by adaptive research on the national level. Hence, the size and quality of NARSs crucially determine the overall impact of agricultural research on production. Consequently, IARCs may help to increase the efficiency of NAR to initiate actual impacts of their research results on agricultural production. This may be done by appropriate communication, cooperation and training activities. In this respect, issues of complementarity and substitutionality between international and national research have to be considered as well.

The adoption of new technologies at the farm level does not only depend on the innovation itself, but heavily on the environment in which the farmers are working. Besides the existence or non-existence of support services, government policies play an important role. Price regulations, taxes and subsidies, input and output quotas can affect the adoption of innovations to the extent of drastically limiting the impact of new technology. But this does not necessarily mean, that the development of a specific technology was a failure. The impact should therefore be assessed for farming systems under similar agro-ecological and socio-economic framework conditions, which have to be clearly specified.

Generally, the adoption process of a new technology and its meaning have to be clarified. It is well-known that farmers often do not adopt the whole package of a new technology, but only components of it. It is necessary, therefore, to identify the relevant constraints for adoption. Under African smallholder conditions, e.g., very often the labor constraint is regarded as one of the major obstacles concerning the adoption of a new technology. However, experience from African smallholders shows that labor supply can be rather elastic, due to changes in motivations and incentives from innovations. This implies, that during the process of assessment of adoption of a new technology one has not only to concentrate on the collection of 'hard facts' like 'labor productivity' but also on qualitative information to understand whether a 'new technology' fits into an existing farming system, how it is related to other elements in the system, and where innovations have changed behavioral functions, thus lifting the constraint level and speeding up institutional changes. Hence, impact assessment on the farm level has to take into account the whole farm system, including the household. The interactions between farm and household may be complementary when, e.g., animal draught is used to transport firewood or even negative when, e.g., more household labor is needed for farm work. All these effects have to be considered to properly assess impacts on the farm level.

The adoption of new technologies can be expected to lead to changes in inputs used, and outputs produced influencing aggregate welfare and distribution of wealth. The influence may be complicated by market and price changes induced by such technological changes. This complex is interwoven and cannot always be neatly separated. For heuristic reasons, however, it is useful to distinguish beween the physical input and output effects and the market and welfare effects, and to give separate treatment to distributional effects.

A basic goal for the CG system is increased food production in developing countries. Hence, impact assessment should carefully try to elaborate what kind of food output effects IARC activities have had and are supposed to have in the future. This may be straightforward in the case of crop products, but is often more difficult for livestock products. Livestock production comprises a multiple of products that all contribute to better living conditions in developing countries (meat, milk, eggs, hides, skins, work, manure, etc.). Such diverse output effects may, taken singly, not be spectacular at all, but may have considerable importance in combination. Besides production, new technologies may equally affect the input side. Hence, IARC activities may change the use of seeds, fertilizer, pesticides, herbicides, and fungicides, and also the use of water, credits, machinery, and labor. In fact, some research in IARCs concentrates on the development of inputs (herbicides) or intermediate products like feed or draught power. Such possible impacts of IARCs are important for food production and for the development process at large and should therefore be assessed. Furthermore, identification of such impacts is a necessary prerequisite to assess welfare and distributional effects.

If production increases ultimately result in increased marketable surplus, supply shifts will occur. As a consequence, the market situation for a product considered will change. In general, supply shifts will affect the exchange of products and welfare. Such an increased offer of products will tend to decrease the price level and, thus, tend to increase demand. This price effect will be greater the more inelastic demand reacts. With a totally inelastic demand, increased supply will result in a sharp price decrease. With a totally elastic demand, on the other hand, prices will remain constant, and the additional supply will actually be bought. Hence, market effects of supply shifts crucially depend on possible price changes. It is important, therefore, to know price elasticities of demand and to incorporate this information in impact evaluation. Based on this information, production and consumption effects of new technologies may be judged. Production will hardly increase in case of inelastic demand, resulting in overcapacities and a pressure for production factors to leave the production sector. With elastic demand, such a pressure will not exist, and increased supply will largely increase consumption.

The impact of new technologies on welfare is evident. Technological changes may affect the cost structure, supply and demand and, hence, welfare. Such an impact can be measured in a simple way. Using a cost-benefit approach, a welfare change consists of the benefit of increased production less incremental costs. The benefit of increased production either represents benefit of consumption or a gain in foreign exchange, which may result from extended exports or reduced imports. Such a gain in foreign exchange increases domestic income and, hence, comsumption possibilities. Saved inputs, on the other hand, can be used to produce and consume alternative products, whereas additional or new inputs require resources, which can no longer be used to produce and consume alternative products.

Distributional implications of IARC activities have increasingly been discussed and analyzed. Establishing a "more even" income distribution, furthermore, is widely looked upon as an important social goal. As a consequence, possible impacts of technological change on the income distribution are to be examined. Income distribution, however, can hardly be described in a single figure, but will comprise different aspects, like:

- the distribution among farmers and groups thereof,
- the distribution among owners of production factors,
- the distribution among regions, and
- the distribution between producers and consumers.

Basically, technological changes tend to reduce the unit cost of production and/or increase output and, thus, may enhance farmers' income. As a consequence, income distribution changes in favor of innovative farmers. This effect may be partly or totally offset if non-innovators also begin to adopt new technologies. With a decreasing product price, due to technological change, the result differs. A decreasing product price reverses the effect of technological change for farmers and reduces income. Consequently, non-innovators will have to adopt new technologies if absolute income decreases are to be avoided. The overall effect of technological change on producers' income is not obvious. It is more likely to increase the less the product price decreases. It is even possible that the overall effect will be negative in cases of rather inelastic demand.

The effect of technological change on consumers' income is straightforward. If the price does not change, income is not affected at all. Income will increase more, on the other hand, the larger price decreases are. As a result, then, changes in relative income distribution among producers and consumers depend on the possibility and the extent of price decreases.

Two more aspects are worth considering. First, if prices go down, those consumers will benefit most who buy relatively more of a product considered. Accordingly, poor consumers may gain relatively more from technological change if the induced price decrease occurs for products which represent a relatively large share of their expenditures. Second, in many cases a third group - the government - has to be considered. As governments intervene into the market mechanism, increased production due to research efforts may decrease or increase budget levels.

Technological change may also affect the use of inputs and input prices. As a consequence, income distribution among factors may change. In this respect, the distribution of income between tenants and landowners or between capital owners and labor are points of particular interest.

Finally, due to trade, the distribution of benefits from increased production has a regional aspect bound to a price decrease in trade. If the trade price remains unchanged the gains of increased production accrue to the original region only. If it decreases, other regions are affected as well. They benefit as importing regions, and they lose as exporting regions.

In summary, the possible effects of research activities on income distribution are complex, and it will hardly ever be possible to identify and quantify all of them fully. But since there may be a trade-off between economic efficiency and distribution, distributional considerations should play a role in evaluating research activities. The least to be done is to calculate the opportunity cost of a particular research activity in terms of distribution. In simpler terms, one is asked to compare the distributional situation "with" and "without" research impact.

A final impact area of research activities may be effects on nonproduction-specific goals or on general socio-economic development. The relevance of non-economic goals for the CG system has increasingly been addressed. Scobie (1984) lists several goals with which at some time or another agricultural research has been charged.

- generating or saving exchange,
- achieving food self-sufficiency,
- creating emloyment,
- improving rural incomes,
- changing the distribution of income,
- increasing the incomes of small farmers, and
- reducing rural to urban migration.

Hence, an assessment of IARC activities could be extended to identify possible impacts on these goals. However, all these goals, apart from food production, are only loosely linked to agricultural production as they are linked to policy actions in many other domains. Since increased food production is the primary goal for the CG system, there is the question which role such secondary impacts should actually play in an overall impact assessment of IARC activities. What can be done in any case is to identify opportunity costs in terms of increased production forgone, whenever impacts on nonproduction-specific goals are to be considered.

Chapter 4

NATIONAL AGRICULTURAL RESEARCH IN TROPICAL AFRICA

IAR and NAR each play an important and interwoven role in promoting agricultural production in developing countries.

The usefulness of IAR in a system of different national research activities is widely acknowledged. There are four basic arguments in favor of international efforts (Pinstrup-Andersen, 1982; Ruttan, 1982a):

a) the public good character of agricultural research,
b) distortions in developing countries' time preferences,
c) distortions in developing countries' risk preferences, and
d) imperfect markets for agricultural research demand and supply.

For these reasons developing countries will generally underinvest in agricultural research, and international efforts are required to fill the gap. On the other hand, strong NARSs are essential for agricultural development. "The ultimate aim of technology-developing efforts of IARCs cannot be achieved without strong national systems where the materials can be tested and adapted to circumstances of farmers; and where there is capacity to work on localized problems that IARCs cannot deal with" (ISNAR/IFPRI, 1981). Hence, in order to appropriately judge impacts of IAR in tropical Africa it is most important to get a clear view of the NARSs.

In this chapter, several aspects of NAR in tropical Africa are dealt with. In a first section a general view is given. Extent, development and structure of NAR in tropical Africa are described, and their general problems and overall performance discussed. The second section presents some qualitative aspects in more detail based among other things on individual country studies. The third section, finally, is devoted to the role of non-CG institutions in strengthening and supporting NAR in tropical Africa.

4.1 General Assessment

Agricultural research is a complex process. It is not self-evident that its importance and performance can appropriately be assessed by a few quantitative indicators. Nevertheless, such information may give a first rough idea about level, structure and trends of agricultural research which, of course, have to be complemented by thorough and careful qualitative judgement.

To assess the overall performance of NAR in tropical Africa, some quantitative indicators are presented in the first step. It is common to concentrate on public sector research and to use expenditures and manpower as the main indicators. The research structure may then be characterized by the relationship of these two variables. Furthermore, a distinction between agricultural research as such and extension is normally made.

Table 4.1 gives indicators of NAR structures in developing country groups of tropical Africa for 1980 based on a study by Judd, et al. (1983). It shows that research and extension expenditures in all developing countries are considerably lower than in developed countries. There is also less manpower devoted to research; on the other hand, extension manpower is much higher in developing countries than in developed countries. For tropical Africa, the figures are remarkably low for research. It has to be mentioned that the figure for West is dominated by Nigeria and the one for South by the state of South Africa. In Annex Table 4.1 the corresponding figures are listed for selected countries which have been chosen for the country studies.

Table 4.1 Expenditures and Manpower of Public Sector Agricultural Research and Extension by Developing Country Group in Tropical Africa, 1980

	Expenditures (a)		Manpower (b)	
	Research	Extension	Research	Extension
Tropical Africa in Percent of All Developing Countries				
West	10	17	5	13
East	4	9	3	10
South	4	3	4	2
Developed Countries in Percent of All Developing Countries				
	269	192	211	49

(a) In constant 1980 US$.
(b) Based on scientist person-years.
(c) The absolute figures for all developing countries are: Expenditures (in million US$), research 2,000, extension 1,178; scientist person-years (in 1,000 units), research 48, extension 234.

Source: Judd, M.A., Boyce, J.K., and Evenson R.E. (1983).

Table 4.1 suggests a shortage of resources for NARSs in tropical Africa, also visualized by the relationship between research and extension figures. The ratio is both very low for expenditures and manpower when compared to the situation in all developing countries and to the situation in developed countries (with the exception of South Africa). The shortage of resources appears to be more serious for manpower in research and less dramatic for research expenditures.

The allocation of resources to research is closely related to the income level of economies. In Table 4.2 expenditures and manpower of public sector agricultural research are shown for developing country income classes.
The figures are related to agricultural GDP, population, and crop area, to better judge the magnitudes involved. Tropical Africa fits well into the overall pattern. One obvious relationship is that, as the income level of developing countries rises, more money is spent on agricultural GDP. The

Table 4.2 Expenditures and Manpower of Public Sector Agricultural Research by Developing Country Income Group (a), 1980

	Number of Countries	Expenditures (b)				Manpower (c)		
		mio US$	per agri-cultural GDP (percent)	per 1,000 inhabitants, (US$)	per 1,000 ha crop area (US$)	(1 000)	per million inhabitants, (number)	per 1,000 ha crop area (number)
Low Income Countries	13	184.70	0.36	185.20	0.80	13.50	13.60	0.06
Tropical Africa	8	45.00	0.58	438.50	1.50	1.20	12.00	0.04
Middle Income Countries	27	271.60	0.46	542.4	2.40	9.60	19.30	0.08
Tropical Africa	4	104.90	0.67	1 111.30	3.30	1.70	18.50	0.05
High Income Countries	11	357.20	1.07	1 384.10	3.10	6.20	24.10	0.05
Total of 51 Countries	51	813.50	0.56	463.30	1.80	29.40	16.70	0.06

(a) Based on 51 selected developing countries.

(b) Based on constant 1975 US$.

(c) Number of research scientists.

Source: IFPRI/ISNAR (1981).

same is true for expenditures per capita and expenditures per area. For tropical Africa, the figures show the same tendency. Poor countries, e.g., spend 0.36 percent of the agricultural GDP on research, which is equivalent to US$ 185 per 1,000 inhabitants or US$ 0.80 per 1,000 ha of crop area. The corresponding figures for tropical Africa are 0,58 percent of the agricultural GDP, US$ 438.50 per 1,000 inhabitants and US$ 1.50 per 1,000 ha of crop area. The result is comparable for the middle income group. Hence, countries of tropical Africa are poor and they spend little money on agricultural research, but they devote relatively more money to research than comparable poor countries in other continents. Overall, the level of research expenditures in tropical Africa is now slightly above the target of 0.5 percent of agricultural GDP as proposed by the UN World Food Conference in 1979 but still far away from a 1 percent level deemed desirable as a rule of thumb.

Considering manpower allocation by developing country income group, the result is not definite. A clear relationship holds for the number of scientists per capita. It is 13.6 for low income countries, 19.3 for middle class countries, and 24.1 for high income countries. The figures for tropical Africa are somewhat below these averages. The ratio of scientists to crop area, on the other hand, does not show a definitive movement. Nevertheless, the figures again seem to indicate not only an absolute, but also a relative manpower shortage in tropical Africa agriculture research as compared to other developing countries.

Resource allocation to agricultural research is, of course, not static and may change over time. To properly assess NARS, it is necessary to look at developments and trends. Annex Table 4.2 shows trends for expenditures and manpower of public sector agricultural research and extension by regions of tropical Africa.

The figures refer to the period 1970-80 and are again based on Judd, et al. (1983). Between 1970 and 1980 the developing countries as a group have increased their expenditures and their manpower allocations for research at rates of over 5 percent p.a., substantially above the rate in developed countries (about 2.5 percent). Extension has expanded at much lower rates, closer to 2 percent p.a. and closer to the rates in developed countries. The figures for research in tropical Africa are well above the average of all developing countries, particularly the figures for West Africa. Research expenditures have grown at an annual rate of 8.4 percent and for manpower even at a rate of 9.6 percent (South Africa, again, is an excemption).

For extension in tropical Africa the development has been different. Expenditures have grown at a lower rate than manpower, and both rates have been far lower than the figures for research. As a consequence, the relationship between research allocation and extension allocation in tropical Africa has considerably changed during the decade from 1970 to 1980. Research has been promoted more than extension, both in terms of expenditures and of manpower. Hence, tropical Africa has changed its research structure towards that of developed countries (Annex Table 4.1).

The rough picture of NAR capacities so far presented only refers to the input side of research. The discussion has to be extended to cover the output side of research, too, which points to the problem of research quality or research productivity, and it is this aspect which, beside quantitative consideration, is most important for assessing NARSs in tropical Africa.

The widespread opinion is that agricultural research systems in tropical Africa are inefficient (Monyo, 1984). "On the whole, the productivity of research in tropical Africa has been low, particularly during the last fifteen years. Inadequate funding, lack of functional linkages between research and extension including political instability in some instances, are among the factors contributing to the poor performance of research and its lack of impact on food and agricultural production." Elz (1984) draws an even more drastic picture:

"Agricultural research is failing to provide the adequate support for producers of both food and export crops. Major advances like those which revolutionized wheat and rice cultivation in Asia have not been made since the 1960s, when new maize hybrids were adopted in southern and eastern Africa. No major breakthrough has been achieved in genetic improvement of rainfed millet and sorghum, which account for 80 percent of the cultivated land in the Sahel and other areas of low rainfall. Nor can rapid progress be expected."

In a meeting of managers of agricultural research systems in African countries, the main reasons for the inefficiency in NARS of tropical Africa (ISNAR/IFPRI, 1981) were stated as:

- inappropriate research organization,
- problem of manpower development for agricultural research, and
- the missing link between agricultural research and agricultural production.

FAO and UNDP (1984) summarize the major constraints and problems for NAR in developing countries in detail. The points are particularly relevant for NARSs in tropical Africa and therefore deserve to be cited here:

i Despite its high economic and social benefits, developing countries still do not devote enough funds to research. This attitude is motivated by the general impression that agricultural research is both a complex and long-term process, and its benefits are not as visible as those resulting from other forms of agricultural investment, e.g. irrigation or expenditures on extension.

ii The advantages of agricultural research are still not fully grasped by the farming community and perhaps least valued by the general public. The problem is exacerbated by the lack of dialogue between research scientists and policy-makers. All these factors are reflected in the low priority given to agricultural research by planners and policy-makers.

iii The planning of research programs remains weak. The major problems are the lack of balance between short and long-term needs, unclear objectives which fail to provide guidance for resource allocation, and lack of commitment to solve the problem of poor farmers. In most developing countries, research continues to be viewed as a scientific discipline operating separately from other closely related disciplines. Its focus is mainly on commodity research; farming systems research is still in its early phases, although some of the IARCs are encouraging the developing countries along these lines. A major difficulty of organizing farming system research is that it is a multidisciplinary effort and requires full cooperation between researchers, extensionists, and farmers. Another problem is the lack of involvement of research scientists from universities and colleges in the planning of national agricultural research.

iv Research programs continue to suffer from shortage of funds and their timely provision and from lack of identifying the real technical and biological research. Often no systematic effort is made to gain a clear picture of the financial benefits emanating from research which accrue to producers and consumers and, among the latter, to landowners and landless workers. Another weakness in programming is the lack of harmonization of research priorities with given resource endowments and the establishment of research priorities, so that the best use can be made of available funds.

v There is a strong tendency to produce improved technology suited for the areas most favored by climate and geography. The development of technology for marginal areas, where complex environmental, technical and socio-economic factors are at play, is still not receiving adequate attention.

vi The possibility of transfer of research results from one developing country to another is not fully exploited. This is caused by the slow progress in promoting networks among national agricultural research institutions in different regions. Similarly, the services provided by the CGIAR system are not fully utilized in the transfer of technology from country to country.

vii Not much attention is being given to the indirect consequences of agricultural research, such as the effects on the environment or on other crops resulting from the introduction of a new technology for a single crop.

viii In most cases research institutions are not structured to facilitate smooth flow of information. Lack of communication among research institutions prevents the cross-fertilization of ideas and experience, encourages duplication of effort, and makes it difficult to fill the gaps in the research system. On the whole, there appears to be a need for restructuring agricultural research organizations.

ix The absence of a professional research environment (intellectual stimulation, recognition of success, and group interaction) is a constraint, especially lack of contact with agricultural research scientists in other countries, particularly those with similar climatic conditions.

x Trained and experienced manpower is in short supply, especially in the LDCs. In fact, most developing countries do not have a coherent plan for training in research. The creation of additional research stations in response to political pressures has further diluted manpower resources in many countries. Most critical is the shortage of skilled research managers, a function which cannot be handled by scientists or political appointees. It requires qualified personnel who, because of private sector competition, demand higher salaries. Although the training facilities provided by the IARCs are being relatively well utilized, the same cannot be said of the facilities offered by the international associations. The retention of manpower in research constitutes a major difficulty. The major factors responsible are inadequate career structures, low salaries, and poor conditions of work.

xi Liaison between research (generation of knowledge) and extension (dissemination of tested technology) is very poor. Instead of interaction, there may be even antagonism, especially if each discipline is attached to a separate ministry. This situation has prevented dialogue between researchers and farmers and has weakened the diffusion process by which research results are adopted.

Thus it is hardly possible to speak of strong NARSs in tropical Africa as counterparts to the CG system. While growing resource allocation to agricultural research on this continent is encouraging, the overall situation is still very unsatisfactory. Most countries still lack an adequate system for planning, allocating and monitoring research resources, which results in low research productivity. This, of course, also determines the potential productivity of IAR in tropical Africa.

4.2 Qualitative Aspects

The general view of NAR in tropical Africa as developed in the preceding section can be complemented by more specific aspects drawn from the country studies. The most important thing to realize from the start is that there is no typical NARS representative of the whole continent. While there are a number of similar problems, there are large divergencies among the NARS. Such divergencies mostly relate to the structure of the national systems, their resource endowments and, most of all, to their efficiency.

Resource endowment

Several countries are rather well-endowed with research resources. In Zimbabwe, government expenditures on agricultural research have generally remained over 1 percent of the agricultural GDP. This is below the World Bank's 1990 target of 2 percent, but above the generally recommended level and certainly a lot higher than in most countries in Africa (in 1980, over twice the average figure for countries in tropical Africa according to ISNAR/IFPRI). Kenya, too, is well endowed with research resources and has one of the largest research establishments in tropical Africa. Currently, expenditures to research are in the order of 1 percent of the agricultural GDP, the target set by the Government. In Cameroon, another example for a NARS with relatively ample resources, the figure is 1.3 percent. These countries also serve to demonstrate that the colonial heritage can be successfully built upon to create strong NARSs, in fact, among the strongest in tropical Africa.

On the other extreme, Ethiopia has a very resource-poor NARS. Over the last three years, total expenditure on research represents only about 0.3 percent of the agricultural GDP. Considering the important contribution of agriculture to GDP, which is currently around 45 percent in this country, the support provided to agricultural research is very low indeed. This may partly be explained by the short history of agricultural research in Ethiopia, which practically only dates back to 1966, when the Agricultural Research Institute was established with UNDP financial assistance and FAO as an executing agency. This marked the formal beginning of nation-wide modern NAR in Ethiopia. Given the meager resource base and the limited indigenous experience of Ethiopia, its NARS probably has to be ranked among the weakest in tropical Africa.

Burkina Faso is another typical example for a country with very few research capacities. Compared to total expenditures for agricultural and rural development activities, expenditures for agricultural research amounted to only 2 to 3 percent since 1960. Moreover, the share of agricultural research in the overall budget has decreased from about 2.5 percent to 5 percent in the same period. This not only points to the low priority given to NAR but, more importantly, to its decreasing role.

Apart from the low level of research expenditures in tropical Africa, instability in research funding raises major problems. Often there is pressure on research institutes during times of economic recession, which hampers or even excludes long-term planning and activities. The relatively well endowed NARSs of Nigeria and Senegal can serve as examples. Many institutes complain about the problem of inadequate and irregular funding. They are unable to maintain facilities and to obtain spare parts for machines and equipment. Furthermore, budgets to the institutes have often been cut to the extent that they are mainly spent on the payment of staff salaries and wages. This also means that there is insufficient transport for field work, and inadequate maintenance of field laboratories and experimental stations.

Efficiency considerations

The endowment with resources is one thing, the efficiency of research another. Efficiency may loosely be defined as producing as much useful research results as possible with a given amount of resources. In tropical Africa, research output is often far below the possible level. Zimbabwe may be the exception from this general picture. The research system in that country has had a history of sound production-oriented research spanning the last seventy years. The advanced nature of NAR is illustrated by the country's maize breeding program releasing a commercial hybrid as early as 1949 making Zimbabwe the second country in the world to achieve this after the U.S.A. Subsequently, local breeders produced the now internationally renowned variety "SR 52", a high-yielding hybrid still in extensive use today in Zimbabwe as well as other countries. The development of the early maturing hybrids in the seventies led to significant yield increases and an expansion of maize into the more marginal rainfall areas. Equally indicative of the strength and competence of the NARS was the country's ability to rapidly diversify from its heavy dependence on tobacco after the imposition of international sanctions. The development of the cotton, soybean and wheat production was based on considerable research efforts. The adaptation and rapid expansion of these crops was, of course, also facilitated by good extension services, a favorable price policy and investment support, especially for irrigation development.

Zimbabwe's NARS is the notable exception in tropical Africa. In no other country have similar impressive research results been achieved or can even be expected currently. This generally reflects inefficiency more than inadequate funding levels. In most cases, the countries readily admit that there has been little progress, or at least that progress is small in relation to the enormous task facing agricultural research vis-a-vis rapidly growing populations. In particular, the NARS has not generated sufficient technologies for the smallholder sector. The widespread inefficiencies are usually brought in connection with unsuitable organization, unsatisfactory management, structural deficiencies, weaknesses in research planning and priority setting, arbitrary division of available talents and resources, overlapping responsibilities, lack of coordination, etc. In several cases these problems are compounded by the frequent turnover of expatriate researchers and/or their exodus. Another complicating factor though not specific to agricultural research lies in the political instability with its detrimental effect on all development efforts in a society.

Organizational instability is another important efficiency issue. Many NARSs in tropical Africa are in a period of transition, which may be beneficial in the long run, but causes adoption problems today. In Nigeria, e.g., the structure of the NARS has been changed several times during the last decade. There have been changes and modifications in policies, guidelines, and emphasis. That the institutes have been able to adjust to these changes is certainly a vindication of the relative strength of the Nigerian NARS. It is obvious, on the other hand, that projects and programs have had to suffer.

Human capital

A crucial problem closely related to the issue of efficiency and central to any research endeavor is the quality of the researchers. The issue of human capital engaged in research requires elaboration. First, one has to note the relatively low experience level of the research scientists. The obvious reason for this is the fact that NARSs on this continent are young and expanding systems. Many of the researchers are newly recruited and cannot yet have acquired a sound research capacity. In Burkina Faso, e.g., the majority of national agricultural researchers has an experience level of less than 4 years.

The problem is aggravated by some other factors. Many NARSs severely depend on expatriates who usually stay for a limited period only or leave the countries in connection with political changes (e.g. Zimbabwe). The result is disruption or, at least, a lack of continuity. Malawi serves to illustrate how the continuity of a crop research program depends on continuity of senior staff. In the maize breeding program abrupt changes resulted when the expatriate team leader terminated his contract and was replaced by a breeder with different approaches and objectives. On the other hand, the groundnut breeding program has been exceptionally stable for over two decades due to continuity of staffing. The original breeder was in charge for 12 years and was replaced by his deputy who ran the program before handing it over to a Malawian who had worked in the section since 1972. The groundnut program ranks among the more promising and more successful in Malawi's agricultural research.

Another problem is the excessive occupation of scientific personnel with administrative tasks. This may be partly due to inefficiencies in the organization of research. Partly, however, this also reflects lack of competence and insecurity of the personnel when it comes to research.

A set of problems receiving general mention may be grouped under the heading of lack of incentives. Salaries in research are often low and result in high attrition rates, further compounded by inadequate service support, poor promotion aspects, poor living conditions in remote field stations, lack of recognition for research efforts, and a lack of training and development opportunities. In Kenya, there is widespread consensus that the attrition rate and turnover of research scientists employed in the NARS are extremely high and constitute one of the most serious constraints for developing an efficient agricultural research capacity. Under such conditions, it is nearly impossible to establish a critical mass of experienced scientific manpower within the NARS. High rates of attrition also dictate that high recruitment rates be sustained. To give an example, it is estimated that the average length of employment in the Research Division of the Ministry of Agriculture is 2 1/2 years for Kenyan personnel and 3 1/2 years for expatriates. In such a short time span, staff cannot do much more than get introduced to the problems rather than solving them. This is a further factor to explain inefficiencies in research organization.

