CIAT IN THE 1990s:
Appendices

Note: This is a companion piece to CIAT IN THE 1990s, A STRATEGIC PLAN. It contains background materials used in the main plan document.

CIAT Centro Internacional de Agricultura Tropical

CONTENTS

INTRODUCTION

"CIAT IN THE 1990s: A Strategic Plan," which accompanies this publication, resulted from an intensive process of internal and external dialogue beginning in June of 1988. Task forces involving CIAT staff, national program partners and consultants prepared documents on:

- CIAT commodity trends
- National agricultural research and development system (NARDS) trends
- Natural resource management and agricultural sustainability
- and Trends in science and technology research.

These reports and the ensuing debate (enhanced in part by national program leaders, many of whom responded to a questionairre designed to test the validity of the assumptions that went into the writing of the Plan) provided the basis for the main document.

This compilation of Appendices is intended to accompany the main document, and provides much more detail than was possible to include in that publication, largely due to our desire to keep it concise, to the point and easily readable.

Appendix A

LIST OF ACRONYMS

ANPPY	Asociación Nacional de Pequeños Productores de Yuca (Colombia)
ASEAN	Association of South East Asian Nations
BNF	Biological nitrogen fixation
BRU	Biotechnology Research Unit (CIAT)
CATIE	Centro Agronómico Tropical de Investigación y Enseñanza (Costa Rica)
CENARGEN	Centro Nacional de Recursos Geneticos (Brazil)
CENTA	Centro de Tecnología Agricola (El Salvador)
CESDA	Centro Sur de Desarrollo Agropecuaria (Dom. Rep.)
CGIAR	Consultative Group on International Agricultural Research
CIAT	Centro Internacional de Agricultura Tropical
CIID	Centro Internacional de Investigaciones para el Desarrollo (Colombia)
CIMMYT	Centro Internacional de Mejoramiento de Maiz y Trigo (Mexico)
CNPAF	Centro Nacional de Pesquisa em Arroz e Feijao (Brazil)
CPAC	Centro de Pesquisa Agropecuaria (Brazil)
CPATU	Centro de Pesquisa Agropecuaria dos Cerrados (Brazil)
DRSS	Dept. of Research and Special Services (Zimbabwe)
DSIR	Dept. of Scientific and Industrial Research (New Zealand)
EMATER	Empresa de Asistencia Tecnica e Extensao Rural (Brazil)
EMBRAPA	Empresa Brasilera de Pesquisa Agropecuaria (Brazil)
EMR	External Management Review

EPR	External Program Review
ESAL	Escola Superior de Agricultura de Lavras (Brazil)
ExCom	Executive Committee (CIAT Board of Directors)
FAO	Food and Agriculture Organization
FEDEARROZ	Federación Nacional de Arroceros de Colombia
FUNDAGRO	Fundación Ecuatoriana de INvestigaciones Agropecuarias (Ecuador)
GRU	Genetic Resources Unit (CIAT)
IAPAR	Instituto Agronomico do Paraná (Brazil)
IARC	International Agricultural Research Center
IBTA	Instituto Boliviano de Tecnología Agropecuaria
ICA	Instituto Colombiano Agropecuario (Colombia)
ICTA	Instituto de Ciencia y Tecnología Agropecuaria (Guatemala)
IDIAP	Instituto de Investigaciones Agropecuaria Panamá
IDB	InterAmerican Development Bank
IICA	Instituto Interamericano de Cooperación para la Agricultura (Costa Rica)
INCAP	Instituto de Nutrición de Centro America y Panamá (Guatemala)
INERA	Institut National Pour l'Etude et la Recherche Agronomique (Zaire)
INIA	Instituto Nacional de Investigaciones Agropecuarias (Chile)
INIAA	Instituto Nacional de Investigación Agraria y Agroindustrial (Peru)
INIFAP	Instituto Nacional de Investigaciones Forestales y Agropecuarias (Mexico)
INIAP	Instituto Nacional de Investigaciones Agropecuarias (Ecuador)
INTA	Instituto Nacional de Tecnología Agropecuaria (Argentina)

IRRI	International Rice Research Institute (Philippines)
ISABU	Institut des Sciences Agronomiques du Burundi
ISAR	Institut des Sciences Agronomiques du Rwanda
ISNAR	International Service for National Agricultural Research (Netherlands)
KARI	Kenya Agricultural Research Institute
MAG	Ministry of Agriculture (general)
MARDI	Malaysian Agricultural Research and Development Institute
NARDS	National Agricultural Research and Development Systems
NARI	National Agricultural Research Institute
NARS	National Agricultural Research System
ODNRI	Overseas Development of Natural Resources Institute (UK)
PCARRD	Philippine Council for Agriculture, Forestry and Resources Research and Development
PNL	Programme National Leguminenses (Zaire)
PROCI	Programa Cooperativo de Investigación
SACCAR	Southern African Centre for Cooperation in Agricultural Research
SCATC	South China Academy of Tropical Crops
SEAG	Servicio de Extensión Agricola Ganadera (Paraguay)
TAC	Technical Advisory Committee
UAPPY	Unión de Asociaciones de Productores y Procesores de Yuca (Ecuador)
UFPEL	Universidad de Federal de Pelotas (Brazil)
UNDP	United Nations Development Programme
USDA	United States Department of Agriculture
VRU	Virology Research Unit (CIAT)

Appendix B

CONSULTATIONS ON STRATEGIC PLAN

I. Chronological Listing of Events

Event #	Date	Description
1	October, 1987	Preliminary discussions with CIAT Board ExCom on planning process.
2	January-June, 1988	Development of the Interim Plan (1989-93) involved a series of brainstorming sessions and discussions with staff and the Board on possible future directions. These served as an useful base for later development of the Strategic Plan.
3	April, 1988	Further discussions with CIAT Board ExCom on planning process.
4	April, 1988	Half-day meeting with Latin American research leaders (present at CIAT for meeting with CIMMYT) to brainstorm early ideas on NARS trends.
5	May, 1988	Discussion of preliminary outline of plan and approval of planning process by CIAT Board.
6	June, 1988	Naming of Strategic Planning Committee and Planning Task Force members.
7	June, 1988	Meetings with Senior Staff to discuss planning process.
8	June, 1988	Meeting of Leadership Group (Directors and Program Leaders) to discuss CIAT system of values.
9	June, 1988	Informal meeting of F. Torres with IICA and Latin American research leaders (attending IICA meeting on sharing of responsibilities between NARIs and IARCs) to discues preliminary draft of NARS questionnaire and plan for NARS consultations.

Event #	Date	Description
10	August, 1988	Think Tank meeting on Natural Resources in Washington, D.C.
11	September, 1988	Think Tank meeting on Science and Technology at CIAT.
12	October, 1988	Meetings with professional support staff to discuss planning process.
13	October, 1988	Think Tank meeting of representative NARDS leaders from Latin America at CIAT.
14	November, 1988	Think Tank meeting on trends in NARDS in Africa and Asia, at ISNAR, Hague, Netherlands.
15	November, 1988	CIAT's Africa-wide Bean Coordinator took advantage of the presence of a large number of African research leaders attending a NARS/IARCs Coordinating Meeting for Eastern Africa and a CIMMYT Workshop for Senior Research and Extension Administrators of On-Farm Research to obtain their comments on the CIAT Draft Center-wide Strategy and a list of questions submitted by the NARS Planning Task Force.
16	November, 1988	Meetings with Senior Staff to discuss progress on Center-wide Strategy.
17	December, 1988	Three days of Annual Program Review meeting dedicated to discussion of reports of Planning Task Forces and Draft Center-wide Strategy.
18	January, 1989	Meeting with professional support staff to discuss draft Center-wide Strategy.
19	March, 1989	Expert consultation preparatory to development of Cassava Program Strategic Plan (at CIAT).
20	April, 1989	Discussion of revised draft of Center-wide Strategy and preliminary drafts of program strategies by Program Committee of CIAT Board and full Board.

Event #	Date	Description
21	April, 1989	Strategic planning workshop of Rice Program with national rice program leaders and external consultants (at CIAT).
22	April, 1989	Strategic planning workshop of Bean Program with national bean program leaders from Latin America, Africa and external consultants (at CIAT).
23	April, 1989	Strategic planning workshop of Tropical Pastures Program with national pasture program leaders from Latin America (at CIAT).
24	May, 1989	Strategic planning workshop of Cassava Program with national root and tuber research leaders from Latin America (at CIAT).
25	May, 1989	Strategic planning workshop with national pasture program leaders from Asia (in the Philippines).
26	June, 1989	Draft Center-wide Strategy and questionnaire on it sent out to 64 NARS leaders in Latin America, Africa and Asia.
27	July, 1989	Revised Draft Strategic Plan presented to EPR and EMR panel and sent to Board Program Committee.
28	August, 1989	Analysis of responses received to questionnaire sent to NARDS leaders.
29	August and September, 1989	Revision and development of final draft of Strategic Plan.
30	September, 1989	Discussion of final draft of Strategic Plan by CIAT Board, taking into account views expressed by EPR/EMR.
31	October, 1989	Preparation of final version of Strategic Plan for submission to the TAC.

II. Persons Contacted External to CIAT

A. CIAT Board Members

Name	Country	Event
Carlson, William	U.S.A.	1, 5, 20
Casas, Eduardo	Mexico	5
Flavell, Richard B.	United Kingdom	17, 27
Gapasin, Dely	Philippines	5, 14, 20
Hayashi, Ken-ichi	Japan	5
Hutchinson, Frederick	U.S.A.	5, 20, 27
Junguito, Nohra de	Colombia	1, 5
Kaneda, Chukichi	Japan	17
Montes, Gabriel	Colombia	1, 5, 20
Mosquera, Ricardo	Colombia	20, 26
Noesberger, Joseph	Switzerland	1, 5, 10, 17, 27
Palacios, Marco	Colombia	5
Parra, Luis Guillermo	Colombia	5
Petit, Michel	France	5, 10, 17, 20, 27
Rosas, Gabriel	Colombia	20
Salazar, Juan José	Colombia	5, 20
Samper, Armando	Colombia	5, 17, 20
Tanner, Jack	Canada	17
Tarté, Rodrigo	Costa Rica	1, 5, 20, 27
Tollini, Helio	Italy	5, 10, 20
Tossell, William	Canada	1, 5
Vaccaro, Lucía de	Venezuela	17, 20, 27
Wang'ati, Frederick	Kenya	5, 14, 20

B. NARS and Regional Organization Leaders

Name	Institution	Country	Event
Acosta Jorge A.	INIFAP	Mexico	22
Aidar, Homero	CNPAF	Brazil	26
Alarcon, Enrique	IICA	Costa Rica	20
Alvarado, Leopoldo	Sec.Est.Rec.Nat.	Honduras	4
Alvarado, Jorge V.	INIAA	Peru	23
Alvim, Paulo	CEPLAC	Brazil	10
Anan, Saharan	MARDI	Malaysia	26
Andrews, Keith L.	Esc. Agric. Panam.	Honduras	22
Arango, Luis	ICA	Colombia	23
Arauz de Gomez, Denis	Univ. de Panamá	Panama	26
Arrandaeau, Michel	IRRI	Philippines	21
Bacigalupo, Antonio	FAO	Chile	11
Baires P., Filadelfo	DIVAGRO	El Salvador	13
Baptista da Costa, M.	IAPAR	Brazil	13
Bastidas, Gilberto	ICA	Colombia	22
Bonman, J. M.	IRRI	Philippines	21
Bressani, Ricardo	INCAP	Guatemala	22
Cafati, Claudio	INIA	Chile	26
Calero, Eduardo	INIAP	Ecuador	26

Name	Institution	Country	Event
Cano, Carlos G.	FEDEARROZ	Colombia	21
Chang, Jorge	FUNDAGRO	Ecuador	26
Chaverra, Hernan	ICA	Colombia	13
Chavez, Marco A.	MAG	Costa Rica	26
Chin Peng, Chen	MARDI	Malaysia	25
Chouzu, He	SCATC	China	25
Claveran, A. Ramón	INIFAP	Mexico	4
Cordero, Alfonso	INIAA	Peru	23
Correa, Helio	ESAL	Brazil	24
da Silva, Genival S.	EMATER/BP	Brazil	24
de Andrade, Ronaldo	EMBRAPA/CPAC	Brazil	23
de Castro, Luis A.	CENARGEN	Brazil	24
Faylon, Patricio	PCARRD	Philippines	25
Fenner, R.	DRSS	Zimbabwe	26
Fumagalli, Astolfo	ICTA	Guatemala	13
Galli, José	EMBRAPA/UFPEL	Brazil	21
Garcia, Carlos M.	CENTA	El Salvador	4
Granger, Michael	NARI	Guyana	26
Gutierrez, Afredo	MAG	Cuba	21
Juarez, Horacio	ICTA	Guatemala	9,26
Knapp, Ron	CIMMYT/CIAT	Colombia	22
Li Pun, Hector	CIID	Colombia	23
Liyanage, Vajira	Coconut Res. Inst.	Ceylon	25
Lotero, Jaime	ICA	Colombia	23
Madrid, Emilio	INIA	Chile	9
Majisu, B.	KARI	Kenya	15
Manidool, Chanchai	MAG	Thailand	25
Martinez, Amin	ANPPY	Colombia	24
Masaya, Porfirio	ICTA	Guatemala	22
Mendoza, Carlos	UAPPY	Ecuador	24
Metz, Socrates	CESDA	Dom. Republic	26
Moog, Francisco	PCARRD	Philippines	25
Morales, David	IBTA	Bolivia	26
Morel, Lino	SEAG	Paraguay	24
Mulenda, Pyndji	INERA	Zaire	26
Muñoz, Dorance	ICA	Colombia	21
Muturi, S.	Min.Res.Sci.& Tech.	Kenya	15
Ndayi, Kilumba	PNL	Zaire	22
Nkwanyana, C.T.	MAG	Swaziland	26
Noriega, Tomas A.	IDIAP	Panama	26
Nzimenya, I.	ISABU	Burundi	26
Ozaeta, Mario	ICTA	Guatemala	4
Palma, Victor	IICA	Costa Rica	5
Perez, Carlos	MAG	Cuba	26
Pezo, Danilo	CATIE	Costa Rica	23
Piñeiro, Martin	IICA	Costa Rica	9,26
Prado, Victor	MAG	Costa Rica	23
Pulido, Gabriel	UNDP	Colombia	20
Ramadan, Adit	MAG	Ecuador	24
Rojanariopiched, C.	Kasetsart Univ.	Thailand	26
Santos, Roberto Y.		Ecuador	21
Sengooba, Theresa	Kawanda Res. Sta.	Uganda	22

Name	Institution	Country	Event
Souza, Serrao E.	EMBRAPA/CPATU	Brazil	23
Spitale, Roberto	IDB	Colombia	5
Tobon, José H.	ICA	Colombia	24
Torres, Carlos	INTA	Argentina	9
Trigo, Eduardo	IICA	Costa Rica	9
Valente, M. Francisco	EMBRAPA/CNPAF	Brazil	21
Vega, Juan G.	INIAP	Ecuador	22
Wagner, Elmar	EMBRAPA	Brazil	9
Wapakala, William	KARI	Kenya	15
Williams, A.	MAG	Belize	26
Xuan Hien, Nguyen	Inst. Agric. Tech.	Vietnam	26
Zimmermann, Maria José	EMBRAPA/CNPAF	Brazil	22

C. Other Consultants

Name	Institution	Country	Event
Beachy, R.	Wash. St. Univ.	U.S.A.	11
Black, Clanton C.	Univ. of Georgia	U.S.A.	11
Brinkman, Robert	AGLS-FAO	Italy	10
Brougham, Ray	DSIR	New Zealand	23
Cassman, Kenneth G.	Univ. of California	U.S.A.	22
Chua, Nam-Hai	Rockefeller Univ.	U.S.A.	11
Cooke, R.D.	ODNRI	United Kingdom	11
Coyne, Dermont	Univ. of Nebraska	U.S.A.	22
Croft, Brian	Oregon St. Univ.	U.S.A.	11
Dagg, Matthew	ISNAR	Netherlands	14
Dufour, Dana	Colorado St. Univ.	U.S.A.	19
Fredericksen, Richard	Texas A & M Univ.	U.S.A.	22
Freed, Russell	Michigan St. Univ.	U.S.A.	22
Fresco, Louise	Univ. of Wageningen	Netherlands	19
Hart, Robert	Rodale Res. Center	U.S.A.	10
Jahnke, Hans E.	Tech. Univ. Berlin	Germany	14
Jarvis, Lovell S.	Univ. of California	U.S.A.	23
Jaynes, Jesse M.	Louisiana St. Univ.	U.S.A.	11
Kramer, Coenraad A.	ISNAR	Netherlands	14
Lal, Rattan	Ohio St. Univ.	U.S.A.	10
Leonard, Jeff	Osborne Ctr.Ec.Dev.	U.S.A.	10
Lynam, John	Rockefeller Found.	U.S.A.	19
Maxwell, Fowden	Texas A & M Univ.	U.S.A.	11
McKenzie, David R.	USDA-CSRS	U.S.A.	21
Niblett, C.L.	Univ. of Florida	U.S.A.	11
Sanchez, Pedro A.	N. Carolina St. Un.	U.S.A.	10,23
Schuh, Edward	Univ. of Minnesota	U.S.A.	13
Shepard, J.	Rockfeller Found.	U.S.A.	11
Shepard, Merle	Clemson Univ.	U.S.A.	21
T'Mannetje, L.	Univ. of Wageningen	Netherlands	23
Thurston, David	Cornell Univ.	U.S.A.	11
Vogel, Jeannette	ISNAR	Netherlands	14
von Oppen, Mateus	Inst.Agr.Soz.Tropen	Germany	22
von der Pahlen, A.	FAO	Italy	5
Whiters, L.	FAO	Italy	11