A final aspect relates to the qualification level of researchers, which generally leaves a good deal to be desired. In Kenya, there was one Ph.D. scientist to every three other scientists in 1960. This ratio has fallen to 1:6 by 1978 (without research scientists working in IARCs and at the University of Nairobi). When only Kenyans are considered, the Ph.D.-level scientist ratio to other agricultural scientists was only 1:6 in 1978, and by 1982 it had dropped to 1:38. In a survey of research stations in 1980, it was shown that only about one third of the research staff in the system had gone through formal post-graduate training up to at least M.Sc.-level and only one tenth had a Ph.D. Out of 23 directors and officers in charge of research stations in the sample only four had Ph.D. degrees. It is obvious, that research leaders and managers must be adequately qualified to provide the necessary guidance, leadership, and continuous evaluation of progress. Thus a major constraint to efficient research work in NARSs of tropical Africa seems to be the qualification level of staff. The countries seem to be well aware of this problem. Training is usually considered as a key issue for NARSs, and the offer of IARCs in this aspect is very welcome. The national initiatives are directed towards strengthening the national agricultural education but this, of course, will only show results in the long run. Post-graduate education overseas can play an important role. Thus, Malawi is currently involved in an impressive exercise of this kind. Nearly one third of the professional officers have been engaged in postgraduate courses, at both Master and Doctorate levels, in the U.S.A. and the U.K. The recent returnees are impressive in terms of competence and professionalism.

As encouraging as such training successes may be, the problem of poor support to these - also newly and additionally trained - scientists persists. The capital/scientist ratio is low throughout NARSs in tropical Africa. This is even true for a well-developed system like that of Zimbabwe. The allocation there in 1984 is the equivalent of US$ 41,000 per scientist, which is low by any standards.

The relatively low funding of research is another reason for the relatively low productivity of human capital engaged in research. Most of the available resources are used for salaries and wages, specific recurrent expenditures, and investment in buildings. Few resources are left to initiate and build up new research programs. In Zimbabwe, more than 70 percent of the 1980/81 NARS budget is used for salaries and wages. In Cameroon, the capital budget increased considerably in the year 1981/82, but most of this was for infrastructure and buildings, not for actual research activities. In Burkina Faso, the "salary bias" was not seen as a problem particular to research but to any development activity, which typically absorbs up to 80 percent of the resources for personnel.

The problems this can cause are highlighted in the ISNAR/IFPRI report: "For a number of those (countries) where it is recorded, the bulk of recurrent expenditure seems to be for salaries... In several cases, little remains for operations, implying both a high degree of inefficiency in the use of scarce resources and of trained scientists, and a high level of frustration among those scientists keen to do a good job." This frustration is often reflected in the resignation of scientists from the NARSs.

In addition to this general capital shortage, assistance by technical personnel is also unsatisfactory. In many NARSs of tropical Africa, like in Zimbabwe and Malawi, the ratio of technicians to scientists is about one for one, which is far from that in highly developed efficient research systems.

A different, though not unconnected, problem is that of extension staff supporting research staff and propagating the research results. The World Bank (1981) advocates a ratio of expenditure on research to that on extension of 1:1. However, research expenditures are generally lower. Taking Zimbabwe as an example, the allocation to research has been in the order of 60 percent of that to extension. It also has to be realized that researchers in developing countries, particularly in tropical Africa, benefit to a much lesser degree from interaction with colleagues. Private research is of limited importance in developing countries of tropical Africa, and university research often lacks the resources to contribute anything substantial. Hence, NAR, as carried out by the national agricultural institutes, is usually quite isolated and has to do without any of the fruitful interactions so common and essential to more advanced systems.

Biased structures

Bias may only mean that in retrospect one would have preferred a different orientation of research. Thus a certain bias against food production, notably against food production in small-scale peasant agriculture, is widespread. In Zimbabwe, there has been a neglect of communal areas and a bias in favor of large-scale commercial farming since the creation of the NARS. In 1980/81, nearly half of the total operating expenses went to livestock, and pastures research, almost completely oriented to large-scale commercial ranching. Much of the research involves exotic breeds and pasture management and improvement practices, such as rotational grazing in fenced paddocks, which are hardly relevant for the communal areas. Also on the crop research side, much of the work is directed towards large-scale commercial farming.

In Kenya also, little attention has been given to research on food crop production by small farmers. Research activities strongly emphasized cash crops for exports like coffee and tea from which, it has to be admitted, smallholders also benefited a great deal. In Malawi, historical patterns are also still reflected today. The two crops that receive research attention well above their relative importance in output are rice and cotton, which each contributed 4 percent to the 1978 value of output while they received 15 percent and 21 percent, respectively, of the 1983/84 research budget. Both these crops are important for export. Maize, on the other hand, contributed 37 percent to the value of output and only received 8 percent of research expenditures in the cited years. However, Malawi has become aware of this bias and is working hard on a reorientation of the NARS. Thus, emphasis on millets and sorghum, two previously ignored local crops, and on wheat, which is not a traditional crop in Malawi but is becoming increasingly important in consumption, is being increased considerably. Such changes are occurring in most NARSs in tropical Africa, but the process is generally only at the beginning. In Cameroon, this dates back a little longer. A massive reorientation set in since the early

1970s. All major food crops in the different ecosystems of the country are given increasing attention. The allocation of research resources for food crops grew by 86 percent from 1981/82 to 1984/85, but only by 29 percent for cash crops. The expenditure ratio between these two categories improved in favor of food crops from 0.9 to 1.3.

Another bias reflecting on potential research success in many countries relates to the extension services. Extension services often suffer from mismanagement, a misallocation of manpower, inadequate training and retraining of extension personnel, a lack of resources, and the absence of an effective linkage with research. Equally, extension services seem to be oriented towards innovative, "better-off" farmers and miss the majority of peasant agriculture. Hence, the downstream transfer of research results is restricted, and the few research results of NARSs, as promising as they may be, can often not be translated into practical agriculture.

4.3 Support by Non-CG Institutions:

The Collaboration of NAR with France (1)

General

It would be quite wrong to characterize research activities in tropical Africa only as a matter of national activities on one side and activities of the CG centers on the other. The situation is much more complex and it would be quite an overestimation of the CG system to imply that it was the only one to interact with the national efforts. The issue can also be put in different terms: The CG system may be relatively well defined through the international centers physically existing and putting demands on budget allocations of a known group of international donors. But over the last two decades bilateral assistance to national research efforts may have been even more important. It is not clear whether this is meant to be included in the term "national research". And international support, of course, is not limited to the CG system at all. Thus the FAO but also other UN activities, World Bank projects, the EEC efforts and others constitute important contributions.

To neglect these would imply a distortion of reality. An even more serious distortion of reality would be to imply that before independence for Africa, say, before the sixties nothing had been done in terms of research. The colonial powers and the various structures that were built under their rule have done more than just lay the foundation for development today. It is quite beyond the scope of this report to attempt to summarize efforts and results of the British, French, Belgians, Portuguese, even the Germans before World War One. However, one can by way of example illustrate what has been done in terms of agricultural research before independence. The choice of the French system as example may seem somewhat arbitrary but there are also a number of objective reasons:

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(1) Based on a report by P. Roche, sponsored by CIRAD as a contribution to the impact study.

- the experience with agricultural research reaches back over decades and is as extensive as any other;

- the system is still in existence;

- because of its centralized organizational structure the system is still today easy to address in its entirety.

Nevertheless it must be emphasized that this section is meant to illustrate additional aspects of research cooperation by way of example rather than to constitute a comprehensive assessment of the French system and its activities in Africa.

Historical development of research collaboration

The start of systematic agricultural research collaboration with France may for most of the francophone countries be put into the 1920s with Senegal and Madagascar leading the way. Between 1938 and 1945 - astonishingly enough during the difficult war- and post-war years - it developed into its most elaborate stage. To be particularly mentioned is the two-pronged approach of ecological orientation on one side and commodity emphasis on the other.

Ecological orientation led to the distinction essentially of (1) semiarid West Africa (Chad, Mauritania, Mali, Niger, Senegal, Burkina Faso), (2) humid West Africa (Benin, Togo, Ivory Coast), (3) the equatorial zone (Central African Republic, Cameroon, Congo, Gabon), and (4) Madagascar.

A consequence of the agro-ecological view of agricultural research was the creation of research centers with regional responsibilities and multiple research interests in terms of crops and agronomic practices. A typical example is Bambey with major interests in millet, sorghum and groundnuts and in cropping techniques including animal traction and with a responsibility for all of semiarid West Africa.

On the other hand, there were the more commodity-oriented institutes like IRHO (oil crops), IRCT (cotton), IRFA (fruits) and the various veterinary research centers. By the nature of the commodities these institutes, of course, also had an ecological bias (oil palms in the more humid, cotton in the drier zones).

Taking it altogether, it means that already forty years ago the French had built up an agricultural research system with a mandate mix - regional versus commodity - that reminds one of the CG system today, although, of course, enough differences exist. One is that the institutes with a primarily regional mandate of the French system were organized and financed in a different way from the others. They were under much closer control from the general overseas administration, which did not turn out to be an advantage because of the bureaucratic mechanisms this implied. Another difference is that the commodity-oriented institutes concentrated on cash and export crops. As a corollary the commodity-oriented institutes were financially much stronger and much more independent than the regional institutes since financed from export taxes.

It would be wrong to characterize the French system as one concentrating on export crops exclusively. The regional institutes (though not functioning as well) covered all the important food crops and many of the so-called export crops play a role as domestic food as well. An emphasis on export crops at the time appeared quite reasonable since (1) there was no food shortage and (2) foreign exchange was needed to finance the efforts at economic development.

Reports are that the period between 1950 and 1960 saw further improvements in quantity and quality of staff and with the regional establishment of ORSTOM in Africa. ORSTOM, as the research branch more concerned with the basic sciences, embarked on studies of flora, fauna, environment, soils, erosion, bioclimate etc.

During the same period the research system as a whole developed new emphases. Mentioned are (1) the physical environment (soil fertility, erosion control), (2) plant breeding, also in the regional institutes (groundnuts, millet and sorghum in Senegal, rice and manioc in Madagascar and so-called secondary food crops like beans) and (3) mechanization through animal traction.

Development since independence meant for many countries also an attempt to disassociate itself from the former (colonial) institutions. France's answer consisted of (1) having the commodity-oriented French-based institutes work more and more through the emerging national institutes and (2) creating new French-based product specific centers:
CTFT (forest)
IRAT (food crops)
IEMVT (livestock)
IRCC (coffee, cocoa)
IRCC (rubber).

They were given a different, more independent status. Their implantation in Africa was discussed with the different countries through the various mixed franco-african commissions. Between 1960 and 1968 these new institutions had practically taken over the old regional institutes. They also recruited more and more non-French expatriates and nationals as they became available, particularly after 1970. In each country a national scientific commission controls the activities in association with the institute (normally on the occasion of the annual meeting). The mixed French-African Commission has the functions of overall political and financial control.

As the number of national structures in all African states grew, particularly after 1970, an umbrella organization, GERDAT (since 1984 CIRAD), was created. GERDAT's/CIRAD's function is to assist the national institutions in collaboration with the France-based institutes:

- which take over and run for the national institutes whole programs, or
- which participate in specific programs.

The mixed commissions meet annually and put proposals to CIRAD. The French Ministry of Cooperation (Directorate of Scientific and Technical Research, the controlling institution for CIRAD) then decides about agreement, discontinuation or changes of the proposals. In principle, there are 50-50 arrangements for the finances. It is stated that the final decision is always with the African side, but, the French side is, of course, free to reduce or pull out support or to mobilize additional funds.

Additional developments worth mentioning since 1960 are (1) the increasing role of ORSTOM (plant genetics, soil sciences, phytopathology, entomology, virology, rural economics), (2) the establishment of Montpellier (for work with heavier and expensive equipment than the African national institutes can afford and that should not be subjected to political vagaries), and (3) an increasing involvement of French-led agricultural research in the French Overseas Departments, in Latin America and in Asia.

An indication of the importance of French involvement in agricultural research may be provided by the following figures:

Tropical Africa
- 200 scientists funded from public French funds
- 97 scientists funded otherwise

French Overseas Departments
- 49 scientists

Non-francophone tropical countries
- 64 scientists.

Going by the number of scientists alone it would appear that France's involvement in agricultural research in Tropical Africa is of about the same order of magnitude as that of the CG system. In addition the CIRAD system alone has some 200 back-up scientists based in France.

Some issues

It is generally felt that, on the whole, efforts have been successful to maintain or reestablish quality and rigor of France's research collaboration with Africa in the post-independence period. The principle of mixed decision-making bodies and joint finance may render work sometimes more difficult, and the comparison is often made with IARCs as being in complete control of their objectives, resources and personnel (which probably constitutes an overestimation of the possibilities of the IARCs). On the other hand, the more formal French-African sharing arrangements means that nobody can charge the CIRAD system of not reflecting the real needs of Africa or the regional diversities in their research program.

The other side of the coin is that the individualized country-by-country approach has the implicit danger of treating certain countries and issues preferentially to the possible neglect of the more generalized agricultural problems (though institutes like IRAT and CEEMAT have retained a strong general base).

An often-heard criticism of the French research collaboration is that it has benefitted the cash (export) crops only. The counterarguments are (1) that the distinction is arbitrary and not very useful (palm oil, copra, cotton, sugar, fruit - all have their domestic markets too), (2) that small farmers participate to a considerable degree in the production of cash crops, (3) that foreign exchange is needed more than ever and that by necessity the countries must exploit the comparative advantages they have in the production of tropical crops and (4) that all evidence shows that expansion of export crops can go hand in hand with expansion of food crops. In any case it has to be realized that the French system has always had a strong line of food crop research (the regional centers, then IRAT e.g.). The basic position is that research has to continue to consider both export crops and crops for domestic food consumption.

Finally it is pointed out, and several plausible examples are given, that French-African research collaboration has helped in many cases to open up the national research institutes for collaboration with the IARS and with CG institutes in particular.

PART B: Country Perspectives

Chapter 5

THE COLLABORATION BETWEEN THE CG SYSTEM AND NAR

5.1 Introduction

Both the CG system and national agricultural research in tropical Africa belong to a global research network established for the benefit of developing countries. It is obvious, that any IARS impact is very much dependent on the collaboration the system has with NARSs. NAR is supposed to translate and exploit the research results provided by IARCs and, thus, produce the actual effects in the countries concerned. Hence a close and productive collaboration between the CG system and NAR is the key for the system's success in attaining its stated goals.

In this chapter, some relevant issues concerning the collaboration between the system and NAR are discussed. It is acknowledged that a great deal has already been achieved in terms of such collaboration. But there have also been problems, and it is important to identify and discuss these problems in order to initiate necessary changes in the future. The aim of this chapter is to contribute to a further strengthening of the collaboration between IAR and NAR by presenting the perceptions of this collaboration as held within countries themselves.

In accordance with the scope of this present report, the viewpoint of countries in tropical Africa is demonstrated. The selection of countries and of people for interviews within countries is by necessity influenced by chance, subjectivity and bias. Hence, the points raised in this chapter should be taken as what they are, opinions and views of involved and engaged people - with varying depth of involvement and level of information - working on the receiving side of centers' research. They may be very relevant in specific cases but cannot always be generalized. Despite these limitations, it is believed that the information provided is unique and of significance for an impact assessment of the CG system and, moreover, for enhancing the centers' success in the future.

The chapter is divided into four parts. Three of them are devoted to potential impact areas and related to the provision and development of biological materials, to other research impacts like farming systems research or policy analysis, and to the enhancement of human capital. In a final part, some more general issues concerning the cooperation between the CG system and NAR are discussed.

5.2 Provision of Biological Material

Extent of collaboration

The provision of germplasm to NARSs is a central aspect of IARC activities. It allows national researchers to base their own activities on a wide range of genetic varieties that would not be available in isolated national breeding programs, due to a lack of resources but also due to the more limited local variability of germplasm. In this way, the provision of biological material by IARCs enhances the potential of NARS and, thus, the probability of success. It is emphasized, on the other hand, that the relationship between IAR and NAR is complementary. The genetic potential provided has to be exploited by NARSs which means to test for locally suitable varieties and to build these into national breeding programs.

There are several examples from recent history to illustrate how well such a collaboration between the CG system and NAR can work. The wheat breeding program in Zimbabwe is a point in case. CIMMYT has been supplying wheat varieties to that country from the 1960s. All the wheat in Zimbabwe is grown under irrigation by either large-scale commercial farms or public estates. Yields are exceptionally stable and among the highest in the world at around 4.5 t/ha on average. It is acknowledged that much of this success is due to a favorable support structure for wheat growing in Zimbabwe including price incentives, but the role of CIMMYT-influenced varieties must still be seen as very important. The sustained production of the crop depends on continued research and constant genetic development as rust limits the use of each variety to a period of 3-5 years. The involvement of CIMMYT material is demonstrated in Table 5.1.

Table 5.1 Parentage of Zimbabwean Wheat Varieties

Variety	Released	Parentage
Gwebi	1979	Straight CIMMYT variety Yecora 70
Angwa	1980	Cross between CIMMYT variety Cajeme and Corre Caminos
Sanyati	1981	Local material crossed with CIMMYT's Saric 70 of the Bluebell series
Chiwore	1982	Originates from a CIMMYT cross involving a number of parents including Asteca 67 and Yehora S
Umi	1983	Mainly local varieties with some CIMMYT material of the Torim 73 series
Lesape	1983	A CIMMYT cross involving Kavkas/Buhos/ Kalyansona/Bluebird. This material has a Vire background as it is a spring x winter x spring backcross

Source : Crop Breeding Institute, Department of Research and Specialist Services (Zimbabwe), internal documents and annual reports.

The superiority of the CIMMYT material is illustrated by the fact that both the predominantly local varieties Sanyati and Umi have had to be withdrawn because of rust problems. Furthermore, in addition to Table 5.1, a direct CIMMYT variety, Torim 73, was released in Zimbabwe under its own name. In the 1984 growing period, now, the varieties Gwebi and Torim 73 comprised 60 percent of the wheat planted, while 25 percent was the variety Angwa. Chiwore and Lesape comprise about 5 percent whereas the rest of only 10 percent is shared by two more traditional varieties (Limpopo and Tokwe), which either are derived entirely from local material or contain only little CIMMYT material in them.

Of all the case study countries considered, Nigeria seems to have received the bulk of biological material provided by IARCs. Most of this material has originated from IITA, which demonstrates that the location of an IARC is most important for the regional spread of its impact. Two maize populations, TZB and TZPB, were developed during the early days of the IITA program. TZB originated from African and Latin American sources with major contribution from Nigerian Composite B. TZPB is derived from Tuxpeno Planta Borja Cycle 7 from CIMMYT. The two populations were passed on to a Nigerian research institute and released as varieties under the names FARZ 27 (TZPB) and FARZ 34C (TZB). Both varieties have good resistance to tropical rust and lowland blight. They are the most widely grown maize varieties in Nigeria, and a total of 200,000 ha was reported by the National Accelerated Food Production Programme to be under these varieties in 1981.

Apart from maize, IITA genetic material has been incorporated into Nigerian breeding programs for rice, cowpeas, and soybeans. Improved, high-yielding, disease- and pest-resistant varieties of these crops have been widely adopted by farmers. Two IITA cowpea varieties released in 1983 have made a widespread impact within so short a time. These are TVX 3236 and IT 82E-60. TVX 3236 has become popular because of its resistance to thrips, its high-yielding potential, and good cooking quality. It is difficult to estimate the extent of its cultivation, but the variety is now grown on a commercial scale in northern Nigeria. IT 82E-60, on the other hand, has spread widely in the paddy rice area of Niger State and beyond.

Two more examples of a successful provision of biological materials with respect to Nigeria are worth considering. The collaboration of this country and ICRISAT on millet research led to the development of high-yielding and pest- and disease-tolerant varieties of millet for the savannah ecological zone and for the very dry savannah ecological zone. The new varieties have spread from the southern Guinea to the northern Guinea savannah ecological zones, which is a clear indication of the extent of adoption by farmers. In the case of cassava, finally, the collaboration between Nigeria and IITA has resulted in the control of some devastating diseases, namely, the cassava mosaic virus, cassava bacterial blight, and, more recently, the cassava mealy bug and green spider mite. The collaborative activities are said to have saved the nation's cassava industry from extinction.

Nigeria is a good example to demonstrate that a relatively strong NARS is able to capture considerable gains from collaboration with IARCs. The outstanding character of this country, however, clearly has to be seen in the context of most other African NARSs. Typically, most countries in tropical Africa receive a whole range of IARC material such as wheat, maize, sorghum, millet, groundnut, cowpea, pigeon pea, cassava, sweet potato, rice, bean, and potato. Thus, Tanzania can point to a number of different crops that have benefited from germplasm stemming from a number of different IARCs. With respect to cowpeas, large and useful germplasm had come from IITA and recently - after further development in Tanzania - two cowpea varieties called Tumaini (TK-1) and Fahari (TK-5) were released. Similarly, green-grain varieties Nuru and Imara recently released originated as an offshoot of IITA work. Other examples for Tanzania are the provision of cassava varieties from IITA, rice varieties from IRRI and IITA, potato varieties from CIP, and sorghum and groundnut germplasm from ICRISAT. CIAT, finally, is becoming increasingly active in sending bean germplasm to Tanzania.

Altogether there is considerable evidence of abundant - often overwhelming - provision of biological material by IARCs. Table 5.2 gives a quantitative impression of provided materials in the study countries considered.

Table 5.2 Provision of Genetic Materials from IARCs in Selected Countries of Tropical Africa

	Zimbabwe	Malawi	Tanzania	Kenya	Ethiopia	Cameroon	Nigeria	Burkina Faso	Senegal	Tropical Africa(a)
CIAT										
- Bean	X				X					X
- Tropical pasture					X					X
CIMMYT										
- Bread wheat	6	6	12	12	7	5	3	1	2	105
- Durum wheat	1		1	5	9	1	1			28
- Triticale	3	1	4	5	4	2	2	1		44
- Barley	6	1	2	12	6	2	2			49
- Maize	15	1	11	40	2	15	4	12	8	263
CIP										
- Potato		X	X	X	X	X			X	X
ICRISAT										
- Sorghum	6	3	1	3	3	3	10	11	1	78
- Pearl millet	1	1				1	8	3	6	49
- Pigeon pea			2	3	1		3			16
- Chickpea		3	1	1	7					14
- Groundnut	1	1						1		8
IRRI										
- Rice		X	X	X		X	X	X	X	X

X = Material provided, but no quantitative information available.
a) West, Eastern and Southern Africa.

Source : CGIAR Secretariat information.

The big problem, however, is that this intensive collaboration has not yet resulted in broad and successful impacts throughout tropical Africa. International research efforts have had some success which has been cited above; but the centers have not yet made a significant difference in the overall food situation on this continent (CGIAR-News, March 1985).

At the same time it has to be realized that in many cases the collaboration is only just beginning. The material may just undergo a first phase of testing or crossing with local varieties. Burkina Faso is a very typical country in this respect. This country's research system is only just building up and is generally very much influenced by the French research system. The collaboration with ICRISAT and IITA, which are the most relevant IARCs for this country, only dates back to 1978. It is not astonishing, therefore, that several of the center activities or even centers themselves are simply not yet properly assessed or even known in Burkina Faso. The provision of biological material by centers, hence, cannot be expected to really have influenced this country's production up to date.

In many countries of tropical Africa, in fact, only few IARC-influenced varieties have been released to date. This is why one can only guess about future adoption and performance of such varieties. The example of CIMMYT-influenced wheat in Zimbabwe is interesting in two respects: It points to future potentials of a collaboration once begun, but it also points to the necessary time horizon since CIMMYT's involvement in Zimbabwe already dates back to the 1960s.

Particular kinds of collaboration

The provision of biological material can be handled in different ways. The centers may play a passive part and just offer their germplasm, leaving selection, testing and further work to the NARSs. Alternatively, they may actively get involved in this collaboration. In the latter case they help to make appropriate choices among the material offered and to incorporate it into local breeding programs. Both types of collaboration are found in tropical Africa. Their relative merit depends on the strength of NARSs in a particular country. In principle, the countries would like the IARCs to be more actively involved in the provision of biological material, but this becomes less important in the case of a more advanced NARS. Hence, in Zimbabwe an active engagement of IARCs is not seen to be of utmost importance.

In some cases problems arise when particular needs and conditions of a country are not fully appreciated. Thus, on a very detailed and specific request to IITA for rice varieties, an agronomist in Zimbabwe received 80 varieties which, in good faith, he incorporated into detailed observation trials at three sites. The majority of the varieties performed very poorly, and after subsequent correspondence the breeder learned that only 4-6 of the varieties sent actually had the characteristics originally requested.

The positive counter-example is Malawi's collaboration with CIAT. The center continues to respond to the country's requests for bean material in a most specific manner. Thus, the country receives material specified according to request by seed color and size, disease resistance, growth habit and the like. Malawi's progress in bean breeding has been particularly rapid because of the intensive interaction with the center.

In general, countries with a weak NARS depend in their collaboration with the IARS on an active role being taken by the centers. As most NARSs in tropical Africa have to be considered weak, this aspect is particularly important for this continent. The dilemma is that the IARCs do not wish to be seen taking over functions that properly belong to the NARSs, but, at the same time, they do aim for practical success, which may force them to do just that.

Centers are aware of this problem and increasingly decide to go for active involvement in the provision of biological material in tropical Africa. This can mean a regional orientation of IARC activities. An early example in this respect is the ICRISAT involvement in semiarid West Africa. In Burkina Faso, e.g., this IARC is represented at several research stations. Recent activities of this center relate to groundnut, sorghum and millet in southern Africa, but practically all centers, within their mandates, get more involved in regional activities. They, thereby, often substitute for the deficient national activities. Malawi and IITA again provide an example for successful country collaboration in the case of cassava. After contact between IITA and the Malawi Government, the NARS was persuaded to start a research program on this important smallholder crop. A member of the staff was sent to IITA for a "Root and Tuber Production" course in 1978. The breeder admits that he went with no ideas about these crops and returned dedicated to them. He was encouraged by IITA staff to first start a collection of local varieties of cassava and sweet potatoes. This collection has identified some very good local lines of cassava, which have been released to farmers and successfully adopted.

The program has been thoroughly supported by IITA. Training has been provided for technical staff involved in the program, and the center runs regional workshops every two years to enable the research personnel in various countries to interact. The breeder has been regularly encouraged by various meetings, symposia, and the workshops. Most impressive is a program that the researcher has recently undertaken to encourage a local milling company to purchase cassava and to support a milling and marketing experiment of this local food stuff. The research worker claims that the close collaboration and support of IITA has boosted his own confidence and been instrumental in developing his keen interest and motivation in this crop.

This example not only demonstrates a center's active role within a country in the provision of biological material, but also points to the importance of providing a research package. Thus, in addition to the active role in specifying and providing the genetic material, the center also gets involved in "downstream activities" to ensure success. This may well be the "condition sine qua non" to achieve impact in tropical Africa. If such kind of activities were not provided one would need to at least ensure that this gap was filled by other kinds of development aid.

Suitability of the material

A crucial aspect of the collaboration between IAR and NAR relates to the suitability of the material provided. Obviously, suitable germplasm is a prerequisite for any impact whether centers actively or passively engage in transfering their material. Suitability of biological material comprises three aspects: The suitability of varieties to

- specific agro-ecological zones,
- local research programs, and
- local consumer preferences.

The suitability of biological material is a most crucial problem in tropical Africa, since in all three respects mentioned the continent is very heterogeneous. As a consequence, the more global view of the role of IARCs is likely to yield unsatisfactory results.