D. EPR/EMR Panel

Name	Panel	Country	Event
Abdalla, Abdalla Ahmed	EPR	Sudan	27
Brumby, Peter	EPR	U.S.A.	11,27
Collinson, Michael	EPR/CGIAR	U.S.A.	27
Coulter, John	EPR	United Kingdom	20,27
Field, Elizabeth	EMR/CGIAR	U.S.A.	27
Hoadley, Kenneth	EMR	U.S.A.	27
Joshi, Joan	EMR	U.S.A.	27
Kearl, Bryant	EPR	U.S.A.	27
Moscardi, Edgardo	EPR	Argentina	13,27
Ozgediz, Selcuk	EMR/CGIAR	U.S.A.	27
Paterniani, Ernesto	EPR	Brazil	27
Villarreal, Ruben	EPR	Philippines	27
Vyas, Vijay	EMR	India	27

III. Strategic Planning Committee and Planning Task Force Members

Strategic Planning Committee

John L. Nickel, Chair
Trudy Brekelbaum, Secretary
(later replaced by Randy Treichler)
Fritz Kramer
Douglas R. Laing
Filemón Torres

Task Force on NARDS

Filemón Torres, Chair
Carlos Pérez, Secretary
Trudy Brekelbaum
Gerardo Habich
Douglas Pachico
Raúl Vera (later replaced by
José M. Toledo)

Task Force on Natural Resources

Filemón Torres, Chair
Peter Jones, Secretary
James Spain
Robert Zeigler

Task Force on Scientific Trends

Douglas Laing, Chair
William Roca, Secretary
James Cock
Mabrouk El-Sharkawy
Miles Fisher

Task Force on Socio-economic Trends

Douglas Laing, Chair
Carlos Seré, Secretary
Willem Janssen
Luis R. Sanint

Appendix C

Task Force Report:[1]
CIAT COMMODITY TRENDS

1. Introduction

The outlook for CIAT-mandated commodities in the developing countries has been examined for the decade of the 1990s within the general socioeconomic context of developing countries in order to establish a basis from which to plan CIAT's future activities in relation to them.

Methodologically, this outlook is based on extrapolations of production trends of the last two decades. Demand projections are based on conservative estimates of future per capita income growth, population growth rates estimated by the World Bank, and constant real prices for CIAT commodities and their substitutes. Thus, these projections do not include productivity gains to be achieved through technical change (including CIAT's contributions) beyond those gains that occurred in the past and that are therefore incorporated in the historical evolution of production (this is particularly the case for rice, among CIAT commodities).

The analyses are based on published statistical information (mainly from FAO) which is variable in its quality, reflecting differences in the development of statistical data collection systems among countries and the present economic importance of individual commodities for specific countries. It should be kept in mind that statistics aggregated at the national level may mask important shifts in productivity of crops in specific regions (e.g., displacement of crops from prime land to marginal land fostered by the development of cultivars better adapted to marginal conditions). Furthermore, given the limited time since release, several CIAT materials have achieved farmer acceptance, but areas are still too limited to be reflected in aggregate national yield statistics.

1.1 Agriculture Within the Global Economy

The global economy of the late 1980s is fragile, with large international payment imbalances and volatile financial markets. This condition is a result of lasting divergences in the macro-economic policies of leading industrial countries. The impact on the industrialized countries was a reduction in their 1980-87

1/ Task force members: D.R. Laing, J. Cock, C. Seré, W. Janssen, L.R. Sanint, W. Grisley.

GDP growth rates to one-half of the 1965-73 level; for the developing countries, this came to 40%.

The world food situation in the early 1980s was characterized by abundant stocks. Recently, these stocks have been significantly reduced, and many developing countries have again become cereal importers. The economic condition of developing countries during this decade is characterized by large external debt burdens, growing fiscal deficits, and increasingly adverse terms of trade with the industrialized economies. The ensuing protectionist trading policies adopted have resulted in distorted market prices both within and between countries.

Developing countries as a group are highly heterogeneous in terms of income, urbanization, and food consumption levels (Table 1, at the end of this Appendix). With regard to food consumption, the situation in sub-Saharan Africa deteriorated sharply over the entire 1971-86 period. In Latin America and the Middle East, per capita food consumption increased up to the early 1980s, but then fell. Per capita food consumption in Asia increased over the entire 1971-86 period.

The consumption of roots and tubers showed a decreasing trend in both Africa and Latin America but an increasing trend in Asia over the 1971-86 period. In contrast, cereal consumption has grown in all regions, but most significantly in the Middle East during the oil boom years of the 1970s. Significant increases are also found in the consumption of eggs and dairy products. While not singled out separately in the aggregate meat consumption figures, the consumption of poultry has also strongly increased. Associated with the increased consumption of poultry and other non-beef livestock products is the increase in demand for oils and cereals in the preparation of animal feeds. The overall trend in the consumption of pulses is downward.

The task force shares the view that economic growth in developing countries during the 1990s will stem from both an increase in trade and technological development in the agricultural sector. These technological developments will provide impetus for effective demand that will produce broad-based participation in the development process. The projections developed in this paper are based on these moderately optimistic economic growth prospects. Demand projections are based on an assumed per capita income growth rate of 1.5% annually and population growth rates estimated by the World Bank in individual countries.

2. Latin America

2.1 Macroeconomic Trends

Latin America underwent a deep crisis in the 1980s when the debt burden took on particularly enormous proportions, terms of trade deteriorated, the capital inflow of the 1970s reverted, and lack of fiscal discipline caused inflation to soar. Economic growth slowed down completely and became negative in many countries. The participation of agriculture in the GDP, a participation which had fallen since the sixties, started to rise again. Employment generation decreased strongly.

During the eighties, the dynamic development of industry--with the exception of its agroindustrial sector--came to a halt. In these dark years, only the decrease in population growth provided a glimpse of light. From rates of 2.6% in 1961-70, it fell to 2.4% in 1981-86.

Urbanization was the norm in the last two decades. In the early 1960s, 51.2% of the Latin American people were rural dwellers compared to 30.7% in 1986. This transformation has had a dramatic impact on the food system (consumer preferences and the development of agroindustry), as well as on the spread of informal economic activities that compete with the formal sector but do not pay taxes nor guarantee any labor stability.

Income is unevenly distributed and the skewedness has probably increased with the recent recession and higher rates of inflation. The incidence of undernutrition is milder in Latin America (13% of total population) than in other regions, but many countries present average caloric intake below recommended levels. Average daily caloric intake ranges from 1905 in Haiti to 3380 in Argentina. The recent recession made things worse for risk groups, particularly urban low-income strata of the population.

In many countries, the debt crisis has led to severe curtailing of government services. In the present years of austerity, the outlook is for relatively limited public funds for investment and increased competition among all sectors for such funds. The key issue is whether, given the increasing awareness of the critical role of agriculture and the high payoff of agricultural research, this activity will receive a particularly high priority in public investment.

2.2 The Agricultural Sector

At the beginning of the 1980s, overvalued exchange rates discriminated strongly against agriculture in many Latin American countries. For some crops compensatory measures existed; but on the average, export products were taxed, food imports were protected, and nontradables were left to the mercy of the free market. Later in the decade, the debt crisis caused realignment of exchange rates, improved domestic competitiveness of the agricultural sector, and stimulated exports. The reduction of food imports and the improved potential for nontraditional exports have also decreased food security, especially among the poor.

In the 1960s and 1970s, agriculture grew at rates of 3.3% and 3.6% per year, below total GDP growth, respectively. From 1980 to 1986 agricultural growth slowed down to 1.6%, but the share of agriculture in the total economy increased because the drop in total GDP growth was more dramatic.

Commercial production, often on medium-sized farms, is becoming more important in the agricultural sector. At the same time, many small farmers are progressively integrating themselves into the market economy. The agricultural sector becomes more heterogeneous as the gap widens between those who respond to new opportunities and technologies and those who do not.

The scarcity of public resources will limit infrastructure development at the frontier. Intensification of land which is already in use, not area expansion, will have to be the source of agricultural growth. The use of extensive pasture land for crop production and the development of integrated crop-livestock systems will contribute to this intensification. Among the migrants of the seventies and eighties, there were many farm laborers. Large numbers of them are still employed in labor-intensive agricultural enterprises close to the cities (peri-urban farming). Because of the reduced prospects of industrial employment, many urbanites will remain dependent on agriculture for their jobs. A class of urban farm laborers has emerged.

Further market integration will allow many farmers greater specialization and might foster improved agricultural efficiency. In the next decade, agricultural growth will have strong forward and backward linkages, particularly with agroindustry. Agricultural growth will thus be characterized by increased efficiency and significant multiplier effects outside the sector.

The prospects of growth in the realm of new economic policies offer the opportunity to tackle hunger and poverty within the framework of market-oriented agriculture. Technology to increase production in agricultural areas with favorable conditions offers great potential to realize such growth, especially if it carries the multiplier effects that were discussed above.

At the same time, the onslaught of farming on the environment can be reduced by increasing the agricultural capacity of less fragile, existing agricultural land. In this way, pressure on the frail frontiers and tropical forests can be relieved.

With the low availability of public funds for infrastructure development, sustainability of ecosystems at the frontier will be most efficiently pursued by developing production-enhancing and stress-avoiding technology for existing agricultural land.

2.3 Beans in Latin America

Beans are a traditional food crop produced under a variety of production techniques by small farmers in wide areas of Central and South America. During the past two decades, annual growth in bean production was slightly greater than 1%, well below the population growth rate of 2.4%. Annual production in the most recent decade increased to an average of 2.3%, primarily because of increased output in Mexico, Central America, and the Southern Cone countries of Argentina and Chile. Coupled with rising imports, the availability of beans increased by 2.5% annually over the 1976-86 period.

The positive performance of the bean production sector during the past decade was primarily due to increases in area cultivated, not increases in productivity. Annual increases in bean hectarage averaged 2.5% in Brazil and the Southern Cone countries and over 3.0% in Mexico and Central America. Even though productivity growth was negative in the 1976-86 period, it was not as low as that of the earlier decade.

Some observations should be made with this brief analysis of area and productivity growth. For some countries, such as Guatemala and Costa Rica, the expansion of the bean area might well have been overestimated. In both countries, improved varieties were released and afterwards adopted by large numbers of farmers. In Costa Rica, these new varieties spread out over more than 21,000 hectares and outyielded traditional varieties by some 240 kg/ha. In Guatemala, these varieties were adopted on over 12,000 hectares and outyielded traditional varieties by some 340 kg/ha. As a result, during the 1982-86 period average yield increases due to the mere diffusion of improved varieties would be equal to 26 kg/ha in Guatemala and 100 kg/ha in Costa Rica. The FAO statistics do show negative yield tendencies for both countries. The evidence of release and adoption would not confirm such data.

Some causes might be mentioned. First, improved varieties have higher profitability and might lead to increases in credit requests. Such credit requests often play an important role in estimating area planted. Second, production statistics are often based on market availability. These data are later traced back to area figures by assuming a constant yield per hectare.

The increase in area in Brazil and Mexico was into nontraditional production areas. Beans have shifted toward these areas, partly because of comparative production advantages, as was the case in Mexico. Here beans have been moving into a semiarid area (the northern highlands) which has one season of 60 to 90 days with rainfall. Early bean varieties are able to provide an acceptable harvest during this short growing season, while most other crops are not. In other countries, beans shifted to nontraditional areas because of low profitability. This is the case of Brazil, for example, where more productive soybeans (but also maize and rice) pushed bean production from prime to marginal land. To stop further marginalization, profitability increases are critical. Such profitability increases should not only imply increased returns to land, but even greater increases in returns to labor. Varieties that fit appropriately in the farm system and selective mechanization will be instrumental for improved labor productivity.

The potential of management practices and improved input use (fertilizer, selective chemical control) to increase productivity has not been sufficiently exploited in many bean production areas. With the increased commercialization of bean production, the inclination of farmers to intensify their bean production systems will grow. A first example of this inclination is the use of chemical controls by bean farmers in eastern Antioquia, a region well integrated into the urban market. Farmers in this area spray their beans an average of six times per crop cycle. Another example is the (inadequately documented) rise of irrigated bean production in Brazil, because of its high pay-off in a short time period. Strategic cultural practices and crop management research to anticipate these intensification trends will be the necessary complement to genetic improvement for obtaining productivity increases.

Beans are an important source of dietary protein for the low- and middle-income rural and urban populations of Latin America. With 70% of Latin Americans living in urban areas, the availability of beans at affordable prices is an important policy consideration. Though the income elasticity of bean consumption is positive only up to middle income ranges, commercial opportunities for bean producers will continue to increase. Three mechanisms are involved here. First, urban population will continue to increase. Second, the impact of urbanization on bean consumption is not always negative, as would be expected for a traditional staple food. In countries such as Colombia, urban bean availability is higher than rural bean availability because beans are not grown in many areas of the countryside. Third, with rising incomes bean consumption shifts from less to more preferred grain types. While this does not raise consumption in kg per person, it does increase expenditures per capita. Evidence from several countries (Honduras, El Salvador, Peru, Colombia) suggests that varieties have to be improved simultaneously for agronomic as well as commercial traits in order to be successfully adopted. Bean producers will increasingly pay close attention to consumer preferences in bean consumption characteristics. Bean storage and marketing will demand increased research and policy attention.

Projections of present aggregate production and consumption trends do not point to a deficit in bean supplies up to the year 2000 (Table 2). However, the level of aggregations conceals the fact that Brazil and the Andean region are projected to have annual deficits of 351 and 107 thousand tons, respectively, by the year 2000. The estimate for Brazil is rather pessimistic, but it reflects lagging productivity growth and consequent marginalization. If new technological options, such as irrigation or increased adaptation to acid soils, are successfully developed, the real deficit might be less. For the Andean region the estimated deficit equals 34% of production. It is mainly concentrated in Peru and Ecuador, and it forms a bleak but real prospect for bean utilization in this region.

Mexico and Central America are expected to have surpluses. For Mexico this depends on the continued expansion of beans in the northern highlands. Since future expansion will take place at a higher cost, production growth might well be reduced, in which case Mexico's surplus would also fall. For Central America production growth is increasingly dependent on improvements in productivity per hectare, brought about by improved planting material and increased input use. After excluding the export-oriented countries of Argentina and Chile, the total deficit for all of Latin America is projected to be 343 thousand tons.

Bean production occurs in farms that often produce many other crops. The importance of beans on these farms is defined by the relative profitability with respect to the other crops. On many small farms, competing crops include vegetables, fruits, or coffee production. Bean productivity will have to be in line with these crops in order to be included in production plans. On large farms, beans compete with soybeans, cotton, sorghum, maize, and sugarcane. Labor productivity will be the key to maintaining or increasing the role of beans on these farms.

Because of the easy substitution of beans for other crops, productivity reductions cause an impact not only through a proportional decrease in production but also by rapid decreases in area planted.

In the seventies and eighties, when productivity per hectare went down, the shift to nontraditional production areas allowed bean production to keep up with population growth. Strong urban demand nevertheless caused bean prices to rise in many countries. In the nineties, these trends have to be reverted. Improved varieties and improved management should increase productivity and allow total production to grow more rapidly than the population of the continent in order to diminish pressure on consumer prices.

2.4 Beef and Milk

In 1986, tropical Latin America had about 240 million head of cattle (19% of the world stock), which produced 5 million MT of beef (carcass weight), corresponding to 10.5% of the world output. In 1979-86, average net exports of beef amounted to 4.7% of total production while 12% of total milk production was imported. At the same time, the region produced 30 million MT of milk (6.5% of world output). This has resulted in relatively high levels of per capita consumption of beef (14 kg) and milk

(96 kg in 1979-86), a fact reflecting the wide land to man ratio and the abundance of cattle in the region.

Beef and milk are staple foods in Latin American diets. Their combined food budget share is above 20%, even in the diets of the lowest income quintile of the population. This wage-good attribute explains the high priority these commodities have in food policies.

During the 1970s, when incomes were growing rapidly, production growth rates were above those of population, and prices trended upward. During this period, declining poultry prices (due to technical change and overvalued currencies which decreased the domestic cost of imported grains) induced a substantial process of substitution in consumption. The recession of the eighties affected beef demand, and production growth rates declined below those of population.