Agro-ecological suitability

Wide adaptability of varieties has been the classical concept for IAR, which almost by necessity has raised problems in tropical Africa. Many of the varieties successful in other continents simply are not appropriate for the agro-biological zones in this continent. The sustained successes in Asian agriculture based on the development of semidwarf rice and wheat, indeed, have very limited transferability to Africa. Another typical example relates to ICRISAT. This center, in mid 1975, launched a West Africa program to increase sorghum and millet yields and yield stability. The center imported improved varieties because it was assumed that imported material would diversify the genetic stock in West Africa and speed up the process to the needs of smallholders (Eicher, 1984). Due to various reasons, these varieties have been relatively unsuccessful at the farmer's level. Moreover, "... the improved sorghum and millet varieties which have experienced relatively more success are improved locals derived from West African genetic stock" (Matlon, 1983). The dimension of this failure may be illustrated by the case of Burkina Faso. In this country, more than 5,000 sorghum varieties have been introduced and tested in the last years. Almost all of these varieties have not been adopted, and, in 1985, only three varieties show promising results after farm level trials. Even these varieties are just at the beginning of adoption. Concerning millet, the situation is even worse. More than 2,000 varieties have been tested, but none has been successful. However, some crossings between imported and local varieties seem to be promising for future adoption. Clearly, this example illustrates the restrictions to a mere transfer of biological material to tropical Africa.

The restriction even holds for the different regions of the continent. When WARDA was established, it was assumed that IRRI's high-yielding - irrigated - rice varieties could be imported by IITA and WARDA and screened through variety trials carried out by WARDA in member states (Eicher, 1984). It also was assumed that IRAT's research on rainfed rice at Bouake, Ivory Coast, would produce improved varieties for WARDA and national programs. But, after seven years of trials with 4,000 imported mangrove swamp types, WARDA found that only two yielded as well as the best local ones.

Although some of IRRI's irrigated rice varieties performed under farm level conditions in West Africa, rainfed rice accounts for 95 percent and irrigated only 5 percent of the area under rice cultivation in West Africa. Because of this disappointing experience with the direct importation of new rice varieties from IRRI, WARDA launched special research projects in the mid 1970s in Liberia, Sierra Leone, Mali, Senegal and Cote d'Ivoire.

Other examples relate to cowpeas and maize. Kenya has received cowpea material from IITA, but the types reported to mature in 60 days took more than 70 days while local varieties mature in 65 days. Given the rainfall variability and the consequent importance of this characteristic, the IITA cowpea varieties are not widely adapted to the local conditions. Moreover, the screening for insect resistance is continuing for incorporation into local varieties.

Ethiopia received several maize varieties from CIMMYT with high expectations. But when the materials were tried under Ethiopian conditions they usually had to be discarded due to disease susceptability and poor agronomic performance. The researchers interviewed in Ethiopia felt that CIMMYT scientists did not seem to have full grasp of the specific agro-ecological and agro-climatic conditions of Ethiopia, probably due to the misconception that the Ethiopian highlands were similar to the Latin American Andes regions. The Ethiopian scientists were concerned that the segregated population of materials at CIMMYT were usually considered as universal materials and that the center scientists did not give due attention to national breeders to encourage more research on the indigenous materials. Consequently, national materials have not been used as a check or control with exogenous materials while their control characteristics are not properly standardized. The potential of the Ethiopian sorghum varieties identified through the Ethiopian Sorghum Improvement Project was given as an example.

In IARCs it is increasingly recognized that research programs must address the specific constraints for a multitude of areas with diverse ecologies. Not only does research need to deal with great diversity in Africa, it also must attempt this in the face of a severe lack of background knowledge of the main food crops of Africa. Many important food crops have received little research attention in the industrialized world - cassava, sweet potato, yam, cowpea, pearl millet and plantain - and, hence, there was little basic knowledge of their genetics and physiology when the CG system scientists began to study them systematically.

Suitability for national programs

Even more important than the agro-ecological suitability of provided materials is the suitability of varieties for local research programs. Some problems have been encountered in tropical Africa. The classical example is CIMMYT's maize involvement in eastern and southern Africa. Traditionally, the countries in these regions and in particular Zimbabwe, have had rather strong research programs with emphasis on hybrids. If research impacts on agricultural production in tropical Africa are worth citing at all, it is the case of maize in these regions. The most significant achievement undoubtedly was the release of the 150 day hybrid SF 52 in 1960 in

Zimbabwe. This variety has been largely responsible for the spectacular maize yields achieved in Zimbabwe over the past 25 years. To quote Eicher: "SR 52 is undoubtedly the Green Revolution success story in southern Africa." (1984, p. 10)

CIMMYT's impact on maize breeding in eastern and southern Africa has been rather limited. The center's breeding program has tended to concentrate on open pollinated varieties and to select for wide regional adaptability whereas emphasis in several national programs was more or less on hybrids for specific regions. It is beyond this study to discuss and evaluate the appropriateness of these different approaches; the divergences, however, have to be clearly seen. As a consequence and with respect to Zimbabwe, CIMMYT did not have a program that caters for the conditions found in this country's High Veld region. For this reason, much of CIMMYT's material has been inappropriate to the national maize breeding program.

Malawi's situation shows similarities. The national hybrid program is continuing using local and promising South African lines plus some American material obtained from Zimbabwe. The current objectives are to produce shorter season varieties. Some material from CIMMYT is included in this program, but the breeder feels that CIMMYT's concentration on open pollinated varieties means that the center does not have material suited to Malawi's hybrid program. Consequently, efforts are directed at evaluating material supplied by IITA. Some lines are indeed considered to be promising, especially those varieties developed in Nigeria for streak virus resistance. In Kenya, too, maize research programs have emphasized hybrid rather than open pollinated varieties which are emphasized by CIMMYT.

There are other examples to illustrate the issue. Zimbabwe has had its own sorghum breeding program for a number of years. The program has concentrated on high yield, short season, red sorghum varieties suitable for breeding. This very specific and narrow breeding objective meant that the available material from ICRISAT is largely unsuitable as it tends to be white and - according to local tests - does not match the yield achieved by the local standards.

Kenya has one of the most advanced potato research programs among African countries. There is a rather close collaboration with CIP, which has excellent local facilities for teaching and germplasm preservation as the center's African regional program is based in Nairobi. The exchange of germplasm and breeding material has been achieved. However, the national program is used to vegetative propagation while CIP seems more interested in true seed propagation.

With respect to pasture legume germplasm, ILCA has recently established a large collection in Malawi. Local researchers feel that at the present time their contribution of material to ILCA has been more beneficial to the center than the possible benefits they may obtain in the future. Their research program sets different emphases, and the value of germplasm selection in the Ethiopian highlands for a tropical lowland country like Malawi is seriously questioned.

Suitability for consumers

The third and final aspect is the suitability of varieties provided by IARCs to local consumer preferences. Consumer preferences and needs are essential for the successful adoption of materials provided. In Zimbabwe, the potato market has developed a preference for smooth skinned, regular shaped, white fleshed potatoes. CIP provided true potato seed from its Peru headquarters in the varieties. Most were rejected on the basis of flesh colour and tuber shape. In 1981 material was received from Kenya. Again, most of the material was considered unsuitable, but four of these CIP varieties have been identified as useful future breeding material and retained because of their reported resistance to late blight, despite the unsuitability of their shape.

Other examples in Zimbabwe relate to sweet potatoes and pigeon peas. In 1981, sweet potato varieties were received from IITA. Many of these varieties were rejected because of the unsuitability to local consumer preferences. The local varieties generally have red skins with white to slightly yellow flesh. A number of IITA varieties had dark maroon skins and pink flesh or were very yellow. IITA also provided a number of pigeon pea varieties. However, the crop has not been traditionally grown in Zimbabwe, and it is doubtful that it will be incorporated into local food preference patterns. Problems with pigeon peas also exist in Kenya. Many of the varieties provided by ICRISAT are too small. In India, such pigeon peas are ground before they are consumed, but in Kenya preference is for bigger grains that are cooked whole.

In Nigeria, the major limitation to the adoption of the IAR sorghum package appears to be the unacceptable food quality of its seeds even though the package provides very high-yield varieties. In the case of maize, although the new varieties released are high-yielding, their seeds are too hard for ordinary eating. Their production is undertaken on large-scale dimensions but mainly for industrial use. Peasant smallholder farmers still prefer the soft-testa, white and sweet varieties. Another example is rice for which consumers prefer the friable and loose grain varieties to the soft and clodding IRRI varieties. Research should, therefore, endeavor to develop varieties that not only satisfy such characteristics as high yield and disease resistance, but also the eating preferences of consumers.

An outstanding example for the role of local consumer preferences can be seen from IRRI's provision of material to Malawi's breeding program. Malawi has been a fairly big rice exporter to Zimbabwe and South Africa for a number of years. This export orientation requires that Malawi continues to produce the same long grained rice quality for its customers. The IRRI varieties received were all short grained, chalky and, therefore, totally unsuited to the objectives of the national program. It is only recently that through communication and interaction between the center and Malawi this state of affairs could be corrected. In collaboration with IITA, IRRI prepared a special nursery containing suitable material selected for Malawian conditions. In just one season of this improved collaboration, Malawian researchers have managed to identify 10 varieties which may be useful. These are medium grained varieties and they have been sent for market preference testing.

What is the lesson to be learned from this "suitability" discussion? Obviously, the suitability of the biological material provided is a key issue for the collaboration between IAR and NAR. Suitability comprises several aspects like agro-ecological environments, local research programs and local consumer preferences, but all these problems can be solved if the centers do not follow a top-down approach in their collaboration with NARSs, but rather a cooperative, bottom-up kind of relationship. There has to be awareness of local particularities in the centers, and this awareness can only be achieved through communication and interaction with NARSs. This cooperation must take place in a regular, long-term manner to avoid divergencies and to improve the allocation of research resources. The centers obviously have learned this lesson over the years. They increasingly get engaged in very specific interaction with NARS. The recent emphasis on regional research programs in tropical Africa certainly is but an indicator of the efforts made to ensure suitability of biological material provided.

5.3 Non-Biological Impact Areas

The collaboration between the CG system and NAR comprises several aspects other than the provision and development of biological material. Such aspects include farming systems research (FSR), policy-oriented research, research organization, but also the provision of techniques and ideas by the centers.

Techniques and research procedures

It is generally acknowledged that IARCs provide a broad range of techniques, ideas, or approaches and procedures that may be beneficial for NAR activities and enhance their efficiency. The importance of this kind of impact, of course, depends on the strength of NARSs. Hence, the impact may not be so great in Zimbabwe with a strong research system, but can be expected to be very relevant for tropical Africa as a whole, given the generally low level of NARSs on this continent.

Researchers in Tanzania have given some illustrative examples. CIAT, e.g., developed a rapid technique for multiplication of cassava to provide large quantities of planting material for this vegetatively propagated crop. IITA has given a description and evaluation of major cassava diseases in Africa which is proving to be very useful to those working on cassava diseases and on the identification and evaluation of resistance. Generally, a number of techniques for evaluating the resistance to major diseases and pests of major crops handled by individual centers have been developed. Examples are the mass rearing of leafhoppers and maize borers for artificial infestations of maize in screening for resistance to streak and maize borers and techniques to identify durable resistance to blast which have worldwide utility. In Zimbabwe, possibly the biggest impact of new research techniques has come from disease scoring techniques used by the IARCs (sorghum, groundnuts and especially cowpeas and cassava).

It is a particular feature that the IARCs provide research techniques and ideas adapted for food crops where NARSs usually have no or only limited research experience. Hence, this kind of collaboration often sets the starting-point for national research activities. The Malawian cassava example cited above is a point in case. IITA provided the know-how to the local scientist and, thus, successfully started a national cassava program. It must be mentioned, on the other hand, that such an ideal downstream transfer of research techniques is often restricted. Techniques and procedures used in IARCs may be unsuitable in NARSs due to lack of resources and material and, most importantly, due to a lack of trained personnel. Unfortunately, several useful techniques and methods can often not be implemented because of the lack of suitably trained research personnel.

A genuine and important feature of IARCs is the provison of improved machinery and production techniques (Anderson, J.R. et al., 1985, hapter 18). Concerning IITA in tropical Africa, the most striking developments have been related to minimum or zero tillage and to crop harvesting. In appropriate areas, the technical advantages of minimum tillage cropping for erosion control and maintenance or improvement of soil structure, fertility and moisture availability, have been shown to be high compared to conventional tillage practices. However, the establishment of such systems requires a drastic change of farming practices as well as heavy investment, and adoption of the systems on farms has been limited and slow. The introduction of a "rolling injection planter" will hopefully increase adoption of minimum tillage cropping in the future.

Centers, too, have had some limited impact in the technical area. Wheeled tool carriers of the types sponsored by ICRISAT are being tried in Niger and Mali and other countries of West Africa under bilateral assistance programs. Part of the work of ILCA is concerned with draught animals, including crossbreeding, and their more efficient utilization. Studies on the matching of implements to pairs of animals, and alternative harnessing to permit use of single animals instead of pairs, are of too recent origin to have yet had any significant impact. Work to improve the local country plough and make it more suitable for single animal use is likely, however, to be directly of use in the local area.

Despite these examples, the proportion of CG effort allocated to agricultural engineering has been rather low. Furthermore, technical information from the centers has not always been presented in a suitable form and, in some cases, has been either poorly understood or poorly applied. An additional problem is that in most of the developing countries the national institutions and extension services concerned with agricultural engineering are weak. Hence, technical progress due to center activities, is not an impact area to be emphasized, but rather an interesting by-product with limited success up to the present.

Farming Systems Research (FSR)

FSR is of growing importance for tropical Africa. The idea is to investigate into the appropriateness of new technologies at the farmers' level. During the past five years a large number of FSR teams have been set up all over Africa with finance and technical assistance from external donors (Spencer, 1985, p. 28). Also, national research programs are being urged and assisted to launch FSR, meaning on-farm research efforts. In Zimbabwe, e.g., the

Department of Research and Specialist Services decided in 1982 to set up a separate FSR unit directly responsible to the deputy director. The international arrangement was chosen to make the FSR unit truly interdisciplinary and especially to bring together crop and livestock considerations. Table 5.3 gives an impression of the present extent of FSR in eastern and southern Africa.

In general, there are some strong and divergent views on the usefulness of FSR. As far as FSR is oriented to the participation of peasant producers and the adoption of farm-based technologies, its relevance is widely acknowledged. "Given the lack of adequate recognition of small farmers' constraints in the past, this effort will bring to the attention of researchers and policy makers alike the true problems faced by farmers. It will also highlight the fact that we have no ready solutions to many problems, i.e. that there is limited technology on the shelf ready to be modified to suit farmers' needs" (Spencer, 1985).

Positive aspects of FSR are, in addition, its orientation towards small-scale farming, which has historically been neglected in NAR, and its motivation effect on researchers and extension workers. Many people argue that the interaction with peasant producers has created a new awareness of the problems at the farm level and highlighted the importance of developing relevant farmer-based technologies. In turn, this motivates research workers and gives them a sense of purpose in their work. Moreover, the farmers' confidence in the extension workers and in their advice is improved through the closer contact that develops in the course of FSR work.

A critical question often directed at FSR concerns its potential guidance function, its function to set research priorities. Such a guidance function is often rejected by researchers in the biological sciences. One breeder in Zimbabwe stated that he did not need an economist to tell him what the farmer's problems were and what varieties he should be breeding to overcome these problems. In many cases this may be so. In most cases, however, it seems safe to assume that a close collaboration between natural scientists and economists enhances the chances of success of both the breeding work and the FSR. In this context, Spencer is worried that FSR may not be able at all to move beyond the recognition-level of the farmers' level due to institutional shortcomings. He argues that many FSR teams do not have the means or capacity to do more fundamental research of the type necessary to move agriculture forward in tropical Africa.

> "What is needed in the short run is the attachment of small farming systems teams to experiment stations to ensure that all research is conducted with a farming systems perspective, rather than the current fad of setting up independent departments and teams which roam over the countryside conducting wide ranging, but unfocused research with non-existent or completely inadequate components" (Spencer, 1985).

FSR marks a central aspect of the collaboration between the CG system and NARSs in tropical Africa. ILCA's research mandate directly reflects the FSR philosophy. Other centers, too, have favored this approach as particularly relevant for tropical Africa. Thus, IITA launched a whole series of FSR

Table 5.3 Status of Farming Systems Research in East and South Africa [a)]

Country	Level of farming systems research activity	Institutionalization of farming systems research	Training programs in farming systems research
Angola	nil	no	no
Botswana	4 projects	weak	very limited
Ethiopia	4 teams	yes	yes [b)]
Kenya	10 teams	yes	yes [c)]
Lesotho	1 project	no?	no?
Malawi	1 project	yes	yes [c)]
	3 teams		
Mozambique	very limited	no	no
Somalia	1 project	no	no?
Sudan	3 projects	in process	yes
Swaziland	1 project	not yet	no?
Tanzania	1 project	yes	yes [d)]
	4 teams		
Uganda	2 projects [e)]	no	no
Zambia	7 teams	yes	yes?
Zimbabwe	1 unit	yes	yes
	2 sites		

[a)] Incomplete summary.
[b)] With help from CIMMYT and ILCA.
[c)] With help from CIMMYT.
[d)] Guidance from CIMMYT.
[e)] No social science components.

Source : Anderson, J.R., et al., (1985), Global Report on the Impact of IAR, Draft, Washington, p. 32.

activities in its earlier years. Even more important is that IARCs often initiated national FSR activities. This is certainly true for ICRISAT in the Sahel. In Eastern and Southern Africa this development is closely related to the name of Mike Collinson from CIMMYT. Taking Zimbabwe as an example, e.g., Collinson came to the country immediately after independence in 1980 and ran a demonstration exercise of the FSR cycle for staff from the extension service. A study taken in a small-scale farming area was one of the first detailed systems evaluations of the peasant farming sector. The amount of useful data generated, coupled with its rapidity and low cost, impressed all involved. Without doubt, this initiative set the stage for a rapid spread of the FSR idea in Zimbabwe which resulted in the establishment of a special FSR unit in the Department of Research and Specialist Services. Altogether one can note a generalized interest and a great deal of activity along the lines of FSR in tropical Africa and most of this - albeit not all - can be traced back to the IARS.

Policy research

Another impact area concerns policy research. The analysis of agricultural and food policies is IFPRI's preoccupation by mandate, but, certainly other centers also have to face and deal with policy questions in one way or another. Thus ILCA has institutionalized this by forming a livestock policy unit. Policy issues are a matter of increasing concern and interest particularly in tropical Africa. It is generally thought that Africa's food crisis is largely homemade and manmade, a consequence of policies biased against agriculture. There is growing awareness among donors that attention should be paid to macro policy issues (Eicher, 1984). For example, the World Food Council has urged African states to prepare food strategies. Today, 32 of the 50 countries implementing national food strategies in the world are African nations. Donors are also pressing for policy dialogue and policy reform as a precondition for aid. For example, Edgard Pisani recently stated that because the project approach was failing to increase food production in Africa the EC was going to finance "policies", - hence the term policy dialogue.

Policy research should not only be helpful in formulating appropriate food policies but also bear on the identification of research priorities and on research planning. However, it has to be realized, that the establishment of appropriate food policies is often not a matter of intellectual insight, but of political will and feasibility. Strong social and political constraints, influence, e.g., price policies to the benefit of consumers and to the detriment of farmers. Then, policies may have to be conceptualized as second- or third-best solutions, but this can become a rather complex task that is beyond the planning capacities of national systems. Policy studies from the IARCs can then be particularly useful in terms of insight. In addition, outside advice from highly acknowledged institutions may help to overcome internal restrictions to policy changes. In comparison to the World Bank or the IMF, immediate implementation of center policy recommendation may be limited due to the absence of any coercion. However, this need not always be a disadvantage as the neutrality and credibility of a research institution may lead to voluntary policy changes and more sustained success in the long run.

Spencer (1985, p. 26) stresses the importance of appropriate empirical information for policy studies. Data are needed not only on the consumption patterns of urban households, but also on that of rural households, in order to identify the numbers and locations of poor and malnourished members of society who should be the target of food policies, and to determine aggregate demand parameters in order to be able to trace the effects of various price and income policies. Data are needed on farming systems in order to understand the characteristics of production systems in terms of seasonality of supply, dispersion of production, the decision making environment of the farms and the potential sources of technological change. Data are also needed on markets and marketing institutions, i.e., on the storage, processing and transportation of agricultural commodities, on the exchange functions and on price formation. Spencer emphasizes that there is not one country in tropical Africa with a sufficient data base to allow effective and comprehensive agricultural policy analysis.

IFPRI is widely acknowledged for the quality of its staff. Some of the respondents interviewed claimed that IFPRI possibly produced the most professional studies of any IARC. Its advice is esteemed in designing and implementing national agricultural policies. On the other hand, it is obvious that immediate and visible impacts will hardly occur from IFPRI's activities. This is seen as the crucial disadvantage of policy research by some people who also point to the fact that a close collaboration with national researchers is essential for success in the policy area. A good number of interviewees did not know much, if anything, of IFPRI's work, which is understandable, as many of them are working in the natural sciences. On the other hand, it underlines the fact that the relevance of policy research is still underestimated, and IARCs could do more to generally stress the importance of this research area. The exemplary information work by IFPRI is certainly acknowledged in this respect.

Research organization

There is general agreement that the level of agricultural research in tropical Africa, with some exceptions, is low. This is partly due to the lack of agricultural research capacities but also to inefficiencies. Hence, the organization of NAR is a key issue in tropical Africa. In this respect, the role of ISNAR is of particular relevance.

As resources in NARSs usually are severely limited, the countries heavily depend on external help for research organization. Moreover, many NARSs in tropical Africa are in a period of reorientation. They have been oriented towards large-scale farming and commercial crops, particularly for export, and now try to move more into research for smallholders. The new emphasis for research in communal areas of Zimbabwe is a typical example for this reorientation. Malawi is another example for a NARS in transition. Research efforts have been rather uncoordinated and accidental in the past, resulting in an inefficient use of resources. The scope for a reorganized NARS is a comprehensive and cohesive organization for planning, promotion and execution of research including the setting of priorities. The establishment of an Agricultural Research Council is a first tangible product on this path.

ISNAR has been influential in bringing about organizational change for NARSs in tropical Africa. In Zimbabwe, the center has recently completed a study on the training needs of the Department of Research and Specialist Services. This report is still in its draft final stage, but is considered a very significant contribution to the future organizational development of the department. In Kenya, the ISNAR/KNST report of 1982 raised some important issues concerning research management and whether research should continue to be under the Scientific Research Division of the Ministry of Agriculture and Livestock Development or be elevated to a Department of Research in the same Ministry or to a parastatal. The research management issues are being addressed by another ISNAR mission which visited Kenya recently. Up to now, several countries, of course, have had only limited contact with ISNAR, one example is Tanzania. It is also an example of a country that is looking forward to technical assistance from ISNAR to tackle problems of program planning, policy formulation and research organization and management. It should be mentioned, in addition, that the ISNAR workshop on research management run in Tanzania is considered and has been cited by several researchers as being one of the most successful workshops of this kind.

ISNAR is active in the field of research organization by its very mandate, but other centers also get engaged in this area. In fact, the organizational structure of IARCs in itself is a guiding example for NARSs, and the collaboration between the CG system and NARSs in general offers incentives for increased efficiency in NARSs. Thus, ILCA's livestock FSR certainly sets the stage for Zimbabwe's organization of livestock research in national areas.

Due to the political sensibility of research reorganizations, not all of the centers' activities and recommendations are welcome, and sometimes misunderstandings arise. A typical example is ISNAR's engagement in Malawi. The reorganization of the NARS in this country has involved ISNAR, but the results of the center's interaction with the Department of Agricultural Research have been unsatisfactory from Malawi's viewpoint. The draft final report produced by ISNAR was rejected. The department had expected a much more detailed report that would make suggestions about how it should change its organizational structure. ISNAR proposed to undertake an additional study, but the department finally rejected this. The whole exercise appears to have generated a fair amount of tension between the department and ISNAR. Anyhow, the ISNAR report is a very good summary of the Malawian NARS and a number of its suggestions have been incorporated in the planned reorganization of the department. Hence, the current impasse seems to be a result of an unfortunate lack of communication by both ISNAR and the Department of Agricultural Research. This is, in fact, what the example could demonstrate: The key to a center's success in influencing NARSs is close cooperation and communication with plenty of feedback possibilities.

5.4 Enhancement of Human Capital

The lack of experienced personnel is generally seen as a principal explanation for insufficiencies of NAR in tropical Africa. The enhancement of human capital in NARSs is a central aspect for the collaboration between IAR and NAR. The capability of NARSs to exploit and use centers' research results at the national level has to be improved. The IARCs are intensively engaged in human capital building by offering training possibilities for NAR personnel and providing widespread information material.

Training

Training is, in fact, considered as the currently most important IARC activity for tropical Africa by most of the persons interviewed. This reflects the general poor state of professional training on this continent, as well as the inability to improve the situation on its own. Hence, through training, centers fill, or at least reduce, an essential gap for achieving research impacts on agricultural production in tropical Africa.

The importance of CG system training activities for tropical Africa can clearly be visualized by some figures. In Table 5.4 the number of individuals from different regions participating in center group courses.

Table 5.4 Number of Persons from Different Regions Participating in Group Courses Held by CGIAR Centers(a)

Center	Years	Number of participants from: Tropical Africa	Near East/ North Africa	Asia	Latin America	Industrial Countries	All Countries	Average number per year recently
CIAT	1968-84	3	2	52	984	0	1041	90
CIMMYT	1966-82	251	286	278	449	34	1298	130
CIP	1978-83b)	415	209	772	448	6	1850	540
IBPGR	1973-82	23	39	246	62	26	396	130
ICARDA	1978-83	1	244	22	0	2	269	40
ICRISAT	1974-82	355	4	202	13	7	581	90
IITA	1970-83	1905	5	74	44	51	2079	500
ILCA	1975-83	1500	0	0	0	0	1500	110
ILRAD	1972-82c)	339	0	32	7	63	441	25
IRRI	1962-82	68	7	1678	15	12	1780	240
ISNAR	1981-83	307	11	97	121	0	536	180
WARDA	1973-84	1081	0	0	0	0	1081	120
TOTAL		6248	807	3453	2143	201	12852	2195

a) IFPRI does not run formal courses.
b) Data include participants attending courses conducted by CIP regional staff in 32 countries.
c) Data include 45 persons who are degree canditates or postdoctoral fellows.

Source : Anderson, J.R. et al., Global Report on the Impact of IAR, Draft, Washington 1985, Chapter 10.

The table reveals that an overwhelming number of these people have come from tropical Africa. As compared to other developing country regions, this continent very much depends on the training offers by IARCs. From all the centers considered, IITA has trained most individuals, more than 90 percent of which have come from tropical Africa. This underlines that a considerable amount of resources has been devoted to training. Tropical Africa cannot be properly judged without emphasizing their training activities.

Apart from group training, centers typically offer a broad range of additional training possibilities. For tropical Africa the possibility to conduct research at IARCs that could be used towards advanced degree requirements has been of particular importance. The number of such individuals from different regions is listed in Table 5.5.

Table 5.5 Number of Persons from Different Regions Conducting Research at CGIAR Centers That Was Used toward Advanced Degree Requirements a)

		Number of participants from						
Center	Years	Tropical Africa	Near East/ North Africa	Asia	Latin America	Industrial Countries	All Countries	Average number b) per year recently
CIAT	1968-84	9	0	4	130	58	201	25
CIMMYT	1966-82	19	18	9	26	20	92	35
CIP	1978-83	0	4	5	67	3	79	10
IBPGR	1973-82	13	12	20	5	4	54	10
ICARDA	1978-83	0	13	2	0	5	20	10
ICRISAT	1974-82	20	0	71	4	21	116	30
IITA	1970-83	172	0	7	2	81	262	65
ILRAD	1972-82c)	28	0	0	0	5	33	15
IRRI	1962-82	10	0	492	13	30	545	150
WARDA	1973-84	47	0	0	0	0	47	20
TOTAL		318	47	610	247	227	1449	370

a) In most centers, M.S. and Ph.D. scholars are included.
b) Number in residence at the center during the year. Progress typically takes 3 to 5 years to complete.
c) Total number at both levels for all regions is 33 allocated as they were distributed in 1983.