Net imports of dry milk powder increased substantially during recent years because of low international prices, the ample availability of dry milk food aid, and the ease of introducing powdered milk into the domestic market. This contrasts with the structural protection of domestic beef markets because of the lack of facilities to handle and distribute highly perishable imported meats.

The lack of productivity gains in ruminant animal production as reflected by aggregate national statistics to a large extent underestimates the contribution of technical change in this sector to overall growth of the agricultural sector. This is due to the contribution of both technical change and infrastructure to the shift of livestock production to more marginal lands to release land for crop production on better soils. Thus, the contribution of improved technology has been to sustain productivity levels in spite of using land resources of lower productivity. This is clearly shown in the case of Brazil, where the Cerrados region has substantially increased its share of the national herd (the share of the cattle inventory of the states of Goiás and Mato Grosso evolved from 15% in 1950 to 31% in 1985; in Colombia, Meta Department of the Eastern Plains comprised 0.6% of the national herd, and in 1985 this share had risen to 6.1%). To a large extent these shifts were made possible by the introduction of pasture germplasm of cultivars adapted to these acid soils, particularly _B. decumbens_ and lately _A. gayanus_, a material developed jointly by CIAT and several national programs, which is being grown on more than 500,000 ha throughout the region.

Beef projections show a trend toward decreasing self-sufficiency levels, with tropical Latin America importing about 360,000 MT of beef in 2000. The Andean region would be almost self-sufficient, with some room for exports; while Central America would continue being a net exporting region. Part of this potential demand will be met by poultry. The task force expects poultry prices to decrease further although at a lower rate than in the past.

Given the structural protection of the beef market, it is expected that most of the potential demand would be absorbed through increased prices. Technical change can clearly contribute to reducing the upward pressure on prices, thus benefiting consumers. In Central America, given the limited outlook for income growth, it is expected that exports will grow.

The outlook for international prices is moderately optimistic; thus, even if domestic incomes do not grow or poultry prices drop dramatically, the international market will act as a floor price, as has been shown in the past by Brazil, which has shifted from being a net importer to a large net exporter.

Tropical Latin America will continue to be a net importer of milk and dairy products, with decreasing self-sufficiency levels. International prices are expected to rise slightly and milk food aid to decrease. Domestic prices are above present international prices in most countries through governmental efforts to maintain a certain level of domestic production. Technical change in pastures could contribute to reducing domestic prices and generating income and employment for generally small- to medium-sized farmers.

The major implications of the above for technology design are:

- Given the global trends of increased consumption of animal products both domestically in most countries of Latin America and in the developing world in general, as well as the magnitude of the available resources (land and cattle), the benefits of technical change in animal production and pastures will be substantial.

- The higher capital costs to be expected in the next decade will increase the pressure to improve the return to capital in the sector. This implies that in the predominant extensive systems, efforts to augment production per animal will increase in importance vis-à-vis increases in carrying capacity.

- The higher opportunity cost of capital and limited public resources for research imply that research will have to be more market driven, emphasizing shorter term benefits. This may imply increased emphasis in upgrading pasture systems at locations closer to markets, where sustainability can be addressed more directly, vis-à-vis the extreme frontier. The lack of funding for infrastructure will limit the payoff of such investments. Screening for germplasm should continue to be done under severe conditions. Pasture management research should respond to market demands.

- The reduction of subsidies for frontier development will, all else remaining the same, raise the relevance of crop-pasture integration. The devaluation of domestic currencies will also promote domestic grain production.

Both forces operating in the same direction will have implications for the development of appropriate pasture germplasm and particularly establishment techniques. This interaction will increase the complexity of the issues involved and will require a more holistic resource management approach.

- The expected further increase in poultry consumption will reduce potential demand for beef to some extent, but will also reduce pressure by governments on controlling prices for urban consumers as well as dampen price cycles. It will additionally permit a more efficient aggregate use of domestic resources.

- By focusing research increasingly on regions with small- to medium-sized operations, pasture research will affect milk more directly. This will increase the equity impact while probably not affecting total impact too seriously because of the high probability of an effective spillover to beef operations. The latter benefits will more directly benefit producers because export markets will put a floor on price reductions. Producers should have the resources to fund at least part of the adaptive research required.

2.5 Cassava

During the decade of the seventies and the early eighties, there was a decline in total cassava production, mainly due to a decrease in production in Brazil, from 26 to 23 million MT in 1976-86.

Cassava is a small farm crop that is grown in marginal areas where soil fertility and moisture limit the growing of alternative crops; nevertheless, cassava farmers in general sell a large part of their production.

Urban consumption of fresh cassava is less than rural levels. The process of urbanization has led to a decrease in per capita consumption of fresh cassava. New technology that makes fresh cassava a more attractive convenient food for the urban dweller has shown very high levels of consumer acceptance, and pilot studies indicate increased demand for the new product.

Cassava is now increasingly being used in animal and shrimp feeds. In the southern states of Brazil and Paraguay, a great deal of cassava is fed to animals on the farm; whereas in Colombia, Ecuador, and Panama, cassava is dried and used by the feed industry. The rapid increase in demand for animal feeds, coupled with the deficit of cereals in tropical regions of Latin America, indicates a large demand for dried cassava in this market if the price for cassava is competitive with cereals.

A series of studies carried out in Latin America in the mid-eighties clearly show that in the absence of price distortions cassava is highly price competitive with cereal grains in tropical areas of Latin America.

The premises for looking at the perspectives for cassava are that (a) governments will not revert to heavy subsidies for competing products, overvalued exchange rates, and massive importations of grains; (b) the animal and shrimp feed industry will continue to grow rapidly; and (c) official government agencies will continue to direct efforts to assisting the rural poor.

The major areas for market expansion for cassava are seen to be "conserved fresh cassava," animal feed, and refined flours. The new cassava conservation technology changes the characteristics of the product in a manner believed to greatly increase the demand for fresh conserved cassava. The incentive for farmers to increase cassava production and their incomes must be a stable minimum or floor price for their product. The animal feed industry effectively guarantees that floor price if farmers can dry their product.

The modern urban tropical dweller consumes large quantities of flours. The traditional flour in Latin America is maize; and in Brazil, cassava. Wheat flour has now become, however, an important basic ingredient in the diet of Latin America. Foreign exchange is scarce; hence, countries are turning to alternatives to wheat imports. Cassava, suitably processed, is such an alternative as flours are used in preparing many foods besides bread. Considerable demand for cassava is foreseen in this area. With the provision of adequate research and development funds and political support we speculate that flour could be a major growth area for cassava in the coming decades.

Another important use of cassava is in the making of starch. The starch industry is very closed, being managed by a limited number of multinationals; thus, it is difficult to assess cassava's future in this market.

There are various reasons to believe that research investment in cassava will increase in the coming years. The establishment of dynamic alternative markets for the crop has created renewed interest in it by farmers who are demanding new production technology. Furthermore, the tendency for Latin America to have pluralist governments will lead to greater attention being paid to the numerous small farmer segments and, hence, the crops they grow. This effect is likely to be reinforced in the case of cassava by the realization that the rate of return on cassava research is likely to be high as so little has been done at the national level up to now; therefore, progress should be rapid.

Land distribution in Latin America is highly skewed. Land reform programs in the past have usually been weak or ineffective. If land reform is seriously embarked upon in more marginal areas of Latin America, it is probable that cassava will play a significant role in setting up the production base.

2.6 Rice

Rice is a relatively new staple food in the diets of Latin Americans. A significant increase in consumption took place over the period 1920-50, when per capita consumption of paddy equivalent went from 14.2 to 30.3 kg. This coincided with the rapid expansion of frontier lands, where rice has always played a fundamental role as a first settler's crop. In 1966-86, thanks to the release of the new modern semidwarf rice varieties, per capita consumption continued its expansion from 36.8 to 45.4 kg, at the same time that real retail prices were falling rapidly. Rice demand responds well to changes in both income and its own price.

Although the majority of the rice area in Latin America corresponds to upland rice (68%), most of the production is obtained in irrigated areas (62%). In Brazil, the largest producer (with 55% of production and 71% of the rice area of Latin America), upland rice accounted for approximately 80% of the total rice area under production. Most rice farmers in the region are small (fewer than 20 ha), but most of the production comes from large farms. Rice is mostly a commercial crop. Farmers are highly responsive to modern, production-increasing technologies, particularly those that have access to irrigation (total or supplementary).

Rice constitutes a major staple food commodity, accounting for more than one-fourth of the caloric intake in countries such as Brazil, Panama, and Cuba. Its importance is greater among consumers in low-income strata, where it is a "wage-good."