Source: Anderson, J.R. et al., Global Report on the Impact of IAR. Draft, Washington 1985, Chapter 10.

The high degree of participants from tropical Africa is obvious, and, again, the particular importance of IITA is emphasized.

Tables 5.4 and 5.5 point to the educational function of IARCs in tropical Africa. National facilities for higher education are rather limited on this continent. IARCs try to fill this gap and, thus, contribute to create and enhance national research capacities. The medium and long-term benefits of this engagement clearly have to be seen.

As compared to NAR in other developing regions, NAR in tropical Africa has to be considered as particularly weak. This did not only result in enhanced center training activities on this continent, but also in a bias towards more basic training. Annex Tables 5.1 and 5.2 present the number of persons participting in individual research or postdoctoral training programs at CGIAR centers. These kinds of training are suited for advanced researchers who want to specialize in particular fields. Though many persons from tropical Africa participated in these programs, it is obvious that their relative share is far lower as the share of African people taking part in more basic training programs. The implications of these facts have to be seen. IARCs cannot rely on NARSs in tropical Africa to exploit and use research results due to non-existing capacities. Instead, centers help to create such capacities themselves. As compared to other regions, therefore, tropical Africa is just beginning to be able to respond to center research results and the centers actively help them to do so. In assessing IAR impacts such different time horizons have to be seen.

There is no disagreement on the vital role of coherent and continued training for NARSs. In addition, to enhancing the basic capability of NAR, training also constitutes a personal incentive and thereby contributes to the overall motivation which is often lacking in NARSs. Several aspects of the beneficial role of center training are emphasized. First of all, training possibilities at the centers offer a solid professional education for relatively young research personnel. Given the staff structure, which is often characterized by a majority of newly recruited researchers with little experience, this is most important for NARSs. At the same time the NARSs, due to their evolution, have little emphasis on fields like food crops and small-scale farming. Hence, there is little knowledge available for a reorientation of research programs. Thus, reorganization is heavily dependent on training facilities at the IARCs. This offers the opportunity of a quick integration of new research fields into the NARS.

There are several examples to illustrate the argument. One is the above-cited case of cassava research initiated by the training of an agronomist at IITA in 1978. There have been similar experiences in that country with sorghum, millet, wheat, and groundnuts. A sorghum breeder claims that a sorghum improvement course and a workshop he attended at ICRISAT converted him from a maize breeder to a dedicated sorghum and millet researcher. Equally, the change of emphasis in Malawi's wheat research to irrigated crops rapidly achieved results because of the good training that staff had received at CIMMYT. In the case of groundnuts, a breeder successfully attended an ICRISAT course and is currently running a complete program on pest evaluation. This has meant a significant improvement of the national research program for this crop.

Even for strong NARSs like that one in Zimbabwe, IARC training courses offer the opportunity of quickly enhancing human capital and entering into new and so far neglected research fields. Thus, research on cowpea, cassava, rice, small ruminants and intercropping was entirely new for Zimbabwe and no experience existed in these new fields. The opportunity for newly recruited researchers to spend time at an IARC, specializing in these research topics, has been a means of quickly training them in the appropriate techniques and procedures required and to add new research fields to the national program.

Several courses have been singled out as particularly good examples of the beneficial impact of IARC training programs: Wheat breeding and pathology courses offered by CIMMYT, groundnuts and sorghum production courses offered by ICRISAT, root and tuber crop and rice production courses offered by IITA, and the animal nutrition course offered by ILCA.

Several other positive aspects of IARC training courses are often mentioned. First, it is acknowledged that most of the courses offered are very useful in complementing national education. When a recent graduate or diplomate gets an appointment in a NARS, he is expected to rapidly adapt to a specific and often very narrow aspect of agricultural research. In these cases, the specific courses offered by the IARCs are ideal for preparation. Secondly, the existence of different levels of courses is positively noted. IARCs do not only offer training for researchers, but also for technical research personnel. This, in general, cannot be provided in a similar professional way by NARSs either.

While the general assessment of IARC training is positive, some critical comments may also be worth mentioning. A first criticism relates to the contents of courses which sometimes are too general and not differentiated enough, according to the background of the participants. Some interviewees had found the course material too broad and general, and too basic. The level of training seemed to be pitched at the least educated and experienced member of the course.

A second criticism concerns the length of the courses and their timing. For example, a 9 month course at CIMMYT can result in staff of a NARS effectively missing two full seasons of work. It was told that if more attention was paid at IARCs to tailor the course work to the participants' requirements, interests and abilities, they could be shorter, more useful, and overall more effective.

Another aspect is a seeming lack of follow-up of trainees. The IARCs appear to make no attempt to follow up the trainees who pass through their training programs. It is felt that continued contact and possibly additional support would make the training more effective. As an exception to this criticism regional programs are mentioned, where a continued close contact with IARC staff is maintained. Thus, the crucial importance of sustained cooperation and communication in the collaboration between IAR and NAR becomes obvious for training as well. Training should therefore be considered as an integral part of the global research network.

A final criticism relates to the lack of graduate training support. The IARCs have been developed on the assumption that a "critical mass" of scientists is essential to assure effective research work. The centers represent a concentration of experienced and professional scientists in an area where postgraduate researchers and university programs in developing countries are struggling to find suitably qualified supervisors and lecturers. It is felt that this educational potential of IARCs could and should be used for graduate training. In this respect it is encouraging to note that the ICRISAT regional sorghum and millet program being set up in Zimbabwe has built into it a provision for senior staff to supervise and offer support to postgraduate students working on small grains in the SADCC region.

The graduate training of students in developed countries currently practiced is a poor surrogate for a potential engagement of IARCs in this field. The following observations from Malawi on recently returned graduates are worth noting. At the existing salary level the graduates and doctors returning to Malawi get less money than they usually received as students abroad. Further, they now experience in Malawi an extreme shortage of research funds in comparison with the situation they have been used to before. These factors combine to produce serious frustrations. As a result, some interviewees suggest that the IARCs should expand their program of support for postgraduate training. Undertaking research work in their own countries with supervision from regional staff of the IARCs would be much more practical and useful than spending three years in an advanced industrial country under conditions which are generally atypical. For example, it seems obvious that a maize breeder would benefit more from working at either CIMMYT or IITA than in the corn belt of a country whose agriculture is as advanced as in the U.S.A.

Information

Apart from training, IARCs devote considerable resources to information activities, which also serve the purpose of enhancing human capital and personal incentives in NARSs. The information activities of IARCs in tropical Africa are generally praised. This refers to the provision of newsletters and other kinds of periodic materials but also to the supply of specific documents on request. In this respect, ILCA's selective information dissemination system has to be mentioned. This is a particularly useful service for NARSs as many of them have a very limited budget for acquiring publications. Many of the important journals are not kept by NARSs, and those that are take considerable time to circulate among all staff interested. Hence, ILCA's computer-based system is very beneficial as it provides subscribers according to their research profile with abstracts of research papers based on key word analysis of documents. Furthermore, the rapid staff turnover experienced in the past has meant that new researchers are unaware of research that was undertaken previously in their own country. Through ILCA's country surveys of livestock literature (published and unpublished) such a shortcoming can be overcome. Another example often mentioned as an excellent information activity is IRRI's "responsive library service".

There were some minor criticisms on the flow of literature and publications from IARCs. Some researchers claimed that they did not receive IARCs' publications because only a few copies were sent and they were not circulated to relevant staff. This can often be explained by the fact that commodity researchers are based at out-stations while materials are being sent to the main station. Of course, such failures are up to the NARSs themselves to be corrected, but given the usefulness of the centers' publications, there appears to be need for the IARCs to find out more about the final distribution. This again touches on the central issue of sustained communication between IARCs and NARSs.

In Burkina Faso, some criticism was related to the presentation of center information, which sometimes was said to rather reflect an IARC's self-promotion than the intention to inform national researchers. The dominance of the English language was criticized, too, which prevents a more widespread use of IAR results. It was suggested, furthermore, that centers should not only present results, but more actively try to demonstrate how these results could be used in NARSs.

In general, however, there are few complaints of local researchers about the communication with centers. It is acknowledged that IARCs actively try to improve contacts and information flow and it is emphasized that this is really a key element in the collaboration with IARCs. Sustained cooperation and communication is essential for downstream technology transfer and feedback, but most of all probably for motivation of local researchers. The best example in this respect, again, is IITA's success in getting cassava research started in Malawi.

A crucial element for a NARS's ability to benefit from IAR results is a close personal contact between the institutions. In Nigeria, it is felt that the NARS has benefited from a number of external institutions and organizations on a wide range of topics. The most outstanding cooperation, however, is seen to be with IITA, which is mostly due to the mere fact of this center's location in Nigeria. The center not only contributed as a corporate body, but also through the interaction of its staff members with Nigerian scientists even on a purely social plane to the evolution and advancement of NARS programs.

Centers actively try to deepen this social element with NARSs by visiting countries. Table 5.6, e.g., shows the number of visits by IARC staff to the case study countries considered. The table also demonstrates that a relatively large share of visits is devoted to NARSs in tropical Africa.

Table 5.6 Number of Visits by IARC Staff to Selected Countries of Tropical Africa, 1983

	Zimbabwe	Malawi	Tanzania	Kenya	Ethiopia	Cameroon	Nigeria	Burkina Faso	Senegal	Tropical Africa a)	All b) developing countries
CIAT	1	1	1	2	2		2			19	113
CIMMYT	35	13	21	10	6	5	2	8	5	158	398
CIP				5		1		1	2	16	107
IBPGR											
ICARDA											
ICRISAT											
IFPRI	7			3					1	16	57
IITA											
ILCA	5	5	1	32		1	21	1	9	122	148
ILRAD	3				3		2			24	26
IRRI		1	4							5	286
ISNAR	1		5	7	3	1	1	1	1		
WARDA											
TOTAL	52	20	32	59	14	8	28	11	18	360	1135

a) West, Eastern and Southern Africa.
b) In addition to tropical Africa: Central America and the Caribbean, South America, North Africa, Middle East, South, Southeast and East Asia.

Source : CGIAR Secretariat information.

It has to be accepted that increased communication and personal contacts can result in the loss of staff from NAR to one of the IARCs. In Kenya, NARS reports to have lost five scientists and four senior technicians as well as some junior staff to ILRAD. However, such movements can be beneficial, as they offer the opportunity for intensified communications with local research institutions due to personal acquaintance.

The importance of regional workshops initiated by IARCs is generally emphasized. Local researchers considered such workshops as most beneficial for improving the communication and cooperation between IAR and NAR and among NARSs of neighboring countries. Many useful contacts have been established between scientists in the regions leading to useful exchanges of information and ideas. Many felt that this interaction was more important than the content of the workshops, and two people interviewed suggested that the IARCs arrange annual meetings of scientists working in related fields. This would greatly enhance the feeling of working in a research community, thus, providing essential incentives. In Zimbabwe, several workshops were cited as being extremely useful. These were ILCA's workshop on small ruminant productivity in Africa, IITA's grain legume workshop, ICRISAT's groundnut workshops, the rice production workshop by IITA and IRRI, CIMMYT's FSR workshop, and the workshops by CIP on potato development and transfer of technology in tropical Africa and on potato post-harvest technologies. Some respondents cited the IFPRI workshop on agricultural policy and food issues held in Zimbabwe as one of the best conferences or workshops they had attended. However, others questioned whether simply discussing policy issues could have any real effect.

The centers' activities in initiating regional centers and programs are very much welcomed because of the importance of regional cooperation and communication. Thus, ICRISAT's regional sorghum and millet program in Zimbabwe will serve as a regional program for the SADCC countries. In Malawi, ICRISAT has established a regional groundnut program following requests from the SADCC Council of Agricultural Ministers. All the individual national programs have been encouraged to select any of the biological material used for incorporation into their own national programs. In Kenya, the NARS has had ample opportunity to interact with regional activities of the IARCs. Of course, ILRAD has its headquarters in Nairobi, and there is a strong cooperation in livestock research. Research activities of the KARI Veterinary Research Department, the Veterinary Research Laboratories of the Ministry of Agriculture and Livestock Development, the Faculty of Veterinary Medicine of the University of Nairobi and ILRAD are coordinated through the "Nairobi Cluster" which also includes ILCA and the Kenya Trypanosomiasis Research Institute. Kenya is also hosting CIMMYT regional programs for East Africa, including the maize improvement programs, wheat and triticale improvement programs and the economics program. ILCA has a major program in monitoring livestock production systems among Kenyan pastoralists, and the African regional program of CIP also has its headquarters in Nairobi. All these are examples cited as beneficial regional activities of IARCs to enhance the collaboration with NARSs.

The progress of the regional groundnut program in Malawi, finally, is a good example of how possible impacts crucially depend on the varying strengths and weaknesses of NARSs. The strength of the ongoing groundnut program in Malawi means that the ICRISAT material has only had a minimal impact in this country. In Mozambique, the poor state of the NARS means that the ICRISAT material has been evaluated and will no doubt be released directly as the country has no viable breeding program of its own. In Zimbabwe, the groundnut breeding program has tended in the past to concentrate on long season, high-yielding varieties, suitable for production by large-scale commercial producers with irrigation. The new orientation towards peasant producers has, therefore, benefited from the large variety of new material supplied under the program.

5.5 Advantages and Problems in Cooperation

In the preceding sections several impact areas resulting from collaboration between IAR and NAR have been investigated. In principle the aim always is to enhance the capacity of a NARS. The collaboration between the CG system and the NARSs, however, also raises some issues that go beyond issues like the exchange of biological material or training. On the positive side one notes the general catalyst function of the IARCs and the advantage of NARSs being bound more and more into a truly global network. However, the collaboration also raises a number of generalizable difficulties.

Advantages

A most beneficial role of IARCs has to be seen in their catalyst function for the NARSs. Traditionally, NARSs have emphasized research for large-scale farming and cash crops, notably for export. There has been a widespread neglect of food crop research and of research on peasant agriculture. Even where NARSs have begun to reorient their research activities, the starting base is generally poor. Here IARCs are extremely useful in filling this gap and getting NAR started in these new fields. By providing biological materials, research techniques and training, a "critical mass" of research potential in NARSs can be quickly built up, allowing for a rapid and efficient reorientation.

There are numerous examples for such catalyst functions of IARCs. Again, the cassava example from Malawi may be recalled. In Zimbabwe, the availability of a large range of cowpea material from IITA has enabled the country to rapidly establish a research program on this crop. This has been achieved without a local breeding program, and the continuing research efforts at IITA should result in a constant supply of new varieties enabling the NARS to avoid the necessity of establishing a national breeding program. Considering cassava, Zimbabwe has not devoted a substantial emphasis to this crop, but has started agronomic trials on varieties supplied by IITA. As with cowpea, the provision of an excellent range of material has enabled the NARS to forego the necessity of a breeding program on this crop. Similarly, sweet potatoes are currently being subject to agronomic trials with material supplied by IITA. A final example relates to groundnuts. This is, in fact, one of the most important crops in the communal areas of Zimbabwe, and very little research has been undertaken on problems facing peasant production. ICRISAT has a regional grain legume center in Malawi, and Zimbabwe is receiving material as part of the regional testing program and collaborating in research on Rosette Virus disease which is the major disease of the crop in the communal areas.

In livestock research, many NARSs are starting to devote more of their research efforts to small stock such as goats and sheep. This class of livestock is found almost universally in peasant agriculture, but has previously not been adequately considered in research programs. ILCA's efforts in helping to formulate research programs in this area are felt to be very valuable, particularly in Zimbabwe. Livestock improvement has proven to be a difficult problem area for both African states and donors. Many studies reporting the failure of livestock projects are never even published (Eicher, 1984, p. 18). It is to be hoped that ILCA can help both NARSs and project implementation to avoid many of the pitfalls that have been encountered in the past with livestock development efforts in tropical Africa.

IARCs do not only initiate research on neglected crops and livestock in NARSs, but also turn their interest to activities whose importance is not yet properly acknowledged in many NARSs of developing countries. A typical example is germplasm collection by IBPGR. This center, e.g., has identified Ethiopia as one of the priority regions for the collection and conservation of germplasm. This recognition attracted the attention of national and international institutions and, as a consequence, the need for the establishment of a gene bank in Ethiopia. The Plant Genetic Resources Center was thus established in 1976 and since then has had a very close work relationship with IBPGR and has received substantial materials.

IBPGR has also given assistance to Zimbabwe. A comprehensive collection was made in 1982, and it is hoped that a similar collection exercise planned for 1984 will now take place in early 1985. This collection mission involved center staff and local researchers and is an example of how the collaboration of an IARC can stimulate and encourage a NARS on important but previously neglected areas. Prior to IBPGR's involvement, there was no systematic collection of genetic material. The collection of local varieties has been coordinated with plant breeders working at the NARS, and the mission devoted considerable attention to small grains (sorghum and millets) which form part of the country's new direction into research on crops in communal areas.

One of the persons interviewed, while not involved with any IBPGR activities, expressed a dissatisfaction with what he saw as part of an exercise to "steal" the genetic resources of developing countries and the use of IBPGR germplasm by multinational seed companies. This issue, given wide currency in some circles, needs to receive attention and shows that there is some room for improving the centers' image.

The collaboration of IBPGR with NARSs is performing a useful function and falls well within its mandate. This activity further illustrates the difficulty of measuring actual impacts. The genetic collection being established may have no real impact at present, but at some future date the collection could provide vital genetic material for one of the national crop breeding programs.

The catalyst function of IARCs also has a regional dimension. The beneficial role of regional workshops and programs in initiating IARC activities has already been emphasized. In addition, enhancing regional cooperation among various NARSs is particularly important in tropical Africa. Historically, success stories of agricultural research are closely linked to supranational cooperation. A striking example is maize in southern and eastern Africa. When the legendary SR-52 was released in 1960 in today's Zimbabwe, the seed was sold and used in several neighboring countries. Malawi, e.g., has directly benefited from the advanced hybrid breeding program in the then Rhodesia. The regional interaction of the 1960s was partly a colonial heritage. The SARCUS network in South Africa linked the countries of the old Federation of Rhodesia and Nyasaland and other southern African states, including South Africa. But more important was the personal network that existed between Malawi and other East African countries. These contacts were the result of expatriate staff - primarily British - employed in various aid programs in the region. It made possible rapid and widespread transfer of biological material. These colonial links have also been important for the success of research on export crops like cotton as recalled by Eicher (1984). The Empire Cotton Growing Corporation was started by the British in 1921 and it became the forerunner of the concept of research networks that were subsequently launched by the Belgian and French colonial governments and later by the IARCs beginning in the 1960s. Under the leadership of French researchers, cotton had become an important crop in Ivory Coast, Mali, Burkina Faso, and other countries.

Today regional cooperation among NARSs in tropical Africa is limited due to lack of resources but also for political reasons, e.g. the collapse of the East African Community. For work in isolated NARSs, economies of scale do not apply. Individual NARSs are too small for many specific research programs and the solitude of specialists is counterproductive. It is in this environment that IARCs play a crucial role in enhancing regional cooperation of NARSs. Workshops and conferences provide contacts between local researchers and regional centers, and programs continuously support supranational NAR collaboration. They may be regarded as germ cells for future institutionalized collaboration of NARSs in specific regions.

Problems

Alongside the positive aspects, some general problems in the collaboration between IAR and NAR have to be discussed. First of all, many researchers in NARSs would like to have their part in this collaboration acknowledged more. It is argued that certainly NARSs benefit from the cooperation, but so also do the IARCs. To give an example, Zimbabwe has an advanced soybean program and there have been exchanges of material with IITA. It is felt that this exchange has benefited the center at least as much as the national program, but apparently this has nowhere been acknowledged. A similar example relates to maize research in that country. The national maize program has been inundated with CIMMYT material for local trials since the head of the institute visited the center in 1980. He sees the execution of these trials as a service being offered to CIMMYT and of little benefit to the national program.

On the other hand, some techniques have been developed by NARSs which have been adopted by the IARCs. A specific example from Nigeria is the "minisett technique" for producing seed yam from "mother seed yams". This technique for the rapid multiplication of seed yam was originally developed by the National Root Crops Research Institute in this country. The technique was picked up by the IITA scientists who have advanced it further to the "microsett technique". Apart from this example, the genesis of ideas, techniques and methodologies in research has tended to create some ill feelings in Nigeria's NARS. Several cases of ideas and techniques developed by national scientists were cited in which these research results were "hijacked" or "pirated" by some scientists of the international system without adequate acknowledgement. This has tended to inhibit national researchers from opening up in discussions from the latter. The sentiment was sufficiently widely expressed, and it is obvious that the centers should approriately honor national research results to avoid such misfeelings in the future.

A closely related criticism is that the requests from IARCs to NARSs for local testing often become so demanding, that the national program is in fact adversely affected. Most of the complaints relate to the sheer bulk of the material. It occupies valuable trial field space. The often complex and atypical plot designs place an extra burden on technical staff. The observation and reporting activities expected are different and, at times, excessive. Often the trial has to be scored for disease and pest incidence without the researcher having the necessary training. A final difficulty is the preparation of detailed trial results and reports on an IARC reporting schedule which is unfamiliar and cumbersome to local scientists. These complaints are compounded to some degree by the inexperience of the local researchers when the IARC intervenes with its requests. The person may only have been working on his program for a short time just getting accustomed to the department's established procedures when the IARC intervenes with its requests. A senior breeder commented that the "mystic" of the IARCs and the feeling that a young researcher may have to prove himself to this "Center of Excellence" means that an excessive amount of time is devoted to these IARC trials to the detriment of the local research program.

Two examples may serve as an illustration. In Kenya, almost 1,000 accessions of IRRI rice varieties were screened for cleanliness. This constituted a major burden without any help from IRRI. In Zimbabwe, the sorghum breeder was sent 100 varieties for testing by ICRISAT in 1979/80, and, although the plot design and size was left to him, he found the detailed observation and the evaluation extremely time consuming. The reporting procedure required measurements of germination, establishment, regular disease and pest scoring and yield measurements. The breeder reported back in 1980 and received some 400 varieties for testing plus his own selection from the previous year. This material had not been requested, and he was unable to handle the trial because of critical labor shortage. Currently, he is running a leaf disease nursery for ICRISAT and claims that, although this is a much smaller trial, it has involved training field staff in fairly complex scoring techniques. The recent establishment of the ICRISAT Regional Center has now alleviated this pressure. When asked why he did not simply refuse to run the trial he claimed that in early stages he feared this would restrict availability of further material.

Obviously, these problems can be eased by closer contacts and cooperation among IARCs and NARSs, by receiving at centers a feedback on a NARS's objectives, resources and needs. Cooperation would also mean a common design of research efforts and a common exploitation of research results. In this respect, the particular issue of publishing research results has been mentioned. In general, NARS researchers would seem to appreciate an intensified partnership with the IARCs.

In this respect, complaints about a lack of "bottom-up thinking" in centers were uttered in Burkina Faso. Some IARC scientists did not really seem to want a deepened collaboration with national researchers. They were said to plan and pursue their research activities as they perceived the problems and irrespective of national views. To a certain extent this was felt to be a new kind of "Balkanization" which has been a typical criticism on traditional development. IAR, however, could not be seen and exercised in isolation but must be integrated into a network of development support, established in close collaboration between donors and recipients.

A particularly suited means to increase cooperation between IARCs and NARSs is to arrange for cooperative research agreements. Centers increasingly try to intensify such collaboration. It has to be admitted, though, that with respect to tropical Africa, this area of cooperation is still at the beginning. In Table 5.7 the number of contracts or collaborative research agreements between IARCs and the countries selected for the report are listed for 1983. As compared to other developing country regions, the amount of contracts is rather modest. It is hoped that the evolvement of NARSs in tropical Africa will help to strengthen these cooperations.

Table 5.7 Number of Contract or Collaborative Research Agreements between IARCs and NAR Personnel in Selected Countries of Tropical Africa, 1983

	Zimbabwe	Malawi	Tanzania	Kenya	Ethiopia	Cameroon	Nigeria	Burkina Faso	Senegal	Tropical a) Africa	All b) developing countries
CIAT							1			1	1
CIMMYT							1			3	22
CIP				6					1	34	130
IBPGR				1	1		1			6	35
ICARDA											
ICRISAT										0	13
IFPRI							1	1	1	6	37
IITA											
ILCA										5	5
ILRAD										0	0
IRRI										0	41
ISNAR										0	4
WARDA											
TOTAL				7	1		4	1	2	55	288

a) West, Eastern and Southern Africa.
b) In addition to tropical Africa : Central America and the Caribbean, South America, North Africa, Middle East, South-, Southeast and East Asia.

It is no secret, on the other hand, that in some countries IARCs are seen as a substitute for national research activities and it is expected that the centers deliver appropriate technologies directly. Of course, this is a fundamental misunderstanding of scope and intentions of the CG system, but may be understandable in countries with a very low level of its NARS. In this case the country may be totally incapable of using IAR results, and depends for any impact on the centers' own activities. In its extreme form this situation may not exist. However, there may be a case for explaining better the respective roles of IARCs and the NARSs. This might help to avoid misconceptions. Thus in Ethiopia it was particularly emphasized that the IARCs should now gear their activities to the national priorities. Many even expressed the belief that the CG system was partly responsible for the famine situation in Ethiopia, because it was too much concerned with global issues and not enough with Ethiopia's specific problems. As naive and unfounded as this view may be, it demonstrates that there is still need for information on the nature of the CG system and its collaboration with NARSs.

A final problem is worth mentioning. Some researchers in NARSs make reference to what might be called an unfruitful market share thinking of IARCs. In Zimbabwe, a cassava breeder found by studying available literature from CIAT and IITA, that CIAT's cassava program was more suited to his local research intentions. Consequently, requests were made to CIAT for the supply of their cassava material. However, the researcher had his request referred to IITA. Further requests were also unsuccessful and he was informed that the supply of any genetic material was to be made through IITA because of this center's mandate for cassava research in Africa. Subsequent approaches to IITA for specific CIAT material failed, and to date the researcher has failed to obtain any cassava material from CIAT.

A similar experience is reported by a rice breeder. After receiving what he considered to be unsuitable varieties from IITA, he wrote to IRRI making a very specific request for material with good cold and heat tolerance at the flowering stage. Initially, he received no reply to his request and after a subsequent letter he was told that he should contact both IITA and WARDA for assistance.

All these problems discussed, again, point to the key issue of this chapter. The collaboration of IAR and NAR cannot be a downstream service of IARCs without feedback. It is crucial to establish close contacts and intensive communication to implement and build up a working relationship based on mutual understanding and partnership. Both centers and NARSs are well on the way to such a state of affairs. The consideration of some of the remaining problems discussed in this chapter may help to speed up this process.

There is, however, one problem complex that is likely to remain: The enormous differences in salaries and in the general material and organizational capacity between the IARCs and the NARSs. One result is that national researchers often take the first opportunity to join an IARC; the NARS may thereby lose their best staff which cannot be in the interest of effective research collaboration. Another result can be that frictions develop and the national researchers withdraw from active collaboration because the differences might appear to preclude true partnership and equal footing.

Chapter 6

RESEARCH IMPACTS ON AGRICULTURAL PRODUCTION

6.1 General Assessment

The ultimate goal of the collaboration between IAR and NARSs is to increase agricultural production and, thus, increase the living standard in developing countries. The crucial questions are whether such impacts really occur, and what their importance is. As both the CG system and NARSs interact, it is difficult to single out the respective contribution. Any impact has to be regarded as the outcome of the combined efforts of the CG system and NARSs, and it is only possible to point to their specific relative roles in this collaboration, not, however to attribute success figures to any one of them.

In this chapter the actual and potential outcome of such combined efforts are investigated. In a first step, actual effects on agricultural production are discussed and the crucial notion of appropriate technologies is analyzed. The following section, then, is concerned with production-related impact areas.

Any impact of agricultural research has to be interpreted as a partial effect, depending on the research environment. In tropical Africa, the particular importance of agricultural policies has to be emphasized. The important link between research impacts and agricultural policies is discussed in a third section. In a fourth section, the specific role of the CG system in achieving impacts is examined. Of particular interest is the question why this role has been of moderate relevance only in tropical Africa up to now.

Again the whole chapter is based on the perception of persons interviewed in tropical Africa. The picture may well be biased in certain respects. It has to be accepted, however, that perceptions are also facts. To present what may in some cases be erroneous perceptions can then show the need for clarification and correction. On the other hand, it has already been emphasized, that the collaboration between the CG system and NARSs in tropical Africa is just beginning. It is too early to come up with figures about, e.g., increased production volumes. The discussion, therefore, has to be qualitative in nature trying to reveal potential impact areas and pointing to possible implementation problems.

6.2 Production Effects and the Relevance of Appropriate Technologies

The historical record in tropical Africa

There are only few success stories of research on agricultural production in tropical Africa in recent history. The outstanding example among food crops is maize production in southern and eastern Africa. In Zimbabwe, the increases in yields have been impressive. In the commercial farming sector, average yields have increased more than threefold since the 1950s, and in the communal area of this country they have doubled. The spectacular development is certainly based on the release of the SR 52 variety, which

Eicher calls the green revolution success story of southern Africa. Zimbabwe's maize breeding program started in 1930 and has achieved worldwide notoriety. After 17 years of research the first hybrid, SR 1, was released to farmers. This made Southern Rhodesia the first country after the United States to produce hybrid maize commercially. The most significant achievement was the release in 1960 of the 150 day hybrid SR 52. This hybrid has, as its parents, two locally bred varieties and has been largely responsible for the spectacular maize yields achieved in Zimbabwe over the past 25 years. All the commercial maize grown in this country today is hybrid maize, and the variety SR 52 makes up for 85 percent of the crop. It is estimated that the development of hybrids alone is responsible for about 45 percent of the noted yield increases in the commercial maize production levels between 1950 and 1980.

The maize example of Zimbabwe demonstrates clearly that research may be a necessary prerequisite for increased output, but not necessarily a sufficient one. This points to the crucial role of the research environment for research success. Maize production has been intensively backed up in Zimbabwe. Currently most of the farmers use nitrogenous compound fertilizers at the rate of 150kg/ha nitrogen, 40kg/ha phosphorous and 30kg/ha potassium. Research data from nitrogenous fertilizer trials show that their use can result in yield increases of the order of 200 percent. This is by far the biggest single contribution to the yield increases experienced in commercial maize production.

Other favorable factors for maize production in Zimbabwe were improved knowledge on plant populations and planting dates, and on pest and weed control. Effective weed control is estimated to account for about 30 percent of the yield increases, and the development of efficient and cheap chemical control measures, coupled with improved agronomic practices based on research into the pest life cycles, have resulted in between 5-10 percent yield increases.

Although the maize success story in Zimbabwe is closely related to commercial farming, small-scale peasant farmers, too, have widely benefited. Various studies of the communal areas all contain evidence of an exceptionally high level of adoption of hybrid maize varieties. In some regions, the use of hybrid maize is almost universal. This high level of adoption is most impressive and is largely a result of the easy availability of the hybrid seed at a reasonable price. The adoption must also be related to the acceptability of the hybrids as a food source. Furthermore, most of the farmers now use fertilizer which has been facilitated by easier access to credit for the purchase of inputs.

Figures from the region of Mangwende may give an impression on absolute yields. The average maize yield in 1971 was only 0.4t/ha, while in 1978 it had jumped to 1.4t, and in 1982 it was 2.8t/ha.

Hybrid maize varieties from Zimbabwe have spread over southern Africa and positively influenced yield levels in several countries. Thus some 10 percent of the farmers in Malawi are growing hybrid maize. Even Cameroon has recently turned to the hybrid varieties from Zimbabwe and notably SR 52, which seems to suit the conditions of the local Adamaoua Plateau well.

Kenya is another example for maize research success in tropical Africa. In this country, too, the development and introduction of hybrid maize has been "the" success story of agricultural research. There now exist early and late maturing hybrids to suit the various ecological zones. In addition, synthetic varieties have been developed for the medium rainfall areas of eastern Kenya and some composites for the coastal region. The adoption of the improved maize varieties by Kenya's smallholders and large-scale farmers is overwhelming. It is observed that the higher-yielding drought-resistant strains of maize are widely applied on smallholdings, including areas of lower agricultural potential. In the period 1964-1973, the production of hybrid maize in Kenya grew to an estimated 324,000 ha with a rate of diffusion higher than that of hybrid corn in the United States in the 1930s.

Apart from the maize success stories, little more can be reported of research success in food production in tropical Africa. The soybean example of Zimbabwe may, however, be cited. The expansion of this crop in the 1960s is largely a result of successful research. Initial work on Rhizobium resulted in the development of very effective legume inoculants. These were made available to farmers and probably led to a significant contribution to the overall yield increase experienced. In addition, crop breeders have produced varieties of high-yielding potential. Research on the crop's agronomy has led to the formulation of more appropriate management and cultural practices. The pest spectrum has been extensively researched and efficient control measures developed. The major thrust of research has been oriented towards commercial farming, it is true. On the other hand, the crop is also expanding in the communal areas with better rainfall conditions.

Historically, research impact on agricultural production in tropical Africa is more related to export crops than to local food commodities (Spencer, 1985).

Agricultural research was not neglected by colonial governments. Between 1900 and 1920 one or more agricultural research stations were established in virtually every country of tropical Africa. But these research stations concentrated almost exclusively on export crops, e.g., oil palm, cocoa, cotton, coffee and groundnuts. This was perhaps understandable in view of the fact that there was no apparent shortage of food in the colonies, while there was much scope to increase agricultural exports to the metropole to satisfy the demands there and to earn revenues for the colonies. There was almost a total lack of research on the major food staples.

The investment in research on export crops did yield rather substantial returns. Hybrid oil palms were developed and contributed significantly to agricultural export growth between 1940 and 1960. Hybrid palms outyielded wild palms by 500 to 700 percent, under farm conditions in West Africa. Cotton research started in Uganda around 1904 and spread to northern Nigeria and the French colonies in the 1920s and 1930s. Substantial yield increases have been obtained under farm conditions by cotton farmers, applying the results of research in Burkina Faso. Similar successes were obtained with research in cocoa, which started in West Africa in the 1920s, and to a lesser extent with groundnuts. A final example relates to coffee and tea research in Kenya, which has been outstanding. Coffee research concentrated on breeding, pathology, agronomy, entomology and plant protection with a particular view to the coffee berry disease. Tea research is currently run along similar lines as coffee. High-yielding varieties and cloves have been developed, but unlike coffee, crop protection has not been an important concern with tea, reflecting the remarkable absence of pests and diseases to date.

The history of agricultural research in tropical Africa clearly shows the successes with some select crops as well as the absence of any marked progress with most other crops. Agricultural research appears to have been most successful in tropical Africa in those countries that have shown relatively good and sustained agricultural performance anyway like Zimbabwe. Another example, perhaps, is Cameroon. A considerable increase in the hectarage and production of food crops has taken place since 1973. This has been due partly to the general economic situation, but also to research by the former French institutes like IRAT, local research, and more lately by the influence of overseas funds for research and IARCs. The efforts of all these bodies have combined to make Cameroon self-sufficient in food production.

However, also in Cameroon the situation is far from ideal. There has been a sharp drop in groundnut production (by more than 50 percent) between 1971 and 1982. Since the area under cultivation has remained about the same, this reflects a decline in yields. The reasons lie in a continuation of generally low standards of crop husbandry (planting time, planting density, weeding, diseases, etc.). Although some research has been done on groudnuts in the past, the poor state of production is certainly related to the lack of appropriate research initiatives. An urgent research requirement for this crop would be the development of a rosette resistant groundnut as well as a high yielding variety.

The groundnut example of Cameroon is very typical for the state of affairs in many countries of tropical Africa. In Burkina Faso yields have effectively decreased during the last decade for many food crops. During 1970-78, the annual rates of yield decline have been 3 percent for millet, 2.7 percent for rice, and 1.6 percent for maize. Only sorghum increased at a rate of 2 percent, but the rate of 12.3 percent for cotton points to the remarkable difference between cash and food crops. This poor state of affairs may not be caused, but closely related to the lack of adequate research activities. On the other hand, one might argue that the situation without research might even be worse. Yield figures for NAR-influenced sorghum, millet, maize and rice varieties in Burkina Faso show that these are still considerably higher than yields of traditional local varieties.

Livestock is another point of particular concern. Cattle productivity and beef quality of indigenous breeds of cattle in Cameroon, e.g., have for a long period of time been a major problem. Several projects failed in this respect, and it is only recently that there have been some successes in crossbreeding and the introduction of trypanotolerant cattle. Closely related to livestock is rangeland research, which also seems to be just at the beginning stage in Cameroon. There have been some significant results on grasses and pasture legumes in the past, but, given the structure of the livestock extension service and other unfavorable factors, few of them have actually reached the farmer.

Factors of success and failure

For tropical Africa as a whole the lack of appropriate technologies appears to be crucial in explaining the prevailing low level of agricultural productivity. Inappropriate technologies result in low adoption rates of research results of African small-scale farmers. According to Spencer, these failures stem to a large extent from two causes. First of all, there is an inadequate understanding of small farmers' goals and resource limitations. Research objectives are, therefore, often very different from those of the potential clientele, the small farmer. One glaring example is the case of intercropping. Numerous studies have shown that in most regions intercropping is much more important than sole crop systems, occupying over 90 percent of the cropped area. Despite some early work in the 1930s, it was not until very recently that intercropping has become the object of serious research efforts. Yet, what little research has been done so far, shows that intercropping is often a more efficient farming system than sole cropping even from the agronomic point of view, not to mention its other advantages to smale-scale farmers, like risk reduction, diversification of subsistence, and spread of labor requirements.

The second major cause for the failure of research systems in tropical Africa to develop a large enough stock of appropriate technologies for farmers is, according to Spencer, the over-reliance on the diffusion or the technology transfer thinking. Following the successes with export crops during the colonial period and the green revolution on other continents, the wide-adaptability approach of agricultural research took firm root in tropical Africa. Not only was this idea adopted by NARSs, but also by IARCs. In the previous chapter, the widespread problems and failures of this approach have been discussed. Taking WARDA and ICRISAT in West Africa as examples, Spencer emphasizes that the extent to which technical solutions, developed elsewhere, can be imported into Africa is quite limited. Spencer explains this with the high rate of demographic change and the difficult physical conditions in tropical Africa.

The problems of designing appropriate technologies for small-scale farming in tropical Africa are manifold. Some examples should further illustrate the case. In Cameroon, there are very different farming systems and most farmers practice mixed cropping. Yet the early emphasis in agricultural research was commodity-oriented: In this country it was the intervention of IARCs and notably of IITA that has intensified efforts in FSR. An agricultural survey by an IITA agro-economist established the heterogeneity in all research efforts. Consequently, FSR is now a full program in Cameroon's NARS. This example points to the role of IARCs in triggering off reorientation of NARSs and to the particular role of FSR for identifying research areas that result in appropriate technologies for tropical Africa.

In Malawi, the national hybrid maize breeding program has been relatively unsuccessful beyond the initial spread from Zimbabwe. Currently it is estimated that only 10 percent of the smallholders plant hybrid maize and about 2-3 percent use composites. In a 1980/81 survey it was found that 90 percent of the producers were using local maizes, and that about 7 percent used hybrids, and only 3 percent composites. The level of adoption of improved maize varieties is exceptionally low considering the substantial effect that has gone into their extension. A number of reasons have been given for this lack of adoption, the major one being the local food preferences coupled with processing methods commonly used. The dent hybrids available do not allow the endosperm to be separated out by pounding as the test is strongly adhered. For this reason, the hybrids grown are rarely processed locally and must be sold to government agencies. Smaller farmers, however, prefer to grow their own varieties, which they easily can process locally.

Usually, there is a multiplication of reasons for lack of adoption of new technologies at the farmers' level (see, e.g., Hardaker, et al., 1984, and the recent survey by Feder, et al., 1985). To realize any impact, it is important to integrate this multiplicity into research efforts in tropical Africa. Spencer (1985) makes the following suggestions: Research should be based on the locally available varieties rather than to rely on the concept of wide-adaptability. The varieties should be responsive to low input levels. Complementary inputs like fertilizers should as much as possible be derived from local sources. In this respect, the importance of research on biological fixation of nitrogen is particularly important. Spencer, further, emphasizes simple mechanical technologies that are within the reach of farmers. A hand weeder that allows a farmer to weed twice as fast as existing weeders would have a big impact on labor productivity. The animal yoke newly designed by ILCA that allows the traditional Ethiopian plow to be pulled by one instead of two oxen is said to be likely to have more impact on agricultural productivity in the Ethiopian highlands than all the mechanization research over the last 30 years.

Also in tropical Africa appropriate technologies will increasingly be linked to intensified production methods, because a good part of the necessary production increase will have to come from densely populated areas. In Malawi, e.g., there will have to be substantial increases in land productivity to keep pace with population growth. Already back in 1978, the total area utilized in that small country made up 98 percent of the total arable land available, and since then the population has increased by 1.3 million. But there are also other situations like Tanzania, where less than 10 percent of the total land area is under cultivation. However, for most countries in tropical Africa, research emphasis will be on increasing land productivity.

A final adoption aspect considers livestock. Livestock is a major part of farming systems, particularly with grazing systems. As this interaction is particularly complex, it seems necessary to adopt FSR, as ILCA does, in designing appropriate new livestock technologies. Historically, livestock research in tropical Africa was mainly veterinary research. This, together with recent work by international organizations like ILRAD, has yielded economical control measures for most of the important diseases, the major exception being trypanosomiasis. On the other hand, it is widely accepted that the lack of reliable feed supply is probably the most limiting factor on animal production. The scope for increasing production from rangelands, e.g., through pasture improvement is extremely limited (Jahnke, 1982). This is why Spencer argues that substantial increases in livestock productivity will probably have to await increased crop production. This, again, suggests that an integrated farming systems view has to be taken in designing appropriate technologies for peasant farming in tropical Africa.

6.3 Production-related Impact Areas

Income and welfare

Research is supposed to enhance agricultural production and would, thus, affect economic welfare but also other goals of society (secondary effects). Since production effects in tropical Africa have been moderate at most, it seems superfluous to investigate for possible secondary effects. This is very much confirmed by the country studies and the interviews: What matters in tropical Africa at the moment is production increase; all additional and related considerations are judged rather unimportant. On the other hand, indirect and secondary impact areas of research have intensively been discussed on other continents. If and when research leads to production increases in tropical Africa, this will undoubtedly raise similar issues. It is useful, therefore, to trace out some relevant aspects as already perceived by the countries.

A crucial aspect of production increase is income generation. First and foremost, this income is distributed among farmers. It is widely acknowledged in countries of tropical Africa, that small-scale peasant agriculture should be the main addressee of research activities, and the present reorientation of NARSs, like in Zimbabwe, Malawi and Cameroon, certainly is a visible result of this view. Increased farm income is therefore generally in line with both overall income and with equity considerations.

Increased production can lead to price decreases which may shift the income distribution in favor of local and urban consumers. It seems, however, that this is less of an issue in tropical Africa where up to 80 percent of the population live in rural areas where subsistence agriculture predominates.

Research-induced income generation in peasant agriculture is the main aspect to be discussed with respect to tropical Africa. If research on major crops is successful it may result in considerable income increases in rural areas. In Kenya, improved maize varieties have largely contributed to increased food and income generation in the country. In 1974/75, maize accounted for 45 percent of the value of food crop production. Particularly in western Kenya, maize is an important source of income. Over half a million smallholders sold some maize for cash in 1974/75.

Considering income generation, the role of cash crops, mostly export crops, is a major issue. The CG system has concentrated on food (staple) crop research in order to enhance the food situation and the living standard of the poor in developing countries. From a classical economic point of view, however, the justification of such an approach is not so obvious. Developing (tropical) countries have a comparative advantage in producing export crops like coffee, tea, cotton, etc., instead of certain food crops, say, wheat. Economically, it would make sense to promote also, through research, such export crops. This could result in increased income generation and may have the country better-off after paying the bill for food imports.

In tropical Africa cash crop production cannot be taken as synonymous for large-scale farming; it is of considerable importance for peasant agriculture as well. In Zimbabwe, e.g., cotton was introduced to peasant farmers in the 1960s. The adoption of the crop was rapid, even spectacular. Generally, the communal areas' share of the crop has expanded significantly throughout the country, and now over two thirds of the crop is produced by this sector. The high labor demand at picking makes the crop ideally suited to the communal areas with their labor surplus. A good pricing policy coupled with the provision of good marketing facilities have been the vehicle of the massive expansion of this crop. However, many of the improvements in cultural practices have been the result of research and extension. In fact, the original research into cotton can be considered as one of the most significant benefits to peasant agriculture from agricultural research in Zimbabwe, the major technical achievement being the control of the cotton pests.

There are other examples to show that smallholders benefit from cash crop development. In Kenya, farmers have adopted various cash crops like coffee, tea and pyrethrum. In Cameroon, the smallholder cash crop production is generally well organized all over the country. Cocoa and coffee are almost exclusively grown on small farms in all provinces except in the North. Cotton, too, is exclusively grown on small farms and has recently yielded well, due to increased mechanization, the use of fertilizers, and price incentives as well as effective extension services. It is noted, furthermore, that in Burkina Faso the rate of adoption for new cash crop varieties is considerably higher than that for food crops.

Thus cash crops can play an important role in the development of peasant agriculture in tropical Africa. One might even argue that it is better for this continent to specialize in these commodities because the value-product of African labor is generally higher in export crops. However, this might be too rigorous a view. Mellor (1985) points to four aspects to be kept in mind. First, given the risk aversion common to farmers, the extent to which they are willing to put their resources into export crop production is determined by their ability to produce adequate home food supplies. Thus food production and export production may be complementary, not competitive; increased productivity of the former allows increased production of the latter. Second, a substantial proportion of African labor resources is already in food production. Failure to substantially raise the productivity of the resources in food production means leaving many of the people in poverty and malnourishment for the decades required to facilitate a shift to alternative production and distribution systems. Third, there is great variability from place to place in the food production resource base in Africa. Although the comparative advantage argument against food production may apply in some areas, it is hardly applicable in others. Fourth, no government, given reasonable prospects of domestic food production, will want to depend on imports for the bulk of its basic food sustenance. As a consequence, the proper role of cash crops has to be seen as one of complimentary support. They generally become more important the higher the development stage of an economy. For tropical Africa, the food crops research is likely to continue to constitute the biggest challenge up to the end of the century. This is particularly so since there is a reasonable level of research on export by parastatal and private bodies anyway.

Food security

Apart from its income-generating function, food production is seen as a key issue for food security. "Today food security - like FSR - is a household word in the development literature and in policy dialogues between donors and aid recipients" (Eicher, 1984). It certainly is an aspect of particular concern for countries in tropical Africa, facing the current food crisis. Food security can be broadly defined as "the ability of food-deficit countries or regions or households within these countries to meet target levels of consumption on a yearly basis" (Siamwalla and Valdes, 1980). There are several ways to achieve food security in a country, but, undoubtedly, the efficient growth of food and agricultural production and the corresponding employment and income-generating opportunities to enable rural and urban people to purchase an improved diet are essential prerequisites to achieve this goal in tropical Africa. This is why agricultural research on food crops is particularly relevant for food security on this continent.

Other impact areas

Apart from effects on income, equity and food security that may result from research-induced production increases, some other aspects require mention. In several cases, research on certain crops is seen to be beneficial in reducing food import bills. The obvious case is wheat in many developing countries. In Malawi, wheat has been grown since the beginning of the century, but total production, until recently, was very small, representing only 5 percent of national requirements. Equally, the crop was given very little attention in the NARS in the past. In the late 1970s, then, the Malawian Government decided to actively encourage wheat production in an effort to save foreign currency. Price increases encouraged additional producers, and smallholders, too, began growing the crop. As part of an increased research effort on wheat, now the NARS began to evaluate CIMMYT wheat varieties under irrigation. The varieties have performed well, and three are considered to be suitable for release. The biological material, supplied by CIMMYT, illustrates again a crucial success condition for the collaboration between the IARS and NARSs. When the objective of a national program, which is import reduction in this case, coincides with the material on offer from the IARC, there can be a rapid acceptance and a substantial impact in a relatively short period of time. On the other hand, the high investment cost of establishing irrigation infrastructure and the relatively high producer prices as compared to other crops may raise the question whether such a reorientation of research resources towards wheat really is the best way for Malawi to increase food production and income in the whole economy.

Another potential research impact relates to nutritional goals. If research on a major crop enhances monocropping, it is argued that this may have detrimental effects on the diet. In Malawi, there has been an increased adoption of cashcropping and a shift towards maize monoculture. This development is partly held responsible for the serious malnutrition in Malawi by some interviewees. It is argued that increases in the maize price in 1982 and 1983 caused farmers to sell more of their maize, which they would otherwise have kept for family consumption. The farmers needed cash to meet their cash needs, e.g. school fees, repayment of loans, etc. Such a line of argument has to be questioned. If the selling of crops contributes to enhanced income, the households will hardly be worse off, as compared to a situation when they do not have this opportunity. Equally, it sounds strange that households will starve in order to make cash. However, this argument demonstrates that there is still misunderstanding on the importance of cash crops. On the other hand, it points to the fact that those farmers who sell crops (and they may have very small holdings) are not those who starve.

A different issue is that of ideological problems connected to the introduction of germplasm. Fears are expressed about the possibility of importing new diseases, insect pest and weeds, with the seed material. There have, in fact, been some negative examples in research history of tropical Africa, and even today the quarantine systems are deficient in many countries. The view on the risks involved are mixed, but in general they are thought to be minor, in comparison with the potential benefits from imported germplasm. Moreover, substantial amounts of grain as food or seed are being imported anyway so that it is not clear why seed grain imported for breeding should constitute such an unusual danger.

A final aspect of potential research impacts relates to gender. Women in tropical Africa are in many cases the backbone of the agricultural labor force. This situation is often further accentuated by male labor migration. When men are absent to earn cash elsewhere, as it is rather widespread in e.g. southern Africa, the farms are run by the women. But while they make all farm management decisions, they are largely missed by the (male) extension service.

A typical example relates to Zimbabwe. The extension workers in this country are all male. Culture places restrictions on men visiting homesteads where the husband is absent. This results in differential adoption rates depending on whether a crop is managed by men or women. For example, groundnuts have traditionally been a female crop. Comparing the adoption of innovations with that of maize, the differences are obvious. For example, the adoption of certified seed in Zimbabwe's Mashonaland East Province was 69 percent for maize and 5 percent for groundnuts in 1978. The use of grain protectant chemicals or groundnut seed dressings are characterized by 79 percent and 8 percent adoption rates, and the figures for the stocking of maize or the use of drying racks for groundnuts are 80 percent and 20 percent respectively. These figures clearly illustrate the low adoption rate of groundnut technologies. In higher rainfall areas, the use of expensive chemical fertilizers on maize leads to yield increases of the order of five times, while the use of small amounts of relatively cheap gypsum on groundnuts can result in a doubling of yields. However, the adoption rates of this improved technology are very low in comparison to fertilizer use in maize.

These low rates of adoption in the groundnut crop are indicative of both the low level of extension advice received by women and their inability to ensure that funds are made available for the purchase of inputs for their own crops. The recent reorientation towards group extension efforts in Zimbabwe and the newly acquired political power of women's groups in the rural area has gone some way in improving the flow of agricultural advice to the previously neglected sector of the rural population. However, the more equitable access of women to cash inputs for their own farming and gardening activities will require considerable restructuring and change in current rural attitudes and societal mechanisms.

Nigeria sets another example for the differing role of men and women in crop cultivation, e.g. in the case of root crop production. In many parts of the yam growing areas, yam production is considered a noble occupation in which women's role is merely subsidiary. Thus, the principal target audience for the transmission of innovations in yam production is the menfolk. Bush clearing is done by men; men make the yam mounds or ridges; provide stakes for the vines and take active part in yam harvesting. Only weeding is normally the task of women. In contrast, the production of cocoyam is still exclusively in the hands of women from land preparation to planting, weeding, harvesting and storage.

Another case is cassava, traditionally a women's crop, even where intercropped with yam. As cassava is becoming an important industrial crop, more men are getting involved in cassava production than was the case 10 to 15 years ago. It is reported that the target audience for the dissemination of innovations and technologies in cassava production is shared equally by both sexes.

Agricultural research and new technologies may considerably affect labor requirements and, thus, women's work in agriculture. The trend towards cash crops often results in a higher demand for labor. In Malawi, this is particularly true for crops like tobacco and cotton. The fairly extensive production of dark fire-cured tobacco has led to a considerable increase in the demand on female labor force in rural areas. This crop is cured in wattle-and-daub barns in which fires burn continuously for a period of two to three weeks. The firewood requirements are great and have resulted in the rapid depletion of natural woodland, which means that even more time must now be devoted to collecting wood because of the greater distances involved. This has tended to reduce the labor available for women's traditional gardening activities, which probably is one of the major reasons for the decline in groundnut production. Equally, the rapid decrease in the degree of intercropping of maize with pulses, beans, or cassava is thought to be more an indication of the reduction in the availability of women's labor than anything else. There are also nutritional implications, because the typical women's crops have traditionally been an important component for a balanced diet.

In Zimbabwe, the adoption of hybrid maize and the use of chemical fertilizers have propelled the crop into a more important position in the farming system. This has increased the labor demand, especially for initial weeding. This increased and more intensive labor requirement of hybrid maize has resulted in a heavier workload for women and, thus, negatively affected their gardening activities. In many rural areas the woman's homeside garden, normally devoted to numerous small-scale food crops and vegetables such as chickpeas, Bambara nuts and groundnuts, have shrunk. On the other hand, maize deliveries to state agencies must be made on a registered grower's number. This is often the male household head, and it is he who receives the cheque payment for the delivery. The mechanism ensures that men retain control of the family finances, in spite of the fact that women account for most of the labor contribution. It seems obvious then, that women will be less enthusiastic about the adoption of new technologies than men.

6.4 Importance of Agricultural Policies for Research Impact Realization

Bias against agricultural production

Research cannot be evaluated in isolation, but has to be seen as one component of an innovation package. Research alone is not sufficient for increased agricultural production. It may be considered as a necessary prerequisite for enhancing production in the long run, however, actual impacts crucially depend on a favorable economic environment. This is particularly true for tropical Africa where factors external to research have hampered innovations such as a lack of credit facilities, inadequate supply of fertilizer and other inputs, inadequate extension services and adverse pricing policies. Hence, research impacts cannot be assessed without looking at agricultural policies.

In recent history there has been a permanent policy bias against agricultural production in tropical Africa. This bias has had several dimensions. Generally, agriculture has been taxed directly or indirectly to extract resources for government spending and for the financing of industrialization. Within agriculture there usually has been a bias in pricing policies against food production in order to keep consumer prices in the urban areas low. As a consequence, the adoption of new technologies and, thus, the realization of research impacts on food production is retarded or even prevented. An additional problem is the lack of adequate extension services, which may hamper the downstream transfer of research results. These factors are worth discussing in some more detail.