Production was projected using the adjusted 1966-86 trend, imposing an upper limit of 5% per year; for higher growth rates, the more recent (and generally lower) 1976-86 rate was used. Yields were bounded at 6 tons/ha, a level that was considered quite high for national average figures. Implicit area is calculated on the basis of projected production and yields. A 10% statistical significance level was enforced for trends. If the condition was not met, zero growth was applied.

For Latin America as a whole, the current 1984-86 observed deficit of 1.2 million MT will remain constant toward the year 2000, which implies an increase in the self-sufficiency ratio from 93% to 95%. There are sharp contrasts when these figures are examined regionally. Tropical Latin American countries will see their current deficit expand from 1.6 to 2.4 million tons while the Southern Cone countries will increase their surplus from 0.4 to 1.4 million tons. Among the many implications of this projection, one is the possibility of increased regional trade from the latter to the former subregions.

A more detailed look at these numbers becomes more meaningful and suggests some possible modifications to the gross trends estimated by the parameters described above. For Brazil, the largest rice producer in the region will see its relative importance diminish from 55% to 53% of production going into the year 2000. Its projected deficit will grow from 0.8 million tons in 1984-86 to 1.4 million tons in 2000. However, given the great potential of "várzeas" (riverside lowlands), it is believed that production, as projected here, has been underestimated. Despite low per capita consumption levels in Mexico, projections show a larger deficit toward the year 2000 (from 0.2 to 0.4 million tons).

Irrigated and favored upland rice conditions are mostly found in the Andean countries. Both area and yields grew at an impressive rate throughout the past two decades, particularly in the earlier 1966-76 period. Crop management practices are a major limitation in a region where new varieties have expressed a great part of their genetic potential. Deficits for Colombia and Venezuela may have been overestimated, given that production has stagnated and therefore a zero growth rate in production was assumed. Crop management as well as policy factors are behind this stagnation. On the other hand, the surplus projected for Ecuador will probably be larger than projected, given the new irrigation projects under way and partly completed now that will incorporate 80,000 new hectares into rice production.

In Central America, favored upland rice is the norm. The lowest yields are found in Panama, the largest producer in the region, where subsistence rice farmers represent 60% of the total number of farmers. Projected deficits are small and could easily be overcome with the release of new varieties that are being tested and a more focused research and extension effort.

In the Caribbean, both Cuba and the Dominican Republic exhibited outstanding growth rates in production over the past two decades and, consequently, their deficits are expected to decrease. The traditional exporters, Guyana and Surinam, confront institutional problems at present and will have difficulties expanding their markets.

Although per capita rice consumption levels in the Southern Cone countries are modest (wheat is the predominant carbohydrate), production shows a vigorous growth. Surpluses are overestimated, particularly in Uruguay, where implicit area increases fourfold, a feat that is hard to believe given the use of additional water implied.

Stability and high levels of self-sufficiency are synonymous in rice. Only 4% of world rice production is actually traded (compared with 16% in maize and 22% in wheat). International rice prices went from US$400/ton in 1981 (2.2 times the price of wheat) to US$215/ton in 1985 (1.1 times the price of wheat), and up again to US$380 in 1987 (3.0 times the price of wheat). Therefore, given the important role of rice in the diets of poor urban consumers, achievement of high rates of self-sufficiency has become a policy goal for countries of the region.

The expanding activity of commercial agriculture, with its continued pressure on the small farmer to integrate into the economy, together with the permanent incorporation of small- and medium-sized farmers into new rice production, imply that crop management research must include adequate machinery. This research must also take into account the resource endowment for different farm sizes, not just for the large, mechanized group as is the case today.

The demand for raw materials of agricultural origin to be transformed by agroindustry also questions rigid breeding standards related to rice acceptability and consumer preferences; acceptability refers to consumers' perceptions at a point in time and is susceptible to changes.

Improving harvest and postharvest technology and practices for rice is an area of high potential impact; waste reduction is a primary means to increase food availability without intensifying pressure on the natural resource base.

With the exception of unfavored upland conditions (the Brazilian Cerrados and the most traditional small farmers), it has been demonstrated that some rice technologies are interchangeable between irrigated and upland conditions. Our new germplasm for unfavored upland conditions is already being evaluated, in terms of adaptability both to the environment and to various cropping systems alternatives.

There is certainty in the Rice Program that there exists a potentially large gap for improving yields both through new, more diversified germplasm for irrigated and upland conditions currently being developed, and through the adoption and improvement of integrated rice management practices. Only then will rice preserve its current leading role in the diets of Latin Americans as the most dynamic indigenous carbohydrate source.

3. Africa

3.1 The Economy

The economic performance of sub-Saharan Africa has been consistently weak for several decades. By the 1980s, per capita incomes had fallen to about three-quarters of the level reached by the late 1970s. This poor performance has been due to external economic shocks as well as weak domestic economic management and unusually high population growth. Recently, many African countries have adopted much needed structural adjustment programs, and efforts currently under way are impressive. Positive adjustments are being made in currency exchange rates, fiscal deficits, export and domestic commodity pricing policies, trade regulations, and government economic management.

The agricultural sector is of paramount importance in Africa. By 1985, 75% of the population earned their livelihood in agricultural production. Average per capita income in this sector was estimated to be US$242 in 1985, which was only 44% of that of the nonagricultural sector. Overall, there has been modest growth in the agricultural sector, but high population growth rates of 3.3% in the 1980s have resulted in decreasing levels of output on a per capita basis.

The key to economic development in sub-Saharan Africa is the agricultural sector. It is the only sector in which future employment opportunities can be readily created. Second, it offers the best opportunity for earning foreign exchange from tradables; and finally, it can provide for a nation's food security needs. Unlike the situation in other developing regions, increases in the output of agricultural nontradables in sub-Saharan Africa are not market driven. Growth in income levels are insufficient to stimulate an increase in the demand for basic food commodities. Developing agricultural technology that is adoptable within such an economic environment is challenging. Because economic returns to production are low and risks for cash input use are high, only those technologies that are low-cost with minimal risk will meet the test of acceptability.

3.2 Beans in Africa

Beans are the principal source of dietary protein for over 70 million people living in sub-Saharan Africa. Consumption levels reach 50 kg per capita annually in the countries of Burundi and Rwanda. Beans are a staple crop produced by small farmers, primarily for subsistence needs with occasional marketing of surpluses. Production is concentrated in the more productive and highly populated areas of eastern Africa, the Great Lakes Region, and widely scattered highland areas of southern Africa.

Bean production in Africa is subject to severe ecological constraints. First, beans are often grown on hillsides, on highly erodible soils. Second, fertilizer availability for the crop is extremely limited, which might cause soil depletion and a shift away from beans to less fertility-demanding crops such as sweet potato or cassava. Third, the disease and insect complex in Africa is different from Latin America. Bean fly, which is an important pest in Africa, is not present in Latin America.

Although beans are not a native crop on the continent, they have been integrated into the agricultural system by very creative means. In many parts of the continent, bean-banana intercrops are important. In other areas, such as Rwanda, beans are grown in varietal mixtures. These mixtures reduce production risk and enhance resistance of the crop to diseases.

Over the past two decades, bean production has grown at an annual rate of 3%, slightly less than the 3.3% population growth rate for the region. In the eighties, the annual growth rate in production has slowed to 1.6%, down from the 4.4% rate in the previous decade. The Great Lakes Region had the slowest growth in production during the past decade at 0.4%, while the eastern and southern regions grew at 2.9% and 2.6%, respectively. The increases were achieved by augmenting area under cultivation as yields were relatively unchanged. However, the increase in bean production due to area expansion is occurring at a decreasing rate--a disturbing indication for future production growth.

Projections of present production and consumption trends to the year 2000 suggest that a significant deficit in production will occur (Table 2). A 750-thousand-MT deficit is projected if trends over the past ten years continue, equaling 18% of expected consumption by the year 2000. Most of this deficit will occur in the eastern highlands and Great Lakes Region.

Land scarcity is a major economic constraint to increasing production in the densely populated countries of Burundi and Rwanda, and in selected areas of Kenya and Tanzania. In response, farmers have adopted intensive land use techniques to increase overall food production. In selected areas of Uganda, Tanzania, Ethiopia, Zambia, and the Kivu Province of Zaire, lack of labor is more of an economic constraint to increasing bean production than land.

The estimated deficits do correctly reflect land scarcity of the Great Lakes Region and parts of eastern Africa. Technological progress is urgently needed in these areas. Such technological progress should have a drastic nature, as is the case in certain areas of Rwanda, where bush beans are being replaced by more productive climbing beans. Adapting the bean crop to nontraditional production areas (e.g., acid soils) might be another response to projected deficits.