Agricultural policy in tropical Africa traditionally has meant extracting resources from this sector for industrial development. With increasing debt problems and growing urban populations, price differentiation policies have been used for redistribution among farmers, government, and consumers. In Malawi, e.g., smallholder agriculture has been taxed for a long time by giving producers a price well below the one the state trading agency receives on the final sale. This particularly holds for tobacco, cotton and groundnuts. The profits on these crops have been used to cover the loss on the maize trading account subsidizing the food bills of urban and estate workers, and they are also invested in ventures unrelated to smallholder agriculture. This is a typical example for a policy support bias against peasant agriculture.

African agriculture has also suffered from institutional restrictions and changes which have been used for social experiments instead of providing appropriate production incentives to farmers as, e.g., demonstrated by Tanzania. The country has invested increasingly in agriculture, but most of this investment has gone into the creation of new institutions like commodity authorities. There exist about 100 parastatal authorities directly responsible for agricultural production. Their functions overlap, and more often than not the result is a deterioration of service to smallholders (input supply, extension, crop collection and cash payment). Little attention, on the other hand, has been given to maintaining financial and material incentives to the farmer. With the possible exception of maize, official agricultural prices have not kept pace with general inflation in the economy and the rising input costs. The marked drop in cotton production, e.g., cannot be explained by failing rain, but possibly by failure to maintain the real value of the producer price.

In Ethiopia, the reorganization of farming (state farms, peasant associations, cooperatives, parastatal marketing and input supply) has not resulted in increased incentives to farmers either. Small farmers have in fact been actively put at a disadvantage by government policies since all inputs are reserved for state farms and cooperatives, and since also the latter are granted higher product prices by the statal marketing organizations. The lesson to be learned is that institutional reorganization is seldom the suitable instrument to solve the socio-economic problems of farmers, and that it cannot substitute for active support at the farmers' level.

How effective peasant agriculture may be if it is not restricted by adverse policies is demonstrated by Cameroon. In this country, too, several attempts at restrictive intervention have been made, but government has not really achieved control over markets and prices. At the same time Cameroon has maintained self-sufficiency in food production despite the fact that food crops received only a little over 0.5 percent of the total public investment. This is attributed to the lack of enforced price ceilings for food crops and, thus, the practical absence of institutional interventions into the market mechanism.

In other countries of tropical Africa, the policy bias against agriculture can simply be interpreted as a neglect of this sector. In Nigeria, years of neglect almost destroyed the agricultural base of the country, which had been self-sufficient in staple foods and even been a major exporter in the 1960s and early 1970s. It probably was the oil-inspired prosperity of the past decade which precipitated the decline in Nigeria's agriculture. The lure of oil-rich cities prompted a massive exodus of labor and capital from the countryside. And the availability of plentiful foreign exchange made agricultural development a low priority for government.

Another, though related, aspect of neglect of agriculture is an implicit bias against food production, as most of the food commodities, generally, are provided by small-scale peasant agriculture. There are simple reasons for this bias. Credits and fertilizer, and inputs in general are almost exclusively provided by government agencies and parastatals. As communication and cooperation tend to be better with the commercial farming sector, support will be biased towards this sector. Generally, the demand for inputs and services will be relatively lower from peasant agriculture due to lower information levels. The result of such a bias can clearly be seen in Zimbabwe where only a smaller percentage of support provided by government agencies goes into the communal areas. In Ethiopia practically all of the agricultural credit goes to state farms, and of the 75,000 t of fertilizer imported in 1982, about 60,000 t were allocated to state farms, which is a typical example for the support bias against peasant agriculture (often synonymous with food production).

Much of the support bias in tropical Africa can be traced to the limited infrastructure. Transportation networks are inadequate and hamper the ability to effectively distribute agricultural commodities to markets. A mayor limiting factor is the lack of all-weather roads. Marketing organizations and supporting state agencies and extension services are often far away from peasant production areas. As a consequence, the timely delivery of inputs and outputs cannot be guaranteed, and a potential marketable surplus of small-scale peasant agriculture cannot be used. Sometimes, such infrastructural shortcomings are compensated by other policies. In Malawi, e.g. state agency buying prices are constant throughout the country, which means that farms close to the market are in fact subsidizing producers in more distant parts of the country. It has to be questioned, of course, whether price policy really is the appropriate instrument to correct for a lack of infrastructure.

The role of pricing policies

Price policies generally are the instruments most effectively and most generally used against agriculture. This holds for export crops and, more importantly, even for local food staples. In Zimbabwe, foreign currency earnings and food security became important issues after UDI (Unilateral Declaration of Independence) in 1965. Producer prices were used to ensure agricultural self-sufficiency and to promote export crops. This policy coupled with a political commitment to maintain low food prices led to increasing agricultural subsidies. In the initial period, it was particularly the tobacco industry, a vital foreign currency earner that was subsidized. Food subsidies started to increase substantially from 1975 onwards. But the financial burden was put more and more on the producers' shoulders through the price policy. For example, in 1983/84, the maize producer price was kept at Z$ 120/t which many claimed was too low to encourage production. A drought reduced overall yields, and because an insufficient area was planted in the traditional maize producing commercial areas, the country was forced to import maize worth over Z$ 200,000 at a cost of between Z$ 240/t-310/t. In the light of this situation, the government announced a substantial increase in the producer price to Z$ 180/t for the 1984/85 season. While this is still far below the world market price, the fear has been voiced that in case of a good harvest the budget might be overburdened. The possibility of external trade does not seem to be taken into account.

Another example for price policies biased against food crops relates to groundnuts in Zimbabwe. The groundnut price is not high enough to encourage delivery of the crop to state marketing boards, and currently producers can get more than double the official price by selling through informal channels. This practice is illegal for the commercial producers who are required to sell their crop directly to the state marketing board, and many of the producers are switching from groundnuts to other, more profitable, crops.

In Nigeria, commodity boards have been established for several crops. These boards operate guaranteed minimum pricing systems either through direct purchase from farmers or through licensed buying agents in the case of export crops. Practically, the boards work as a producer tax system. The producer prices have been gradually raised in the past, but open market prices for some food commodities are 100-290 percent higher than the guaranteed minimum producer prices. For some individual commodities, these "tax rates" are listed in Table 6.1. The table also shows that price ratios are distored due to government intervention. Above all, maize and Guinea corn production is favored to the disadvantage of rice and palm oil. Such enormous price interventions must have their effect on agricultural production.

Table 6.1 Open Market Prices and Guaranteed Minimum Prices of Some Food Commodities in Nigeria, 1985 (a)

Commodity	Guaranteed Minimum Price (Naira/t)	Open Market Price	
		Naira/t)	(in % of guaranteed minimum price)
Maize	400.0	900.0	225
Millet	420.0	1,200.0	285
Milled Rice	596.0	1,920.0	322
Beans	650.0	1,800.0	277
Groundnut	650.0	1,800.0	277
Guinea Corn	420.0	950.0	226
Palm Oil	600.0	2,040.0	340

(a) At Enugu, March 1985.

Source: Skoup and Co. Ltd., 1985.

In Burkina Faso, too, price distortions are evident. Traditionally price increases for cereals have lagged behind price increases for cotton, and it is only recently that the relative price for cereals like sorghum, millet and maize has improved. But the ratio of producer and consumer prices is still distorted. Due to government intervention, consumer prices for sorghum, millet, and maize in 1980 were about 40 percent higher than producer prices, and for rice the difference even amounted to about 100 percent.

Examples like these can be found throughout Africa. Pricing policies are used erroneously or rather arbitrarily for various political objectives, but almost never to maximize overall agricultural production, and they seem to have little to do with the notion of comparative advantage. That governments could use price policies to increase the production of staple foods has been shown by Malawi. Here the relative importance of tobacco, groundnuts and maize has been changed effectively and quickly by pricing policies. From 1967 to 1983 the value of tobacco purchases as a percentage of total purchases decreased from 24 percent to 14 percent. Groundnuts equally experienced a decline from 35 percent to 11. Maize purchases, on the other hand, increased significantly. In 1967 the crop represented only 22 percent of the total value of crops purchased; by 1983, this had increased to 57 percent. The shift towards maize away from tobacco and groundnuts reflects the changing returns to labor that the government's pricing policy has created.

Pricing policies may even result in increased fluctuations instead of preventing them. In Malawi, again, the pricing policy for maize is intended to prevent costly and politically embarrassing imports in poor years, and the country has built the necessary infrastructure to store maize. However, after a deficit, prices are normally increased, resulting in surpluses the following year. For example, in 1970 after maize had to be imported, prices were increased, and in the following years, there was maize for export. The same situation repeated itself in 1975 and again in 1980. There is ample evidence that such a pattern of pricing mechanisms and production is typical for many countries.

Extension concept

A final policy bias against food production, notably from peasant agriculture, can be seen in an inadequate extension concept. Traditionally, the "master farmer" concept has been used in many developing countries of tropical Africa. This concept corresponds to the classic North American approach to extension according to which farmers were divided into a more advanced group, and the rest. The extension service would then tend to devote most of their time to the more advanced, often better-off, farmers, thereby further increasing the already existing income differentials. Justification for this extension methodology was based on the "across the fence" or "trickle down" theories of extension. This view cannot be completely wrong as is demonstrated by the high adoption rate of very visible innovations such as hybrid maize, e.g. in Zimbabwe. Given the poor resource base available to the majority of small-scale farmers, this extension concept has come under more and more criticism and is thought by a number of authors to be responsible for the relatively poor adoption record of African peasant agriculture.

A further problem has been the preference of extension services for crops like maize, often less suitable for lower-rainfall areas than sorghum and millets, and for non-food cash crops, like cotton, tobacco or sunflowers. It can be argued that the promotion of these crops has increased the risk of crop failures in more marginal areas and has significantly reduced the range of minor food crops, so important for a balanced diet. In Zimbabwe, the predominance of maize and the decline of groundnuts, Bambara nut and chickpeas have significantly reduced the quality of diet in many rural areas. It is not uncommon to find extension workers who are completely conversant with the technologies required for growing cotton, yet are unable to even supply the local names of the most commonly grown sorghums in their area. In addition to these problems, the education level of extension workers is often rather low, resulting in poor quality of advice. Finally, there is, as mentioned above, the neglect of women in their agricultural role.

6.5 The Contribution of the CG System

There have not been many cases of research impact on agricultural production in tropical Africa. In general, the performance of research and the adoption of new technologies on this continent have not been impressive, and the role of IARCs has been rather modest. Hence, IARCs cannot identify themselves with many success stories but they cannot be held responsible for widespread failures either.

Evidence and extent of center effects in the past

The crucial role of IARCs in developing high-yielding rice and wheat varieties is well known. The term "green revolution" denotes this success story of IAR. The great bulk of economically tangible benefits from the CG system has come from semidwarf wheat and rice varieties, developed by national programs from genetic materials, provided to them by CIMMYT and IRRI. The modern wheats are now grown on over 35 million ha (or 45 percent) of the wheat area of the developing world, and the modern rices are grown on over 70 million ha (55 percent) of the rice area of the developing world (Anderson et al., 1985).

In tropical Africa this green revolution did not really take place. Rice traditionally has not been a major crop in Africa, although it is becoming increasingly important, particularly in West Africa. New varieties from Asia and from IRRI have been tested under local conditions with mixed results. Under controlled irrigation conditions as well as on some broad flood plains, not subject to deep flooding, they have shown considerable potential and are commercially planted. They have not performed as well under other cultural conditions including upland sites, deeply flooded land, and mangrove. They also are susceptible to local strains of diseases. In Burkina Faso, e.g., several varieties have been introduced and tested in a joint effort by IRRI, WARDA, and FAO. Six IARC-influenced varieties have been retained and are further tested, but new varieties have not yet really entered the farm level. Altogether, the adoption of new varieties is rather low although research to develop varieties suitable to local conditions is underway in IARCs, NARSs, and regional programs.

Concerning wheat, the high-yielding varieties have found a modest foothold in some African countries, principally in eastern and southern Africa, such as in Ethiopia, Kenya, Sudan, Tanzania, Zambia and Zimbabwe (Dalrymple, 1984). In addition, the high varieties are being grown in several West African nations. In Senegal, these varieties were planted for the first time in 1973/74 on an experimental basis. Small areas were reported in Cameroon, Chad, Ghana, Mali, and Burkina Faso in 1975. Wheat is also grown in Nigeria, Mauretania, Mozambique and Niger. However, these developments have to be characterized as a "quantité négligeable" in tropical Africa's food production.

The discussion of center impacts on agricultural production in tropical Africa, therefore, cannot focus on any obvious success stories on this continent. Collaboration with NARSs is just beginning. Visible past impacts are the exception, but potential impacts may be building up. Furthermore, the search for impact areas must not concentrate on spectacular events, but look for possibly modest but steady and helpful improvements in agricultural production. Tropical Africa is no example for quick success stories, but may demonstrate the necessity for long-term and continuous support of agricultural research in order to achieve results.

Table 6.2 gives an impression of the broad involvement of IARCs in tropical Africa to increase production through higher yielding crop varieties. It shows that many varieties released by national African authorities can, in fact, be related to center material (cassava, cowpea, millet, pigeon pea and potato). In total, however, CG-related varieties are much more widely used in other developing country regions.

Table 6.2 Number of CG-related Varieties Released by National Authorities in Developing Countries, 1983

Crop	Number of CG-varieties in use				
	Africa	Asia	Latin America	Near East/ North Africa	Total
Rice (a)	30	187	30	2	249
Wheat, bread	62	32	100	44	236
Wheat, durum	0	0	1	9	10
Maize	59	44	96	2	201
Barley	0	2	0	8	10
Sorghum	8	18	5	0	31
Millet	5	3	0	0	8
Cassava	26	5	32	0	63
Potato	31	16	12	2	61
Chickpea	0	1	0	3	4
Cowpea	14	2	12	1	29
Pigeon pea	5	2	0	0	7
Field bean	4	2	90	0	96
Pasture species	0	0	12	0	12

(a) Excludes semidwarfs developed by national programs from sources similar to those used by the centers.

Source: Anderson, J.R. et al., Global Report on the Impact of IAR, Draft. Washington, 1985.

The table shows, on the other hand, that modest CG impacts in terms of varieties used in Africa do exist though they may not be detected at first glance. This is due to the centers' complex interactions with NARSs and to their widespread engagement. To properly assess their activities, therefore, it may be helpful to look at a particular country in more detail.

In Nigeria, e.g., production impacts of IAR are beginning to be felt in several areas. In cooperation with the NARS and IITA, already far-reaching innovations on cropping/farming systems have been made. They include the development of suitable intercropping systems for yam/maize, and cassava/maize, and maize/rice/cowpeas in the different ecological zones of the country as well as the identification of herbicides, insecticides and fungicides suitable for these particular farming systems.

In the field of animal research, a number of important innovations have been recorded (artificial insemination, pasture species, pasture seed harvesting techniques). Concerning crop production, there are several proofs of center impacts. The high demand for cassava planting material by government institution, the enthusiasm shown by a number of private farmers in the yam minisett technique, and the hurried formation of private seed companies for the production and marketing of hybrid maize are a measure of the interest in these innovations.

For rice it is difficult to estimate what proportion of the area planted carries the improved varieties. But based on a study by Skoup and Co. Ltd. on rice production in the river basin development authorities in 1983/84, it may be estimated that about 17 percent of the total area planted to rice carried some new improved varieties while the output from these improved varieties is estimated at about 55 percent of the total paddy produced in the country.

The extent of adoption of new sorghum varieties can be indirectly inferred from the qualities of sorghum seeds, supplied to various states. Sixty-five percent of the total is of the improved varieties. For millet, yields have considerably improved in recent times. The main achievements of research collaboration between IITA and the NARS have been the development of high-yielding and disease-resistant varieties of maize and their release to the farmers through the extension service. For the 1985 season, 800 t of seeds have been distributed, sufficient for planting about 30,000 ha. For cassava, finally, yield and area figures show that the new improved production technology is being widely accepted. But there is still a wide gap between the achieved and the potential yield from improved varieties.

The case of Nigeria demonstrates that it is difficult to trace back production effects to center activities, but that such links do exist. A further example for the beneficial influence of IARCs is the role of CIMMYT wheat varieties in Zimbabwe and Malawi that have been noted as successful. These cases also serve to demonstrate, however, that (1) a longer period of collaboration, and (2) a functioning national "research environment" are necessary to achieve such impacts. Another positive example is IITA's research on high-yielding varieties of cassava combining resistance to bacterial blight disease and to African mosaic virus, and its research on streak resistance maize germplasm (Eicher, 1984). A visible impact can also be seen for cassava research and production in Malawi.

These are positive examples of impact but their proper dimension has to be recognized. The production effects can at most be characterized as modest when compared to the overall food situation in tropical Africa or to the green revolution success story. Moreover, Nigeria is probably only one of very few countries, where visible impacts can be found at all. Nevertheless, the picture derived for Nigeria may characterize the perspective for other countries, provided that continuous and strong collaboration between IARCs and NARSs exists in the future.

Senegal, e.g., is one of those countries with positive indications. In some regions, millet varieties (IBV 8001 and IBV 8004) are planted that clearly relate to ICRISAT material. Several IRRI rice varieties are grown in irrigated areas (IR-442, IR-1529, IR-8 and IR-22). The most widely used variety is 144B9, which originated in the French research institution IRAT.

Lessons from failure

These developments cited are encouraging, but there is also disappointment with the overall performance. To learn from the past, lack of success if not failures, have to be noted and analyzed in West Africa, this especially relates to maize, rice, sorghum and millet (Eicher, 1984). Maize is a minor crop in this region relative to millet and sorghum, which are the staple foods in rural areas, and relative to rice and wheat in the cities. Smallholder maize yields are low compared with maximum yields of 8t/ha on research stations. For reasons that are unclear CIMMYT, IITA, IRAT and national research and extension services have been unsuccessful in producing maize varieties that are "self-spreading" like those in Zimbabwe and Kenya. Perhaps one reason is that a sustained (decade-long) maize breeding program has not been carried out in West Africa.

Considering rice, WARDA's lack of success in testing imported material from IRRI has already been discussed. Equally, ICRISAT's attempts at direct transfers of high-yielding sorghum and millet varieties to West Africa have been largely unsuccessful. These examples, too, demonstrate that rapid widespread and sustained impacts of IAR in tropical Africa have not been achieved in the past. After the green revolution experience, particularly in Asia, the hopes for Africa were high. IITA was opened only a few months after IRRI had released its high-yielding variety after only six years of research (Eicher, 1984), and consequently, expectations of rapid successes were high. In the meantime it is acknowledged that quick results from research are more the exception. Progress has to be expected to come in small cumulative steps as a result of sustained efforts over a long period of time.

This latter perception of agricultural research, renders the role of IAR even more important. It has been argued in the preceding chapter that the CG system is a central part of a global research network initiating and fostering research to the benefit of the poor in developing countries. This role is complex and cannot only be assessed by whether a "Green Revolution" has been triggered off or not. Tropical Africa probably constitutes the biggest challenge for this new and complex interpretation of IAR. Some elaboration therefore appears appropriate.

First of all, the importance of agricultural policies and, in particular, pricing policies cannot be overemphasized. Promising research results fail to have an impact if the "research environment" is not appropriate. Several examples illustrate the dilemma. In Malawi, groundnut yields have not increased significantly because of the generally low standards of crop husbandry (timely planting, adequate plant populations, weeding, etc.) Other factors affecting yield appear to be the lowering of the soil pH where sulphate of ammonia has been used and the effect of calcium deficiencies. These problems can be solved with known technologies; however, most of these would require an increase in purchased inputs, which is not economical at the prevailing low price paid for groundnuts. Pricing policy currently precludes any improvement in groundnut production. A similar problem exists in Kenya, where triticale and durum wheat varieties have been released, but not adopted at the given price (incentive) levels.

How beneficial, on the other hand, research efforts can be if they are appropriately backed and supported by agricultural policies is demonstrated convincingly by two examples from Zimbabwe and Malawi. Zimbabwean maize research is known to have provided a number of important varieties and technologies. Their adoption by the commercial farmers has been facilitated by factors which include easy access to credit facilities and the high degree of mechanization of this group of farmers. More important may even be the agro-industrial complex developed in Zimbabwe, producing the full range of compound fertilizers, available everywhere at reasonable prices. The high capital and recurrent cost of these innovations would have prevented their adoption if they had not been supported by a good producer price for the crop, efficient and well distributed grain purchasing depots and an undertaking by the government for financial relief in the event of crop failure as a result of drought.

The Malawi example relates to wheat. In this case the government substantially increased the wheat price and provided and supported irrigation schemes in an effort to cut the wheat import bill. Hence, CIMMYT's success in Malawi's national wheat breeding program may basically be characterized as policy-induced. Programs of other centers have not been so lucky to date.

Another crucial aspect for production increases concerns the wide-adaptability concept of IARC whose limitations have already been noted. The transfer of biological material is not sufficient for success. It is necessary to also ensure a transfer of research capacities (Eicher, 1984), which may be done by increasing NARS resources and human capital. In addition, there is a need to improve downstream services and the "research environment" in general in order to increase adoption rates. The need is for an integrated research approach and the provision of usable technology packages. The question of whether IARCs should play a restricted or an all embracing role in such a network exceeds the scope of this present paper. But it is a crucial question, particularly for tropical Africa.

A third aspect is the kind of impact that IARCs generate. Obviously, the ultimate goal is to enhance agricultural production, but apart from such potential direct impacts, a necessary prerequisite is to have indirect impact on NARSs. Such impacts arise from the collaboration between IAR and NAR and consist in the enhancement of NARS productivity. Due to the weakness of NAR in tropical Africa, this is, in fact, most important for any major impacts in practical agriculture. The centers are well aware of this problem and get increasingly engaged in this field. Enhanced research collaboration may not have visible production results today, but has been recognized as a necessary prerequisite for the future.

Related to the issue of indirect impact is the question of time. One of the reasons for a lack of direct impacts of IAR in tropical Africa may be its short period of involvement. Crop research is time-consuming and results only occur after a minimum period of time, which many estimate to be about 10-20 years. Livestock research demands even more time. The collaboration between the CG system and NARSs in tropical Africa is only just in about the middle of the minimum nearing that time span. Political instability all too often interferes with long-term continuity of the collaboration. Thus cooperation with Zimbabwe, only dates back to the time after independence with the exception of CIMMYT. ILCA's program in Ethiopia was built up during a phase of turmoil and revolutionary change in that country. A large number of African countries most in need of production advances do not provide the necessary stability for fruitful collaboration with the IARS. It is obvious that direct impacts cannot be expected under such circumstances. As a consequence, the few advances in food production that tropical Africa has had are largely due to factors other than the collaboration with the IARCs. This is true for the case of maize in South and East Africa as it has been discussed above. Other examples are the control of the East Coast fever in Zimbabwe and the eradication of the tsetse fly over large areas of southern and eastern Africa as well as in Nigeria. It is true also for smallholder dairy development in Kenya.

Innovations with potential impact

At this point in time, impact evaluation of the CG system in tropical Africa is mostly evaluation of potential impacts, the pipeline. Everywhere new varieties are being tested, and some are ready for release. Promising are, e.g., IITA's early cowpea varieties, able to mature within 55 to 60 days (Eicher, 1984). In general, much effort is also devoted to crops like sorghum and millet which have traditionally been neglected. Research on crops like cowpeas and field beans could effectively help in the overall improvement of the cropping pattern and of the diet on subsistence farms. In Kenya, many new varieties are expected to be released soon. This concerns cereals, but also a broad range of other food commodities. There is also quite some expectation concerning the development of a vaccine against theileriosis. Recently, a drug has been developed and shown to be effective against the disease. However, it is still too expensive except for highly productive grade animals. Cheaper vaccines are currently being tested. In the long run this is likely to be one of the most important developments in the livestock industry.

Considering mechanical improvements, IITA's "zero tillage" farming technology has to be mentioned as a viable alternative to the current bush fallow system. In Cameroon, tissue culture and germplasm maintenance are considered as innovations with potential impact now that the NARS has started a program on genetic resources. It is hoped that IITA and CIAT collaborate with Cameroon to strengthen this field for the benefit of Central Africa as a whole. Another major concern is rangeland deterioration and widespread erosion. Few studies have been done to appraise these rangelands of sound management and little, if any, information exists concerning the major factors and parameters, which should be manipulated for range improvement. This then dictates the establishment and development of range research programs covering all ecological zones involved to achieve the multiple use of range resources and increase rangeland productivity. ILCA is to play a major role in this endeavor.

Several more pipeline technologies are worth mentioning. At ICRISAT it was estimated that new sorghum varieties currently being tested could result in a doubling of yields in tropical Africa up to the year 2000. The gross value of additional output of current research would then be 1.1 billion US dollars at current prices. With twice as much resources devoted to sorghum research, the additional gross value of production could even reach two billion US dollars (Anderson, J.R., et al., 1985).

CIP expects its major future impacts to come from its collaborative networks with national programs, its training and information programs, its use of research contracts for basic studies, improved research methods, integrated pest management, rapid multiplication, the use of true potato seed and improved post-harvest storage and processing. Many of these activities are not aimed solely at increasing potato yields but at having a broad impact on overall efficiency of NARSs.

CIMMYT's future impacts will come from the expanded maize gene pools available to national programs. Special attention is given to problems like streak virus in tropical Africa where, within five years, new materials should offer the potential for yield gains of up to 10 percent on a good part of the area.

At ILRAD it is expected that, within five to seven years, an improved method of vaccination against East Cost fever will be available. The probability of developing a vaccine against trypanosomiasis may be lower. Within ten years, it might be possible to identify a genetic marker in trypanotolerant animals. Improved understanding of trypanosomiasis transmitted by the tsetse fly would aid in the control of all trypanosomiases and provide additional knowledge for the control of human trypanosomiasis. Contributions to parasitic immunology and enhanced knowledge of bovine immunological systems are other important potential research impacts. In case of final success over the two diseases, it is estimated that an additional 120 million animals could be carried in tropical Africa.

The future impact of the IITA/CIMMYT Africa Maize Program is expected to come from large-scale adoption in tropical Africa of improved open pollinated varieties, and hybrids. Maize populations with combined resistance to streak virus and downy mildew are being improved and, by the early 1990s, should be grown extensively in countries where these two diseases coexist, including Burundi, Mozambique, Nigeria, Somalia, Sudan, Uganda, Zaire and Zambia. Populations resistant to stem borers and drought-tolerant varieties will also be available by the early 1990s. Equally, resistance to the parasitic weed Striga has been observed in a few hybrids and may possibly be incorporated into some elite populations. The possible achievements in maize production, taken together, are expected to boost average yields to at least 3 t/ha over the coming decade. This would represent an annual increase in production of about 28 million t worth US $ 4 billion at current prices.

Cassava clones developed at IITA or based on IITA material are currently grown on about 1.5 million ha in 12 African countries. With the development of the tissue culture technique and as links with national programs are strengthened through training and collaborative research, these clones should spread to 5 million ha by the early 1990s. This would generate additional annual gross income of about US $ 9 billion to African farmers, every year at current prices. Also, initial results from the two-pronged attack on the mealybug and green spider mite have been promising. Clones resistant to these pests have been identified and are being incorporated into high-yielding and disease-resistant clones and populations. Natural enemies of the mealybug and green spider mite have been introduced from Latin America in collaboration with CIAT, reared and released experimentally in various countries. Effective control of these two pests, which cause severe damage, may be achieved within the next five years. Overall, this could result in net benefits of 220 million US $ (present value, discounted at 10 percent per year). This would correspond to an internal rate of return of 41 percent or a benefit cost ratio of 4.5.