The potential of bean production to keep up with demand increases is better in southern Africa. In this region, the possibilities to introduce beans in nontraditional areas are less constrained than in the two other regions. This can be illustrated by the acceptance of Carioca, a variety proceeding from Brazil, in the Central Province of Zambia, where previously only cowpea was produced.

For the landlocked regions of Africa, there is evidence that the high caloric-yielding crops of maize, sorghum, roots and tubers, and bananas are increasingly replacing beans within intercropped systems and when in direct competition. For beans to remain economically competitive, production technologies that reduce variability in output and/or increase yields will need to be developed. In multiple and intercropping areas, beans are often the crop of secondary importance. Therefore, the development of bean production technologies that are complementary to existing production systems will be required in these areas. Production technologies that can compete effectively with other crops are needed in areas where monocropping is the norm. The fragile agroecological environments in which beans are produced are highly susceptible to soil erosion, with accompanying losses in soil fertility--factors that require special consideration in agricultural research.

4. Asia

4.1 The Economy

Asia, the largest and most populated of the developing regions of the world, is particularly heterogeneous in terms of its resource endowment, social and political systems, and economic performance. This analysis does not pretend to cover this wide range of situations. It emphasizes countries of particular relevance to CIAT's cassava research.

Growth in the agricultural sector has proceeded at a relatively high rate over the past two decades, but not as high as that achieved by the economy as a whole. Agriculture has generally been discriminated against by policies to protect domestic industry. In some countries, subsidies for agriculture have compensated for low prices of farm outputs; however, in the aggregate, agriculture has performed worse than it would have without government price interventions.

Since 1980, Asian economies have made major structural adjustments that will allow them to face the future with more flexible economies poised for rapid growth. Diversification will probably be demand led and will be best stimulated by programs that have the broadest impact on increasing rural incomes. Thus, market forces rather than government solutions are likely to be the locomotives of development; nevertheless, governments should be in a position to support new development. Furthermore, demand-led growth in Asian economies is likely to be increasingly for regional or domestic markets rather than international trade. In the more marginal areas, environmental degradation is likely to accelerate unless rural incomes increase, as rural poverty is a major cause of environmental degradation in the region.

We can summarize the trends in Asia as follows: the 1960s was the decade of production; the seventies, the decade of new directions and equity concerns; the eighties, the decade of the private sector and policy concerns; and the nineties will likely be the decade of sustaining technical and institutional excellence in support of economic development.

4.2 Cassava

In the last twenty years, cassava production has more than doubled in the region, from about 20 million to about 47 million MT, a growth rate of more than 5% per year. The largest producer in Asia is Thailand, with 38% (18 million MT) of total production in 1984-86 and an estimated production for 1988 of 23 million MT.

It is well known that the Thai cassava industry is based on the export of cassava pellets to the EEC and other developed-country markets. The Thai cassava industry has brought wealth and stability to large areas of the country. The imposition of quotas on cassava exports by the EEC (effective 1982) has surprisingly not halted the continued increase in cassava production. This appears to be for two reasons: (1) farmers have an asymmetric supply response to price; once they start growing cassava, they tend not to stop as prices decline below their entry point due to the lack of viable alternatives; and (2) the Thais have proven remarkably adept at finding new markets. Six years ago it was predicted that Thai cassava production would decline with the imposition of quotas, but history does not reflect that.

Excluding Thailand, cassava production has increased at a healthy rate of 2.7% per year for the last twenty years. The increase appears to be largely through demand-led diversification of the end uses of cassava. Thus, in India, cassava production in the traditional forms in Kerala has declined while in Tamil Nadu, starch production increased from 0.7 million MT in 1973-74 to 1.5 million MT in 1984-85. Similarly, in Indonesia, cassava has moved increasingly into the starch market, which in turn provides the basic raw material for numerous food products. In the coming years, it is expected that cassava will continue to move into new markets and that Asian native ingenuity will continue to find new uses for cassava as it has in the past. In addition, the poultry feed market is growing extremely rapidly in Asian countries.

Certain Southeast Asian countries have fallen out of the mainstream of the Pacific economic miracle. Annual growth rates in cassava have been very high in these countries over the last two decades: Burma 13%, Kampuchea 10%, Laos 12%, and Vietnam 8%. These countries indicate the fundamental role that cassava plays in maintaining food supplies under crisis conditions and when economies revert to close to subsistence levels. Cassava will continue to play this role; what is new, however, is the realization that cassava has an increasing role to play in rapidly developing economies such as those of Indonesia and China.

5. Concluding Remarks

It is concluded that the demand for production and utilization technology of CIAT commodities will grow and become more diverse. The agricultural sectors of developing countries are at the same time becoming more heterogeneous. Although other important staple food commodities were not examined here, it is considered that given the limited growth prospects for CIAT and its existing stock of scientific agricultural knowledge, it will be cost-effective to maintain involvement in only the currently mandated commodity portfolio. Nevertheless, the task force contends that in the areas of human resource development and basic scientific research, the Center could offer broadly interchangeable methodologies to achieve a widespread impact on the increasingly diverse agricultural sectors of developing economies.

Table 1. **Selected socioeconomic indicators of developing regions.**

Indicators	Latin America	Africa	Near East	Far East
Population (1986) (in millions)	413.6	464.8	248.9	1400.3
Population growth rate (1970-86) (%)	2.4	3.0	2.7	2.3
Population density (inhabitants/km^2)	19.7	18.7	19.4	162.4
Urbanization (%)	68.4	35.6	48.0	38.2
GDP per capita (1985 US$)	1673	469	2090	451
GDP growth rate (1965-85) (%)	2.6	0.6	2.9	2.4
Area in crops/inhabitant (1985)	0.44	0.34	0.34	0.20
Potential crop area/inhabitant in 2000	0.87	1.01	0.39	0.17
Irrigated land/inhabitant (1985)	0.03	0.01	0.08	0.05
Head of cattle/inhabitant (1986)	0.74	0.30	0.23	0.20

SOURCE: FAO Production Yearbook (several years); World Bank (1987); FAO (1981).

Table 2. Beans in Latin America: 1984-86 and outlook for production and consumption balances in the year 2000.

Region or country	1984-86 Production (000 MT)	1984-86 Consumption (000 MT)	1984-86 Balance (000 MT)	2000 Production (000 MT)	2000 Consumption (000 MT)	2000 Balance (000 MT)
Brazil	2465	2514	-49	2945	3296	-351
Mexico	989	1104	-115	1643	1536	107
Andean region	260	294	-34	298	405	-107
Central America	290	309	-19	462	442	20
Caribbean	120	125	-5	146	158	-12
Southern Cone	334	85	249	496	104	392
Total	4458	4431	27	5990	5941	49

Beans in Africa: 1984-86 and outlook for production and consumption balances in the year 2000.

Region or country	1984-86 Production (000 MT)	1984-86 Consumption (000 MT)	1984-86 Balance (000 MT)	2000 Production (000 MT)	2000 Consumption (000 MT)	2000 Balance (000 MT)
Eastern Africa	1090	n.a.	n.a.	1509	1926	-417
Great Lakes Region	593	593	0	746	968	-222
Southern Africa	497	478	19	817	840	-23
Others	182	173	9	210	312	-102
Total	2362	n.a.	n.a.	3282	4046	-764

SOURCE: FAO and CIAT estimates.

Table 3. Beef in Latin America: 1984-86 situation and outlook for production and consumption balances in the year 2000.

Region or country	1984-86 Production (000 MT)	1984-86 Consumption (000MT)	1984-86 Balance (000 MT)	2000 Production (000 MT)	2000 Consumption (000 MT)	2000 Balance (000 MT)
Brazil	2095	1768	327	2658	2702	-44
Mexico	960	968	-8	1273	1541	-268
Central America	323	281	42	539	450	89
Caribbean	260	377	-117	308	509	-201
Andean countries	1369	1359	10	2169	2101	68
Trop. Latin America	5007	4753	254	6947	7303	-356
Southern Cone	3199	2833	366	3991	3514	477
Latin America	8206	7586	620	10938	10817	121

SOURCE: FAO and CIAT estimates.

Table 4. Milk in Latin America: 1984-86 situation and outlook for production and consumption balances in the year 2000.