The future impact of ILCA is expected to come from enhanced knowledge of African livestock systems. In particular, the introduction of forage legumes could greatly increase both crop and livestock output. Systems such as alley-cropping, intercropping and legume-crop rotations are being explored. The introduction of crossbred dairy cows and leguminous forages can raise annual milk yields and farm cash incomes substantially. Cooperative work with national programs is leading to the design of smallholder dairy projects.

The realization of future impacts

These few examples may have illustrated the possibilities of future direct impacts of IAR in tropical Africa. Generally, expectations are high, and this not only reflects wishful thinking, but also familiarity with the pipeline technologies currently in various stages of design, testing, and improvement in collaboration between NARSs and IAR. The expectations are not so much for spectacular results but for real and sustained step by step improvements.

In a similar way people in NARSs of tropical Africa are optimistic about their future collaboration with the CG system, but realistic at the same time. Thus, in Zimbabwe one is expecting further yield increases due to CIMMYT wheat varieties but not in the order of three to four times, but 5 to 10 percent per annum, nevertheless. The importance of new material in sustaining yields should also not be underestimated. Wheat consumption in

Zimbabwe continues to expand in line with trends from other developing countries, and the increase in the degree of self-sufficiency whether economically justified or not is an important policy goal by itself, given the country's foreign currency shortage. In any case, a production increase of 5 to 10 percent per annum due to research is no longer a "quantite negligeable". This demonstrates the need to sustain and increase food supply and living standards through small but solid and continual research efforts. Massive production increases of the green revolution type, as welcome as they might be, are rather atypical in research work.

CIMMYT's maize engagement in Malawi is another example. The center's varieties have been tested and compared to the best local varieties, and it is evident that they do not offer dramatic yield increases. The percentage difference in yield between CIMMYT varieties and local ones range from negative 17 percent to positive 33 percent. In most of the trials, the CIMMYT material has proved to be superior at a rate of about 5 to 14 percent. Given, that much of the imported material is not well suited to local preferences, the CIMMYT varieties could not be expected to compete effectively against the local varieties on a large scale. It is recognized, however, that in certain regions (marginal maize growing areas) the CIMMYT material is performing well and promises successful adoption.

This is an important aspect in evaluating direct impacts of IAR on production. Much of the research is directed to improve productivity in marginal areas, which have formerly been neglected by NAR. This is due to the orientation of the CG system towards food production in small-scale agriculture but also to the fact that land scarcity has become a central problem for research in tropical Africa, and the enhancement of land productivity and the integration of marginal areas into production will be a major issue for future research. It is a question whether this will result in diminishing returns to research efforts in the future. In Malawi, there have not been any significant increases in average yields between 1968/69 and 1980/81 despite the adoption of modern varieties and improved agronomic practices (higher planting density, improved spacing and the cessation of intercropping). The stagnation in average maize yields, therefore, indicates that increasingly more maize is being planted in marginal areas or, indeed, that general soil fertility is falling, thereby masking any increase due to improved technologies.

This "marginal area problem" is only one factor that operates against the IARCs in terms of research productivity and impact. Another aspect is the orientation towards tropical crops with a shorter research history. And, related to this is the emphasis on food crops of peasant agriculture on which NARSs and private research have not accumulated a comparable mass of knowledge. Altogether this can be expected to result in lower research productivity and lower impact potential at least in the immediate future.

To summarize the role of IAR in tropical Africa, there are only few direct impacts, a good number of failures and beyond that many initiatives towards collaborating with NARSs and developing innovations for impact in the future. Hence, today the concern with impact is much the concern with indirect impacts resulting from the emerging and growing cooperation with NAR. The beneficial role of the IARCs relates to the reorientation of NAR, the enhancement of scientific capital and the systematic elaboration of promising research areas in view of a slow but sure progress in agricultural productions. Tropical Africa illustrates the well known facts that effective research systems are difficult to establish, that research is time-consuming, and that research efforts must be nourished steadily and permanently. This process and the central role of IAR in it is just beginning in tropical Africa.

The crucial role of the NARSs in this collaboration with IAR requires some elaboration. The idea of IAR is to offer germplasm and other technologies, potentially useful for a range of countries. NARSs are expected to exploit and modify this offer and build it into national research activities. If actual impacts on practical agriculture are finally achieved it seems arbitrary, if not impossible to isolate the specific contribution of IAR. Rather, the impact has to be considered as the result of a successful collaboration between IAR and NARSs. The attempt to separate partial contributions to impact makes little sense. This is demonstrated by wheat research in Zimbabwe. CIMMYT's role in enhancing wheat production in that country has already been described, but a quantitative evaluation of the historic role, played by CIMMYT genetic material, is extremely difficult. One can only point to a successful interaction between the NARS and the IARC that supplied biological material. It may in fact be part of an IARC success not to elaborate on its contribution to a national technology development. Thus, in Zimbabwe national wheat breeders were allowed to use CIMMYT material in their program and to name the released variety. The exact nature of the CIMMYT parentage was therefore hidden in the minutes of the release committee. This unrestricted provision of material and the process by which the national breeding program is allowed to take credit for the new variety is an excellent example of an IARC providing incentives for local researchers and making a useful contribution to the development of a NARS.

There are several more examples in this respect. In Kenya, CIMMYT has had a collaborative shuttle breeding program for wheat and triticale. The program has produced many high-yielding wheat varieties, and several of these varieties were derived from CIMMYT's Mexican collections. In 1984, 16 varieties were recommended for production, and of these, 13 appear to have Mexican heritage. Other centers, too, have contributed to Kenyan national breeding programs in a similar way. ICARDA material has been incorporated into barley varieties. Cowpeas from IITA and pigeon peas from ICRISAT were selected for the Kenyan situation. The former took too long to mature while the latter had too small grains. Nevertheless, the varieties have provided a source of materials for breeding of varieties with better characteristics, e.g. better disease- and pest-resistance. Equally, a sweet potato variety has its origin at IITA and a rice variety at IRRI. Tanzania, to give a final example, has benefited from useful cowpea germplasm from IITA and recently two cowpea varieties were released from the national breeding program.

The attribution of impact successes, therefore, will always be arbitrary and the contribution of IAR will tend to be underrated for the same reason that the value of basic research is often underestimated when compared with applied research. Formally, IAR may be interpreted as a factor in national research production functions which enhances their output but whose marginal effect is principally unmeasurable.

Another aspect is also brought out by the examples. The success of IAR is closely linked to the success of NAR and, hence, to the strength of NARSs. To quote a senior official of the Malawian NARS: "A research organization has to know what to ask for if it expects to gain from the IARCs. Equally it must have the ability to tell the centers what it does not like and what it expects." Obviously, the strength of NARSs is the crucial problem for IAR success in tropical Africa. The shortcomings of the NARSs are many. They are mostly due to organizational problems, lack of human capital and lack of support for scientists. Furthermore, as has been mentioned, there has been a traditional bias against food production in small-scale peasant agriculture and an inadequate extension service.

Despite these severe shortcomings of NARSs and their negative effect on IAR impact in tropical Africa there is no substitute for the NARSs. According to Ruttan "only a country that establishes its own research capacity in agriculture can gain access to the advances in knowledge that are available to it from the global scientific community and embody that knowledge in the technology suited to its own resource and cultural endowments".

High priority should therefore be given to strengthening and improving the performance of NARSs (Spencer, 1985). It is acknowledged that even today a large part of NARSs is funded by external aid. In Malawi, over 50 percent of the agricultural budget including research expenditures has been raised from both internal and external loan and grant funds in the first half of the eighties. In Ethiopia, the establishment and development of the NARS has been largely dependent upon technical assistance from UNDP and FAO and in Cameroon, external sources of funds also account for more than 50 percent of food crops research.

It is essential for IAR success in the future that there be a continuous and strong NARS support in the future. However, the centers also play an important role in this respect. Their contribution in strengthening NAR lies in the close communication and cooperation with NARSs. It is essential to establish a bottom-up approach and develop an awareness of local needs and problems. This is only possible in an atmosphere of close interaction and partnership. To illustrate such collaboration, ICRISAT's regional groundnut program in Malawi may serve as an example. The relationship between the Malawian groundnut program and ICRISAT is extremely good and to mutual benefit. Thus the previous breeder left Malawi to join ICRISAT and help establish the groundnut program at the center. It is generally accepted that with the advanced stage of Malawi's groundnut program, ICRISAT has benefited at least as much from the interaction as has the national program. The interaction between the IARC staff and the national program is good, and the ICRISAT staff have been careful to ensure that the national program is encouraged and developed. The local breeder is able to choose what he likes from the large number of lines being evaluated by ICRISAT. Two of these advanced lines have been selected by the national program and they have been incorporated into the breeding program where they will be crossed with local material. The close proximity of the two experienced ICRISAT staff has been helpful to the local program because of their thoughtful and supportive interaction. A senior member of the NARS stresses that the interaction is good because the Malawian breeder is experienced and is on equal footing with the IARC staff. Without this, he feels that national scientists are often overawed by IARC staff and that in these cases, interaction can be one-sided, problematic and unsuccessful.

Chapter 7

CONCLUDING REMARKS

The system of international agricultural research centers with all its different types of activities on the whole performs well by any standard but has not so far had the expected impact in tropical Africa. Tropical Africa in that sense constitutes the biggest challenge to the system and begs answers to a number of far-reaching questions:

- Should the system retain its global nature or become more region-specific? It can certainly be argued that in terms of commodity value or importance of products in the diet the research pattern does not adequately reflect the African situation. By adjusting, however, the system may gain in regional equity but lose in global efficiency.

- Should the centers continue to go for wide adaptability of their biological material or should they be more conscious of the ecological diversity so characteristic of the African continent?

- Is the concentration on applied research adequate for Africa's problem or should the system go "downstream", i.e., getting more involved in local testing, dissemination, extension and similar activities?

- Is it appropriate for the centers to do most of their work "in abstracto", i.e. without consideration of practical policy frameworks, infrastructure, administrative capacity? Is it possible to usefully take such aspects into consideration thereby making research more applicable and more relevant?

The centers have already taken initiatives to meet African needs and, in fact, an implicit compromise between global and regional responsibility would best describe the present state of affairs. There is no such thing as a free meal, however, and any strengthening of specific regional efforts will necessarily restrict global impact potentials. It is up to the system to make explicit decisions in this respect facing the costs of alternative evolutionary paths.

In whichever way the system responds to the African challenge it should be very modest in its expectations for achievements in Africa. Agricultural development is a complex process. If the European experience is anything to go by it teaches that the introduction of biological material by no means is the only, seldom the most important change. Institutional reforms, infrastructural developments and an increased emphasis of economic thinking towards farming have at least been as important.

The other lesson to be learned from history is that development is not a painless and self-sustaining process that comes about and is accepted voluntarily. The development process, instead, has to be backed by strong political and social support. There are not many African governments at present that are benevolent and foresighted enough to properly take care of this process.

Development is a societal process and the impact of individual research project successes should not be overestimated. It is not the possible speed of a single car that counts but the rate of flow of traffic. Societal processes take time and there is no mechanistic way of controlling speed and direction. It is norms that change and institutions that are torn down or built up. This happens within a society and very little influence can be exercised on this process by external intervention and aid.

A realistic view of IAR in the overall development process, therefore, is necessary. Expectations in the possibility of development by research efforts should not be too high. Research is only one component in that process. The international agricultural research centers are only one component of research. Whatever reactions there might be of the system to the African challenge, modesty is the key word when it comes to specifiying expectations.

ANNEX

Terms of Reference for Country Studies

The country studies are based on the terms of reference as given by the CGIAR Secretariat. The secretariat also provided a guide for personal interviews in NARSs. Both informations are listed below.

It was a genuine opportunity to carry out studies for several countries at the same time. The advantage was to get both detailed country information and an integrated view of the impact of IAR in tropical Africa. In order to use such an opportunity it was necessary, of course, to prepare the country studies in a comparable way. These studies are all based on a standard table of contents, which is listed below. Furthermore, a standard interview schedule was provided.

Terms of reference from CGIAR Secretariat

1. Conduct a series of interviews with the directors and principal scientists in the National Agricultural Research System (NARS, incorporating government, university and private sectors) and document their perceptions of the contributions the International Agricultural Research Centers (IARCs) have made to research capacity in the country through:

- the flow of information from the IARCs;
- the provision of genetic materials;
- the enhancement of human capital;
- contributions to research methodologies, and
- approaches to problem solving.

A guide to the institutions and individuals to be covered by these interviews is attached together with a list of central issues to be addressed.

2. Collate and summarize published and informal written materials available in the country, which document the spread and impact of innovations (stemming from collaborative work with IARCs) on food production, nutrition, income distribution, structural organization of agriculture. Any differential impact on men and women in these areas which is noted. These innovations include those developed in association with IARCs located both within the region and IARCs outside the region which have programs in the region.

3. Based on information and data obtained from national research system administrators and scientists and other available studies, document the evolution of the National Agricultural Research System since 1960 with attention to:

- The number of professional staff and their level of academic/professional training.

- The budget of the national research system and its breakdown by major regions/commodities, etc.

- Institutional structure (semi-autonomous, within the ministry, combined with extension services, etc.).

- Linkages to other agencies with responsibilities in the agricultural sector (credit, inputs, marketing, extension, price policies, imports/exports).

- Shifts in emphasis between commodities (cash crops, export crops, energy cropping, food cops).

4. Based on information from principal assistance, organizations within each country outline the major activities of non-CGIAR bilateral and multilateral agencies in supporting the national research system noting: the extent of this support relative to the role of the CGIAR and the nature of the support (these may include World Bank loans, USAID programs, IICA, FAO/UNDP, IDRC, GTZ, DANIDA, Foundations, etc.).

5. Based on information obtained from national scientists, document the linkages between the NARS and the IARCs by which the research needs and priorities of the NARS are reflected in the allocation of resources by the IARCs (informal contacts, visits, regular planning meetings, involvement of IARC staff or national and regional bodies, involvement of NARS staff on CGIAR, TAC, Boards of Directors of IARCs).

6. Enumerate and briefly describe potentially significant innovations currently being tested and adapted by NARS prior to release, and the expected magnitude of their impact on agricultural production.

7. Based on published and unpublished research papers and data readily available within the country, describe the extent to which the institutional and economic environment in the country has enhanced or impeded the demand for technological change with special attention to the evolution of the structure of incentives facing the agricultural sector, and the relative incentives between commodities within the sector.

8. Examine the division of research effort between the NARS and the IARCs noting the nature of tasks performed by each, and assessing: the extent to which the IARCs are complementing the NARS; the extent to which resources in the NARS are being dedicated to basic research in areas and commodities which lie outside the mandate of the IARCs.

9. Conduct a series of interviews with approximately 10 professionals in each of three or four selected commodity programs (a total of 30-40). The programs chosen should be those with major collaborative linkages with the IARCs. The professionals selected would include those working in regional research centers. The questionnaire will be provided.

Guide for Personal Interviews in NARSs (1), Provided by CGIAR Secretariat

Category/ Position		Suggested No. of Interviews
A.	National (and some State) Government Research Programs	
	Director and Deputy Director	1+
	Assisting Directors (including social sciences and training)	3+
	Commodity (1) and/or Regional Directors	5
B.	University and Research Institutes	
	Agricultural Faculties (1 or 2 most significant), Deans	4-6
	Research Institutes, Directors	0-4
C.	Private Sector Firms	
	Research Directors of private firms supplying agricultural inputs (seeds, chemicals or involved in processing)	0-4
D.	Producing Organizations	
	Executive Director or Deputy	0-2
E.	Planning Commission/Office of Agricultural Planning	
	Principal Officers including program for women in agriculture	2-4
F.	National Extension (and perhaps some State) Programs	
	National Directors/Principal Officers	3-4

(1) Restricted to those commodities for which the IARCs have responsibility

Standard Table of Contents for Individual Country Studies

Measurements and Currency
Abbreviations and Acronyms
Acknowledgements
Summary

1 BACKGROUND

- 1.1 The Study (purpose, approach, implementation)
- 1.2 The Country
  - 1.2.1 Natural Setting
  - 1.2.2 Population (abundance, distribution)
  - 1.2.3 Economy (per capita income, sector contribution, employment by sector, trade and foreign exchange position, public budget allocation)
- 1.3 The Agricultural Sector
  - 1.3.1 Structure
  - 1.3.2 Infrastructural Support
  - 1.3.3 Pricing (incl. standard table of price indicators)
  - 1.3.4 Past and Present Performance (sector contribution, production by commodity, export crops, food imports)
  - 1.3.5 Policy Issues

2 THE NATONAL AGRICULTURAL RESEARCH SYSTEM (NARS)

- 2.1 Overview (definitional problem, role of private research, CG and non-CG activities)
- 2.2 Institutional Structure
- 2.3 Budget (in relation to total public budget, to allocation to agriculture, to value of agricultural production; budget by type research/commodity; budget evolution since 1960)
- 2.4 Staff (structure by seniority, expatriate involvement, turnover, evolution since 1960, numbers by type of research/commodity)
- 2.5 External Influence (bilateral and multilateral non-CG; CG-IARCs and their importance by mandate; overview of funds and personnel from abroad)

3 IMPACT OF IARS (1) ON THE NARS (2)

- 3.1 General Issues (factors affecting impact; the with-and-without problem)
- 3.2 Biological Material
- 3.3 Ideas, Research Techniques and Methodologies
- 3.4 Research Organization (incl. regional cooperation)
- 3.5 Information and Training (incl. e.g. ILCA microfiche activities; dissemination of IARC info: formal and informal training)
- 3.6 Relationship between IARS and NARS (complementarity of activities; competition for staff; coincidence of needs and priorities)

4 RESEARCH IMPACT ON AGRICULTURAL PRODUCTION (3)

4.1 Important Innovations (list and describe important research-generated innovations from the last two decades; give their origin)
4.2 Adoption of Innovations (describe the organization of the transmission mechanism (extension); interaction with complementary inputs; estimate extent of adoption for the different innovations)
4.3 Production Effects (area, yield, quantities; with-and-without problem)
4.4 Other Effects (income, welfare, nutrition, structural changes, distribution, gender issues)
4.5 Innovations with Potential Impact (presently under test; estimate potential impact)
4.6 The Contribution of the IARS

5 CONCLUSIONS

6 REFERENCES

7 APPENDICES

7.1 Persons Interviewed
7.2 Places Visited
7.3 National Agricultural Research Institutes
7.4 Itinerary

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(1) International Agricultural Research System; to refer to the CG-financed centers only.

(2) The section uses the replies from the questionnaire which gives the perceptions of persons, but then presents facts from any source and discusses issues for each impact area.

(3) The section is not limited to research impact through the IARCs.

ANNEX TABLES

Annex Table 2.1 Yield (a) of Important Commodities in Selected Countries of Tropical Africa in Percent of Total Yield in Developing Market Economies 1981-83

	Zimbabwe	Malawi	Tanzania	Kenya	Ethiopia	Cameroon	Nigeria	Burkina Faso	Senegal	Africa	All Developing Market Economies
Cereals											
Rice	21	34	65	204	-	90	82	46	57	61	100
Wheat	309	189	86	135	75	52	163	-	-	59	100
Maize	81	75	81	103	121	55	58	48	60	68	100
Barley	530	-	109	89	107	-	-	-	-	92	100
Sorghum	50	106	63	102	144	-	56	59	-	67	100
Millet	69	-	116	264	172	126	105	78	94	97	100
Roots, Tubers and Starchy Foods											
Cassava	38	71	62	94	-	20	107	81	34	72	100
Potato	134	28	50	63	55	19	125	-	58	62	100
Sweet Potato	26	-	83	127	-	50	189	42	67	87	100
Yam	-	-	59	-	45	50	120	67	-	102	100
Cocoyam	-	-	-	-	-	-	149	-	-	92	100
Plantain/Banana	5	21	103	78	149	39	-	-	97	50	100
Pulses											
Chickpea	-	102	41	-	123	-	-	-	-	98	100
Cowpea	-	271	115	-	-	-	92	114	182	97	100
Pigeon Pea	-	97	90	-	-	-	-	-	-	88	100
Lentil	-	-	-	-	132	-	-	-	-	92	100
Not elsewhere specified	110	-	77	91	130	33	93	128	107	100	100
Soybean	106	-	15	-	218	32	24	-	-	44	100
Groundnut	67	80	67	63	110	31	103	60	87	78	100
Beans dry	145	111	104	-	148	136	-	-	-	142	100
Vegetables	7	7	5	5	12	2	18	8	17	61	100

Livestock and livestock products											
Beef and Veal	94	93	63	80	68	93	79	58	85	79	100
Mutton, Lamb,Goat	102	102	94	91	73	87	93	61	94	92	100
Milk (b)	72	19	8	47	26	21	12	9	16	15	100
Pig Meat	101	92	73	119	92	55	81	81	92	81	100
Poultry (c)	50	8	20	13	8	8	12	8	10	91	100
Eggs (d)	26	22	52	21	20	17	30	30	17	44	100
Oilseeds											
Oil Palm (e)	-	-	112	-	-	105	73	-	86	56	100
Coconut	-	-	29	-	-	-	-	-	-	97	100
Cotton Seed	101	107	104	106	106	99	105	98	110	103	100
Other Oil Seeds	3	10	12	25	29	8	6	2	-	46	100
Other Food Crops											
Sugar	193	207	37	217	291	64	94	146	193	109	100
Fruit	0.4	-	0.5	-	0.2	0.2	-	-	0.2	7	100
Cocoa	-	-	177	-	-	70	67	-	-	81	100
Non Food Crops											
Coffee	223	139	91	131	50	58	91	-	-	65	100
Tea	222	155	81	113	-	161	-	-	-	105	100
Tobacco Leaves	172	74	48	89	58	54	47	56	-	85	100
Cotton Lint	103	77	99	97	90	113	97	111	110	104	100
Jute, Jute-like Sisal	-	7	25	38	35	18	-	-	-	69	100
Rubber	-	-	-	-	-	90	-	-	-	169	100

(a) For crops based on yield per ha, for animal products on kg per animal.
(b) Milk of cow, sheep, goat, camel.
(c) Chicken, duck, goose, turkey, based on grams per animal.
(d) Hen eggs and others, based on grams.
(e) Palm cereals and palm oil.
Source: FAO Data Files 1984.

Annex Table 2.2 Extent of Major Climates and Growing Period Zones in Africa, 1975, in Percent of Total

Major climates / Growing period zones (a)	Tropics			Subtropics summer rainfall			Subtropics winter rainfall		Total
	warm	moderately cool and cool	cold	warm	moderately cool and cool	cold	cool and cool		
Dry (0)	6.3	.1	.1	7.9	.2	0	14.9	.2	29.7
Arid (1-74)	15.1	.2	-	.3	0	-	1.3	-	17.0
Semiarid (75-179)	17.1	.8	-	.1	.1	-	.9	-	19.0
Subhumid (180-269)	17.0	1.5	-	0	0	-	.5	-	19.0
Humid (270-365)	14.0	.6	-	-	-	-	-	-	14.7
All year humid (365+)	.7	-	-	-	-	-	-	-	.7
Total	70.2	3.2	.1	8.3	.3	0	17.6	.2	100.1 (b)

(a) The figures mark growing period days.
(b) The absolute figure is 2 878.1 mio ha.

Source: FAO/UNFPA/IIASA, Potential Population Supporting Capacities of Lands in the Developing World, Technical Report of Project TNT/75/P13, Rome 1982.

Annex Table 2.3 Land Suitability (a) in Major African Climates (b) by Crop, in Million ha

	Tropics		Subtropics			Africa	Input level index (c)
	warm	moderately cool	warm, summer rainfall	moderately cool and cool, summer rainfall	cool, winter rainfall		percent
	low input level (d)						
Total (e)	415.0	15.2	4.6	-	-	434.8 (g)	100.0 (f)
Wheat	-	10.5	-	4.0	9.5	23.9	100.0
Rice	61.0	-	0.4	-	-	61.4	100.0
Maize	177.3	11.0	3.5	1.3	-	193.1	100.0
Pearl millet	134.5	-	2.7	-	-	137.4	100.0
Sorghum	172.3	9.4	3.5	1.2	-	186.4	100.0
White potato	-	8.5	-	3.9	-	12.4	100.0
Sweet potato	200.0	-	3.4	-	-	203.4	100.0
Cassava	36.3	-	1.1	-	-	37.4	100.0
Phaseolus bean	140.9	8.5	2.9	3.4	-	155.7	100.0
Soybean	142.1	-	2.9	-	-	145.0	100.0
Cotton	53.9	-	1.4	-	-	55.3	100.0
	high input level (g)						
Total (e)	546.7	16.2	5.9	-	-	568.8 (g)	130.8 (f)
Wheat	-	11.3	-	6.1	9.8	27.1	113.4
Rice	132.2	-	1.2	-	-	133.4	217.3
Maize	272.0	13.5	3.9	1.3	-	290.6	150.5
Pearl millet	239.5	-	4.2	-	-	243.7	177.6
Sorghum	257.1	13.3	3.9	1.4	-	275.7	147.9
White potato	-	10.1	-	3.7	-	13.8	111.6
Sweet potato	299.5	-	3.4	-	-	302.9	148.9
Cassava	236.6	-	1.7	-	-	238.3	636.8

(Table continued on following page)

Annex Table 2.3 (continued)

	Tropics		Subtropics			Africa	Input level index (c)
	warm	moderately cool	warm, summer rainfall	moderately cool and cool, summer rainfall	cool, winter rainfall		percent
Phaseolus bean	264.6	12.8	3.4	3.4	-	284.2	182.6
Soybean	265.4	-	3.6	-	-	269.0	185.5
Cotton	214.1	-	3.8	-	-	217.9	394.1

(a) This table is based on the agro-climatic suitability assessment of FAO's agro-ecological zones project. Suitability comprises very suitable and suitable land as opposed to marginally suitable and not suitable land.

(b) Only those climates are listed which are suitable for at least one of the crops considered.

(c) Area in percent of low input level area for Africa.

(d) Low technological level and hand cultivation.

(e) As climates may be suitable for several crops aggregation over crops is not possible. The figures show the aggregated area fo the most suitable crop in each growing period.

(f) Without moderately cool and cool subtropics.

(g) Mechanical cultivation under capital intensive management practices.

Source: FAO, Report on the Agro-ecological Zones Project, Vol. 1: Methodology and Results for Africa, World Soil Resources Report 48, Rome 1978; cited in Jahnke, H.E. and D. Kirschke, Quantitative Indicators for Priorities in International Agricultural Research. Background working paper commissioned from GFA by FAO for TAC, Hamburg and Rome, 198 , p. 43.

Annex Table 2.4 Projected Populations (a) and Potential Population Supporting Capacities in Selected Countries of Tropical Africa, 2000

	Zim-babwe	Malawi	Tan-zania	Kenya	Ethiopia	Cameroon	Nigeria	Burkina Faso	Senegal	Africa	All (b) developing countries
Projected population in mio. persons	13.9	15.5	33.5	31.5	53.0	13.6	149.6	11.7	9.9	828.5	3638.1
Projected population density, persons/km²	.36	1.76	.38	.55	.44	.29	1.64	.43	.50	.29	.56
Potential population supporting capacities in percent of projected populations											
-low input level (c)	95.7	47.1	113.4	18.4	38.1	562.5	36.6	51.3	76.8	150.8	153.6
-intermediate input level (d)	366.2	152.3	434.6	43.5	134.0	1530.2	138.3	228.2	226.3	540.1	408.9
-high input level (e)	1329.5	347.7	1485.7	165.1	580.6	4480.2	468.5	1155.6	1068.7	1549.1	914.3

(a) Projected data used in AT 2000 data files (FAO, undated).
(b) Central and South America, Southwest and Southeast Asia.
(c) Hand labor only, no fertilizer and pesticide applications, no soil conservation measures and, hence, full productivity losses arising from land degradation, and cultivation of the presently grown mixture of crops on potentially cultivable rainfed lands.
(d) Use of improved hand tools and/or draught implements, some fertilizer and pesticide application, some simple soil conservation measure lessening productivity losses from land degradation and cultivation of a combination of the presently grown mixture of crops and the most calorie - protein productive crops, on potentially cultivable lands.
(e) Complete mechanization, full use of optimum genetic material, necessary farm chemicals and soil conservation measures, and cultivation of only the most calorie - protein productive crops on potentially cultivable rainfed lands.

Source: FAO/UNFPA/IIASA, Potential Population Supporting Capacities of Lands in the Developing World, Technical Report of Project INT/75/P13, Rome 1982.

Annex Table 2.5 Calories Supply Per Capita and Per Day in Selected Countries of Tropical Africa by Commodity (a), 1975, in Percent of Total Calories Per Capita and Per Day

	Zim-babwe	Malawi	Tan-zania	Kenya	Ethiopia	Cameroon	Nigeria	Burkina Faso	Senegal	Africa (b)	All (c) developing countries
Wheat	4.5	1.1	3.1	4.4	10.6	2.7	2.4	1.1	6.7	9.9	16.4
Rice	0.5	1.2	4.0	0.8	0.1	1.4	2.3	2.5	19.8	5.1	26.4
Maize	53.9	65.1	24.5	44.4	17.5	17.9	6.0	5.8	4.0	13.8	7.9
Barley	0.2	0.0	0.2	0.6	9.0	0.7	0.3	0.1	0.1	2.6	1.5
Millets and other cereals	14.2	4.5	7.4	8.0	33.4	14.6	31.3	65.8	31.9	17.0	7.2
Roots	0.2	1.9	26.8	9.2	3.7	20.7	31.9	2.3	3.0	21.1	6.6
Sugar	7.9	3.0	3.6	8.1	2.1	2.4	1.4	1.2	7.0	4.0	9.0
Pulses	1.6	8.8	4.6	7.2	8.2	3.3	3.2	10.2	1.2	4.1	4.1
Vegetables	0.4	0.9	1.6	0.8	0.5	1.0	1.1	0.3	0.5	1.0	1.3
Bananas	0.4	0.4	6.7	1.9	0.1	8.6	2.2	0.0	0.1	3.4	1.4
Citrus fruit	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2
Fruit	0.0	1.6	1.3	0.4	0.2	0.8	0.6	0.4	0.5	1.0	1.5
Vegetable oils	6.4	6.8	6.1	3.1	3.1	17.0	12.2	6.3	16.5	9.3	7.2
Cocoa	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Beef	4.4	0.4	1.9	2.4	2.0	1.3	0.7	0.8	1.6	1.2	1.4
Mutton	0.2	0.1	0.4	0.5	0.9	0.4	0.2	0.4	0.4	0.5	0.4
Pig meat	0.6	0.7	0.0	0.1	0.1	0.7	0.2	0.2	0.5	0.3	0.7
Poultry	0.2	0.2	0.2	0.4	0.2	0.2	0.1	0.2	0.2	0.2	0.3
Milk	2.4	0.4	4.1	5.1	2.8	0.8	0.7	1.6	2.4	2.2	3.7
Eggs	0.2	0.3	0.1	0.1	0.4	0.1	0.2	0.1	0.1	0.2	0.3

Cereals (d)	73.3	71.9	39.2	58.2	70.6	37.3	42.3	75.3	62.5	48.4	59.4
Other food crops (e)	17.0	23.4	50.7	30.7	17.9	53.8	52.6	20.7	28.9	44.0	31.3
Livestock (f)	8.0	2.1	6.7	8.6	6.4	3.5	2.1	3.3	5.2	4.6	6.8
Total (g)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total, abs. figure (g)	2531	2266	2105	2161	1821	2369	2190	1980	2218	2180	2180

(a) According to FAO's AT 2000 project data.

(b) Including 37 major countries.

(c) Including 90 countries and 98 percent of total population in developing countries with the exception of China.

(d) Wheat to millets and other cereals.

(e) Roots to cocoa.

(f) Beef to eggs.

(g) Cereals, other food crops, livestock, and other commodities like nuts, spices, other meat, offals, animal fats, fish, and non-food crops.

Source: FAO, AT 2000 data files (Table 2.1 Supply Utilization Accounts).

Annex Table 2.6 Change in Input Requirements under FAO's AT 2000 Scenario B in Selected Countries of Tropical Africa (a), Annual Rate of Change 1975-2000, in percent

	Zim-babwe	Malawi	Tan-zania	Kenya	Ethiopia	Cameroon	Nigeria	Burkina Faso	Senegal	Africa (b)	All (c) developing countries
Arable land area	0.9	1.1	1.2	1.0	0.6	0.8	0.8	0.5	0.4	0.7	0.8
-good rainfall (d)	0.8	1.1	1.3	0.4	0.1	0.7	1.0	0.4	0.5	0.8	0.9
-low rainfall (e)	1.1	0.0	0.6	1.5	1.3	1.3	0.8	0.2	0.2	0.4	0.3
-naturally flooded (f)	0.0	2.7	1.2	2.0	1.9	2.3	2.3	0.0	0.5	1.6	0.6
-desert (g)	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	2.9	0.6
-problem areas (h)	1.0	1.3	0.8	1.8	2.2	0.8	0.2	1.1	0.3	0.7	1.1
Irrigated arable land (i)	2.8	6.7	1.3	2.9	3.5	3.9	7.9	5.8	2.2	2.0	1.5
Harvested land area	1.4	1.5	1.5	1.4	1.2	1.2	1.6	0.7	0.7	1.4	1.2
-cereals (j)	1.2	1.1	1.6	1.2	1.4	1.1	1.5	0.3	0.9	1.2	0.9
-other food crops (k)	2.4	1.9	1.2	1.9	1.2	1.3	1.7	1.4	0.2	1.5	1.8
-non-food crops (l)	0.7	1.9	0.9	1.1	0.5	1.1	0.6	3.7	5.0	1.6	1.4
Cropping intensity (m)	0.6	0.4	0.3	0.5	0.6	0.4	0.8	0.3	0.3	0.6	0.5
Trad.cereals seed	0.0	0.6	2.5	-1.4	1.3	0.5	1.3	0.3	0.7	0.5	-1.6
Impr.cereals seed	2.3	5.7	5.7	5.0	5.9	7.4	8.4	-	3.3	4.2	5.2
No. of animals											
-cattle	2.1	3.1	1.2	1.1	0.2	2.7	1.4	0.7	2.1	1.3	1.3
-sheep and goats	2.3	2.4	1.1	2.1	0.1	2.2	1.5	1.7	2.7	1.6	1.5
-pigs	2.7	3.4	4.9	5.2	1.9	2.1	3.3	1.2	2.7	2.7	2.4
-poultry	1.7	4.9	3.9	6.2	1.1	3.1	5.6	2.4	2.9	4.2	4.1
-milking cattle	1.2	4.1	2.5	1.9	1.7	3.3	2.1	1.5	0.8	2.1	2.0
-milking sheep and goats	0.0	0.0	2.6	2.2	-0.2	0.0	0.0	2.8	0.9	2.1	1.7
-laying hens	1.9	4.8	3.5	4.5	0.8	2.9	4.1	2.4	1.9	3.1	3.5

Labor (n)	2.4	2.1	2.4	2.1	2.1	1.7	2.2	1.5	1.1	2.0	1.7
Draught animals (n)	1.4	1.4	1.4	1.5	0.8	1.9	2.0	2.5	2.2	1.4	0.7
Tractors (n)	0.7	6.8	2.8	4.7	3.6	4.5	6.6	0.0	4.0	4.1	5.2
N fertilizer (o)	3.9	5.4	8.0	6.5	6.3	7.8	7.2	5.5	4.1	5.8	7.2
Pesticides (p)	3.0	3.9	3.5	4.8	3.4	2.8	3.6	5.7	5.1	3.6	3.5

(a) According to FAO's AT 2000 project data.
(b) Including 37 major countries.
(c) Including 90 countries and 98 percent of total population in developing countries with the exception of China.
(d) Rainfall providing 120-270 growing days, soil quality very suitable or suitable.
(e) Rainfall providing 75-120 growing days, soil quality very suitable, suitable or marginally suitable.
(f) Land under water for part of the year and lowland non-irrigated paddy fields
(g) Land with less than 75 days growing season and suitable for cultivation only under irrigation. It represents only that share of total desert land for which water is likely to be available.
(h) Rainfall providing more than 270 growing days, soils of all qualities in this zone, plus that part of the 120-270 growing days zone where soil rating is only marginally suitable.
(i) Equipped for irrigation.
(j) Wheat to millet according to Table 2.4.
(k) Roots to cocoa according to Table 2.4.
(l) Coffee, tea, tobacco, cotton, jute and hard fibers, rubber, and fodder crops.
(m) Harvested area/arable land.
(n) Based on person-day equivalence.
(o) Based on nutrient content.
(p) Based on value.

Source: FAO, AT 2000 data files (Table 4 Livestock production, Table 5 Agricultural Land Use and Inventory, and Tables 6.1 and 6.5 Input Requirements for Crops).

Annex Table 3.1 Differences between Regional and Global (a) Value of Production Shares and Calories/Protein Shares, Respectively, by Commodity, 1979/81, in Percentage Points

	Value of production shares				Calories/protein shares in the diet			
	East/South Africa	Equatorial Africa	Humid West Africa	Semiarid West Africa	East/South Africa	Equatorial Africa	Humid West Africa	Semiarid West Africa
Cereals	-11.4	-19.2	-21.7	-16.6	-8.3	-28.3	-18.3	- 8.4
Rice	-17.6	-12.9	-13.5	-17.3	-24.3	-16.6	- 8.0	-20.4
Wheat	- 3.9	- 5.0	- 5.0	- 5.0	-11.7	-15.6	-12.7	-12.9
Maize	9.9	- 1.5	- 1.8	- 2.3	28.4	3.0	4.2	- 1.4
Barley	- 0.4	- 0.6	- 0.6	- 0.6	- 1.3	- 1.2	- 1.3	- 1.2
Sorghum	0.3	- 0.1	- 0.5	2.3	0.7	- 0.6	- 0.8	9.8
Millet	0.3	0.8	- 0.2	6.2	-	2.7	0.2	17.7
Roots, tubers and starchy foods	- 0.5	26.8	22.2	37.0	8.6	23.8	19.7	9.4
Cassava	2.8	4.2	0.9	1.1	10.7	18.5	9.4	3.7
Potato	- 0.2	- 0.2	- 1.6	- 1.5	- 0.6	- 0.6	- 0.9	- 0.9
Sweet Potato	- 3.9	1.5	- 6.0	- 6.0	- 2.0	0.8	- 2.5	- 2.6
Yam	- 1.9	2.2	21.3	39.9	- 0.3	0.3	7.8	7.5
Cocoyam	- 0.3	0.6	4.6	4.2	- 0.1	0.1	2.7	1.6
Other roots and tubers	- 0.1	3.1	- 0.2	- 0.1	- 0.1	0.3	- 0.1	-
Plantain/Banana	3.1	15.4	3.3	- 0.5	0.8	4.4	3.3	0.2
Pulses	0.3	2.1	- 2.5	1.7	- 1.3	6.6	- 1.8	2.0
Chickpea	- 0.5	- 0.7	- 0.7	- 0.7	- 0.9	- 1.0	- 1.0	- 1.0
Cowpea	0.1	-	- 0.1	2.3	0.1	-	- 0.1	4.6
Fababean	- 0.3	- 0.3	- 0.3	- 0.3	- 0.7	- 0.7	- 0.7	- 0.7
Field bean	0.8	3.1	- 0.7	- 0.9	0.6	5.5	- 0.9	- 1.7
Groundnut	1.1	1.5	0.9	2.8	0.7	4.0	2.1	1.9
Lentil	- 0.1	- 0.1	- 0.1	- 0.1	- 0.1	- 0.1	- 0.1	- 0.1
Pigeon pea	0.3	-	- 0.1	- 0.1	0.1	-	- 0.1	- 0.1
Soybean	- 1.1	- 1.4	- 1.4	- 1.3	- 1.2	- 1.1	- 1.1	- 1.1

Livestock and livestock products	2.4	-12.9	-19.9	-10.1	- 0.6	- 4.5	- 7.3	- 4.5
Beef	8.6	0.4	- 4.0	-	3.2	1.3	- 0.9	0.5
Sheep and goats	0.5	- 0.4	- 0.7	1.7	-	-	-	1.5
Milk	1.0	- 4.3	- 5.4	- 3.4	1.1	- 1.0	- 1.2	- 1.2
Other livestock (b)	- 7.7	- 8.5	- 9.9	- 8.3	- 3.9	- 4.7	- 5.0	- 5.2
Vegetables	- 1.4	- 3.8	- 3.7	- 3.0	- 0.6	0.5	0.6	- 2.1
Oilseeds	- 0.2	-	1.5	1.4	0.2	0.7	2.3	2.2
Coconut	0.2	- 0.4	- 0.1	- 0.4	0.3	- 0.2	-	- 0.1
Oilpalm	- 0.2	1.0	1.8	1.6	-	1.4	2.8	2.2
Other oilseeds	- 0.2	- 0.5	- 0.2	0.2	- 0.1	- 0.5	- 0.4	0.1
Other food crops (c)	- 0.2	0.2	17.6	- 4.1	2.0	1.2	4.7	0.1
Non-food crops (d)	10.9	6.8	6.5	- 6.4	./.	./.	./.	./.

(a) This table is based on 90 developing countries of FAO's AT 2000 study plus China. The regions refer to the country grouping explained in Section 3.3.

(b) Pig meat, poultry, eggs.

(c) Sugar, citrus fruit, fruit, cocoa.

(d) Coffee, tea, tobacco, cotton, jute and hard fibres, rubber, fodder crops.

Source: FAO, AT 2000 and ICS data files; FAO, The State of Food and Agriculture 1981, FAO Agriculture Series, No. 14, Rome 1982.

Annex Table 3.2 Production in Regions of Tropical Africa by Commodity, 1979/81, in Percent of Production in All Developing Countries (a)

	East/South Africa	Equatorial Africa	Humid West Africa	Semiarid West Africa	Tropical Africa	All developing countries	(in mio.t)
Cereals	1.0	0.7	0.4	1.5	3.6	100.0	173.3 (b)
Rice	0.1	0.7	0.5	0.4	1.7	100.0	366.2
Wheat	0.3	-	-	-	0.3	100.0	157.7
Maize	5.6	1.2	0.8	1.2	8.8	100.0	149.1
Barley	0.5	-	-	-	0.5	100.0	21.3
Sorghum	2.0	1.6	0.6	11.1	15.3	100.0	43.0
Millet	2.1	3.8	1.1	25.9	32.9	100.0	26.4
Roots, tubers and starchy foods	1.5	5.9	4.0	12.5	23.9	100.0	72.6 (b)
Cassava	9.4	16.5	3.7	9.3	38.9	100.0	122.1
Potato	1.4	1.6	-	0.1	3.1	100.0	49.8
Sweet potato	0.6	2.4	0.1	0.3	3.4	100.0	140.1
Yam	-	4.2	18.5	72.9	95.6	100.0	21.3
Cocoyam	-	5.0	20.3	40.7	66.0	100.0	4.9
Other roots and tubers	0.7	32.6	-	1.6	34.9	100.0	2.7
Plantain/banana	4.1	17.8	4.1	2.4	28.4	100.0	57.0
Pulses	1.6	2.8	0.7	4.4	9.5	100.0	26.9 (b)
Chickpea	0.4	-	-	-	0.4	100.0	5.9
Cowpea	4.5	1.4	-	88.9	94.8	100.0	1.4
Fababean	-	-	-	-	-	100.0	3.8
Fieldbean	2.7	7.6	0.4	0.4	11.1	100.0	10.6
Groundnut	3.0	4.4	2.6	11.0	21.0	100.0	8.2
Lentil	-	-	-	-	-	100.0	0.9
Pigeonpea	5.1	1.1	-	-	6.2	100.0	2.0
Soybean	0.3	-	-	0.3	0.6	100.0	29.0

Livestock and livestock products	1.7	0.9	0.3	1.9	4.8	100.0	140.7 (b)
Beef	4.0	2.1	0.4	3.3	9.8	100.0	15.0
Sheep and goats	2.2	1.3	0.7	7.4	11.6	100.0	4.2
Milk	1.8	0.5	0.1	1.3	3.7	100.0	108.0
Other Livestock (c)	0.6	0.6	0.3	1.1	2.6	100.0	69.8 (b)
Vegetables	1.3	1.0	0.8	2.0	5.1	100.0	42.5 (b)
Oilseeds	1.4	2.0	2.6	5.5	11.5	100.0	11.6 (b)
Coconut	2.2	0.2	1.1	0.4	3.9	100.0	4.0
Oilpalm	0.9	5.5	6.8	13.7	26.9	100.0	5.0
Other oilseeds (d)	1.3	1.1	1.3	4.0	7.7	100.0	6.0 (b)
Other food crops (e)	1.5	2.0	4.6	1.6	9.7	100.0	46.1 (b)
Non-food crops (f)	3.6	3.5	2.6	0.7	10.4	100.0	46.7 (b)
Total	1.6	1.9	1.5	3.2	8.2	100.0	560.3 (b)

(a) This table is based on 90 developing countries of FAO's AT 2000 study plus China. The regions refer to the country grouping explained in Section 3.3.

(b) In million US $.

(c) Pig meat, poultry, eggs.

(d) Castor and linseed excluded.

(e) Sugar, citrus fruit, fruit, cocoa.

(f) Coffee, tea, tobacco, cotton, jute and hard fibers, rubber, fodder crops.

Source: FAO, AT 2000 and ICS data files; FAO, The State of Food and Agriculture 1981, FAO Agriculture Series No. 14, Rome, 1982.

Annex Table 3.3 Production in Selected Countries of Tropical Africa, 1981/83, in Percent of Production in Developing Market Economies

	Zim-babwe	Malawi	Tan-zania	Kenya	Ethiopia	Cameroon	Nigeria	Burkina Faso	Senegal	All Countries	(in mio. t)
Cereals											
Rice	0.0	0.0	0.2	0.0	-	0.0	0.5	0.0	0.0	100.0	222.4
Wheat	0.1	0.0	0.0	0.1	0.3	0.0	0.0	-	-	100.0	327.0
Maize	2.0	1.5	2.1	2.4	1.6	0.3	1.8	0.1	0.1	100.0	92.0
Barley	0.2	-	0.1	1.5	6.2	-	-	-	-	100.0	17.9
Sorghum	0.3	0.4	0.6	0.4	3.4	-	8.6	1.6	-	100.0	38.9
Millet	0.6	-	0.7	0.5	1.1	1.9	14.4	2.0	2.7	100.0	20.3
Roots, tubers and starchy foods											
Cassava	0.1	0.1	5.9	0.5	-	0.6	9.2	0.4	0.0	100.0	118.5
Potato	0.1	0.4	0.4	0.8	0.7	0.1	0.0	-	0.0	100.0	33.5
Sweet Potato	0.0	-	2.1	2.4	-	0.9	1.7	0.3	0.1	100.0	14.4
Yam	-	-	0.0	-	1.2	1.7	73.1	0.1	-	100.0	24.0
Cocoyam	-	-	-	-	-	-	49.6	-	-	100.0	3.7
Plantain/Banana	0.1	0.1	2.9	0.7	0.1	1.7	2.4	-	0.0	100.0	57.6
Pulses											
Chickpea	-	0.3	0.1	-	1.9	-	-	-	-	100.0	6.1
Cowpea	-	3.1	1.7	-	-	-	60.0	5.7	1.8	100.0	1.4
Field bean	0.4	0.6	1.5	-	0.3	3.1	-	-	-	100.0	10.0
Groundnut	9.2	1.3	0.4	0.1	0.2	2.1	4.0	0.6	6.3	100.0	13.9
Lentil	-	-	-	-	3.9	-	-	-	-	100.0	1.3
Pigeon pea	-	3.9	1.1	-	-	-	-	-	-	100.0	2.2
Soybean	0.4	-	0.0	-	0.1	0.0	1.0	-	-	100.0	21.7

Livestock and livestock products											
Beef and veal	0.7	0.1	1.1	1.5	1.8	0.4	2.0	0.2	0.3	100.0	12.2
Sheep and goats	0.1	0.1	0.8	1.4	3.9	0.4	4.7	0.2	0.3	100.0	3.7
Milk	0.2	0.0	0.4	1.1	0.8	0.0	0.3	0.1	0.1	100.0	107.0
Pig meat	0.2	0.2	0.1	0.1	0.0	0.7	1.1	0.1	0.1	100.0	4.4
Poultry	0.1	0.1	0.3	0.5	1.0	0.2	3.5	0.2	0.2	100.0	7.0
Eggs	0.2	0.2	0.7	0.4	1.2	0.1	3.4	0.1	0.1	100.0	6.5
Vegetables	0.1	0.2	0.9	0.4	0.4	0.3	2.9	0.1	0.1	100.0	117.3
Oilseeds											
Coconut	-	-	0.9	0.3	-	0.0	2.5	-	0.0	100.0	36.3
Oil palm	-	-	0.5	-	-	7.2	51.8	-	5.7	100.0	2.0
Other oilseeds	0.5	0.1	0.7	0.2	1.4	0.4	1.5	4.8	1.3	100.0	24.4
Other food crops											
Sugar	0.5	0.2	0.2	0.5	0.2	0.1	0.1	0.0	0.1	100.0	761.2
Citrus fruit	0.2	0.0	0.1	0.1	0.1	-	-	-	0.1	100.0	28.0
Fruit	0.0	0.3	0.6	0.3	0.1	0.2	1.3	0.1	0.1	100.0	76.7
Cocoa	-	-	0.1	-	-	6.4	10.0	-	-	100.0	1.6
Non-food crops											
Coffee	0.1	0.0	1.1	1.6	3.7	2.1	0.1	-	-	100.0	5.5
Tea	0.8	2.8	1.3	8.0	-	0.2	-	-	-	100.0	1.3
Tobacco	3.9	2.6	0.6	0.2	0.1	0.1	0.7	0.1	-	100.0	2.3
Cotton	1.1	0.2	0.8	0.2	0.5	1.6	0.4	0.5	0.3	100.0	5.4
Jute and hard fibers	-	0.0	1.9	1.5	0.0	0.0	-	-	-	100.0	3.1
Rubber	-	-	-	-	-	0.5	1.2	-	-	100.0	3.6

Source: FAO data files.

Annex Table 4.1 Expenditures and Manpower of Public Sector Agricultural Research in Selected Countries of Tropical Africa

	Zim-babwe	Malawi	Tan-zania	Kenya	Ethiopia	Cameroon	Nigeria	Burkina Faso	Senegal	Tropical Africa (a)	All (b) developing countries
Expenditures											
1980, in mio.US $	10.6	5.7	7.2	22.7	3.4	3.8	121.8	1.1	9.7	298.2	1 936.5
1980, in % of tropical Africa	3.6	1.9	2.4	7.6	1.1	1.3	40.9	0.4	3.3	100.0	649.4
1974-80, annual rate of change, %, (c)	5.5	8.7	-5.2	9.1	-0.2	1.6	21.3	8.7	4.1	9.8	5.3
Manpower											
1980, scientific person years	201	276	212	400	155	106	1 084	12	172	4 397	46 256
1980, % of tropical Africa	4.6	6.3	4.8	9.1	3.5	2.4	24.7	0.3	3.9	100.0	1 052.0
1974-80, annual rate of change, %	1.9	4.8	6.5	6.1	15.6	1.7	23.9	1.5	1.2	8.0	4.6
Expenditures/manpower											
1980, 1,000 US $ p. scient. pers. year	52.5	20.5	34.0	56.8	21.9	35.7	112.4	92.1	56.5	67.8	41.9
1980, % of tropical Africa	77.4	30.2	50.1	83.8	32.3	52.7	165.8	135.8	83.3	100.0	61.8
1974-80, annual rate of change, %	3.6	3.7	-11.0	2.8	-13.7	-0.1	-2.1	2.8	-	1.6	0.7

(a) West Africa, East Africa, and Southern Africa with the exception of South Africa state.

(b) Asia, Africa and Latin America with the exception of South Africa state and Japan.

(c) Based on constant 1980 US $.

Source: Judd, M.A. J.K. Boyce and R.E. Evenson, Investing in Agricultural Supply, Center Discussion Paper, No. 442, Economic Growth Center, Yale University, New Haven 1983.

Annex Table 4.2 Trends for Expenditures and Manpower of Public Sector Agricultural Research and Extension by Developing Country Group in Tropical Africa, Annual Rate of Change 1970-80, %

	Expenditures (a)		Manpower (b)		Research/Extension		Manpower/Expenditures	
	Research	Extension	Research	Extension	Expenditure	Manpower	Research	Extension
Tropical Africa								
West	8.4	1.2	9.6	3.0	7.0	4.8	-1.1	-1.7
East	4.3	2.1	8.6	2.6	2.2	5.8	-3.9	-0.4
South	3.0	-1.9	4.4	1.5	5.2	3.1	-1.4	-3.3
All developing countries	5.5	2.4	5.4	2.0	2.7	2.9	0.0	0.4
Developed countries	2.6	2.4 (c)	2.2	1.3 (c)	-0.1	1.0	0.2	1.1
World, total	3.3	2.4	3.1	1.7	0.7	1.3	0.1	0.7

(a) Based on const. 1980 US $.

(b) Based on scient. person-years.

(c) Including East Asia.

Source: Judd, M.A., J.K. Boyce and R.E. Evenson, Investing in Agricultural Supply, Center Discussion Paper, No. 442, Economic Growth Center, Yale Unviersity, New Haven 1983.

Annex Table 5.1 Number of Persons from Different Regions Participating in Individual Research Training Programs at CGIAR Centers

Center	Years	Number of participants from						Average number per year recently
		Tropical Africa	Near East/ North Africa	Asia	Latin America	Industrial Countries	All Countries	
CIAT	1968-84	25	1	35	1265	73	1399	135
CIP	1978-83	16	5	35	135	9	200	50
IBPGR	1973-82	2	5	16	5	6	34	5
ICARDA	1978-83	1	48	1	0	4	54	10
ICRISAT	1974-82	3	5	9	2	0	19	15
IITA	1970-83	212	1	17	6	17	253	25
ILCA	1975-83	57	0	0	0	21	78	15
IRRI	1962-82	28	6	405	14	25	478	100
TOTAL		344	71	518	1427	155	2515	355

Source : Anderson, J.R. et al., Global Report on the Impact of IAR, Draft, Washington, 1985, Chapter 10.

Annex Table 5.2 Number of Persons from Different Regions Participating in Post-doctoral Programs at CGIAR Centers

Center	Years	Tropical Africa	Near East/ North Africa	Asia	Latin America	Industrial Countries	All Countries	Average number per year recently
		Number of participants from						
CIAT a)	1969-83	0	0	0	37	9	46	15
CIMMYT	1966-82	3	6	13	18	48	88	15
ICRISAT	1974-82	9	0	32	9	21	71	20
ICARDA	1978-83	0	11	0	0	10	21	5
IITA	1970-83	33	1	17	2	23	76	10
ILCA	1975-83	9	0	0	0	4	13	5
IRRI	1962-82	2	0	169	5	41	217	20
IFPRIb)	1975-83	14	0	51	6	0	71	10
ILRADc)	1972-82	36	0	0	0	64	100	10
TOTAL		106	18	282	77	220	703	110

a) Allocated in proportion to CIAT's overall geographical distribution of trainees.
b) Research collaborators at the professional level.
c) Distributed across regions in proportion to the 1983 distribution.

Source : Anderson, J.R. et al., Global Report on the Impact of IAR, Draft, Washington, 1985, Chapter 10.

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