Region or country	1984-86 Production (000 MT)	1984-86 Consumption (000 MT)	1984-86 Balance (000 MT)	2000 Production (000 MT)	2000 Consumption (000 MT)	2000 Balance (000 MT)
Brazil	12248	12996	-748	16728	19496	-2768
Mexico	7508	8885	-1377	12043	13779	-1736
Central America	1481	1803	-322	1736	2619	-883
Caribbean	1709	2469	-760	2295	3253	-958
Andean countries	6582	7586	-1004	8752	11353	-2601
Trop. Latin America	29528	33739	-4211	41554	50500	-8946
Southern Cone	7643	7696	-53	9604	9586	18
Latin America	37171	41435	-4264	51158	60086	-8928

SOURCE: FAO and CIAT estimates.

Table 5. Paddy rice in Latin America: 1984-86 situation and outlook for productio
and consumption balances in the year 2000.

Region or country	1984-86 Production (000 MT)	1984-86 Consumption (000 MT)	1984-86 Balance (000 MT)	2000 Production (000 MT)	2000 Consumption (000 MT)	2000 Balanc (000 MT
Brazil	9482	10325	-843	13094	14478	-1384
Mexico	605	794	-189	780	1172	-392
Central America	682	700	-18	965	1015	-59
Caribbean	1749	2040	-291	2906	2686	220
Andean countries	3718	3992	-274	4950	5897	-947
Trop. Latin America	16236	17851	-1615	22695	25257	-2562
Southern Cone	975	529	446	2047	664	1383
Latin America	17211	18380	-1169	24742	25921	-1179

SOURCE: FAO and CIAT estimates.

Appendix D

Task Force Report: NARDS' TRENDS[1,2]

Background

During the decades of the seventies and eighties, CIAT's relationships with the NARDS focused on the following activities related to its specific mandated commodities:

1. Germplasm development

   Except for the Rice Program (which uses the IRRI collection), the programs have built up germplasm collections, which have been or are in the process of being characterized. The collections are screened for resistance/tolerance to biotic and abiotic stresses. Based on these materials, the program breeders develop improved varieties (i.e., higher yielding and resistant or tolerant to environmental stresses), using classical techniques.

2. Applied research, with limited basic and adaptive research for specific areas

   - Basic research with a high potential for payoff in the development of new technologies.

   - Applied research to develop varieties adapted to specific constraints in a given environment under low external input conditions.

   - Adaptive research to develop methodologies for selected areas that are directly related to the effectiveness of CIAT commodity research strategies (e.g., on-farm research) and cultural practices emphasizing minimum purchased inputs.

   - Development research in support of integrated production, utilization and commercialization, as well as technology transfer projects in order to develop models, methodologies and techniques that can be used by NARDS.

1/ The acronym NARDS used herein refers to the whole gamut of public and private institutions engaged in some aspect of agriculture within a given country; e.g., national agricultural research institutions (NARIs), universities, development organizations, nongovernment organizations, and agribusinesses including seed companies.

2/ Task force members: F. Torres, C. Pérez, R. Vera, G. Habich, W. Janssen, D. Pachico and T. Brekelbaum.

Except for basic research, which is conducted in collaboration with advanced research institutions, these activities are carried out in close collaboration with the NARDS, whose primary function is to conduct adaptive research and technology transfer activities.

3. Formation and strengthening of national agricultural research institution (NARI) capabilities

CIAT's role in institution building has focused on the formation and strengthening of commodity research and seed technology programs. In many cases the NARIs did not have programs dedicated to the commodities in CIAT's mandate; thus it was necessary to establish them where the governments were interested in doing so. Intensive research-oriented training programs have been provided for NARDS' staff, and in-country technology transfer-oriented courses have been supported. Where there was some installed research capacity, the emphasis has been on strengthening it through specialized training in different disciplines. The NARIs have been backstopped by senior scientists, primarily from headquarters. Specialized information, publications and audiotutorial materials have also been produced and distributed to them.

As the programs have become stronger, CIAT has fostered the creation of regional commodity research networks to (a) achieve economies of scale by having individual members address common problems, and (b) provide the basis for horizontal transfer of germplasm, experiences and knowledge among participants.

Development Trends Related to the NARDS

The NARDS task force first developed a discussion paper addressing the issues of (1) expected development of the agricultural sector in Latin America and its consequences for technology demand by the farmer; (2) the evolution of the NARDS; (3) the NARDS' capacity to satisfy the demand identified in point one; (4) the implications of the NARDS research plans vis-à-vis their collaboration with CIAT; in other words, the determination of the derived technology demand; and (5) collaborative mechanisms that could be pursued by CIAT in satisfying this derived demand for R & D technology effectively.

Then two think tanks were held: one for Latin America and the other for Africa and Asia. The groups were comprised of expert consultants, representatives from the NARDS and ISNAR, members of the CIAT Board of Trustees from the respective regions, and CIAT staff outposted to these regions (see list of participants in Appendix B). The findings of these groups were then discussed with the CIAT leadership group and at the internal program review in December 1988. A synthesis is presented herein.

Socioeconomic Context

Scenario

1. Stronger economic growth for developing countries.
2. Greater government recognition of agriculture as a driving force in economic development.
3. Globalization of the agricultural market and an increasing market orientation of agriculture, primarily in Latin America and Asia, which will also lead to further specialization.
4. The urban poor as a stronger force in domestic politics; pressure for low-cost staples.
5. Emphasis on productivity and efficiency, given the need to compete in more sophisticated international markets and to satisfy the domestic demand for low-cost staples.
6. Increased R & D focused on market-oriented farmers.
7. Equity issues related to marginal groups to be dealt with indirectly through integrated rural development projects, not through targeted agricultural research.
8. Increased pressure from the international community for sustainable agricultural production.

Implications

1. There will be a greater demand, on the one hand, for technology to produce both high-quality and more diverse products for the international and domestic markets; and on the other, for low-cost staples to meet growing demands from the urban poor. Demand will be location specific.
2. There will be a greater diversification of products for both domestic and international markets, leading to a greater demand for postharvest and processing technologies.
3. Low capital availability will hinder infrastructure development in frontier areas.
4. The primary target of the NARDS will be farmers with access to markets and the capacity to apply new technology.
5. The needs of the low-resource and subsistence farmers, who cannot be brought into the market economy, will have to be met otherwise (e.g., integrated rural development projects).
6. Donors will become increasingly concerned about IARC/NARDS relationships and sustainability issues.

Institutional Context

Scenario

1. Despite projected economic growth, no substantial impact on the resources available to the NARDS in Latin America and Africa within the ten-year time frame.

2. Many more actors involved, primarily in the form of private foundations and profit-oriented companies, as well as more farmers organizations in Latin America, broadening the spectrum of partners from NARIs to NARDS.

3. Growing concern for transfer of technology, resulting in greater resource allocation to this area than to technology generation.

4. Greater pressure internationally from donors and the CG Secretariat for formalizing and strengthening regional networks (the PROCIs, SACCAR, ASEAN) to orient regional research, establish priorities, and organize training and workshop efforts.

5. Better qualified human resource capability for technology generation (except in Africa), but the capacity of the NARIs to remain weak, except in Asia.

6. Except for Asia, a diminished capacity for human resource development, at both the undergraduate and graduate levels, in both technology generation and transfer.

7. Insufficient managerial capacity, affecting NARDS research productivity.

Implications

1. The NARIs will be faced with a broader mandate (including nontraditional export-oriented crops) and spectrum of activities (both up- and downstream).

2. There will be more interinstitutional interfaces within and among the NARDS, requiring more complex institutional arrangements and managerial skills.

3. The NARDS will require more operational funds. Given donor reluctance to provide soft monies, this will necessitate more creative mechanisms to channel, administer and account for funds because their highly centralized system does not permit R & D programs to seek external funds for special projects.

4. The advanced NARIs will want to assume regional research responsibilities. If their scientists do not receive sufficient motivation, there is the increased danger of their being attracted by the growing private sector.

5. Given the ever-rising costs of graduate education abroad, language difficulties, and the lack of relevance to tropical agriculture, there will be a greatly increased demand to strengthen national and regional educational institutions.

6. In addition to their success in generating and transferring technology related to their commodities, the IARCs will be held more accountable for the effectiveness of their relationships with the NARDS and the impact of their technology on the environment.

Derived Demand (NARDS/CIAT)

The NARDS vary in scope, size, stage of development, and relative emphasis given to CIAT's commodities; thus the derived mix of cooperative activities and demand for services will vary. For purposes of this discussion, the focus is on two groups: the more advanced national commodity programs with both the capability and capacity to carry out their R & D strategies; and the less-advanced programs that have more limited capability and capacity.

Although the specific analyses of derived demand will be made at the program level, the task force has developed a general list of tendencies for these two groups with respect to scientific research and institution building.

Advanced NARDS

Given the increased capacity of the advanced NARDS in the scientific field, there will be a move from a demand for applied research to one for more basic, strategic research as follows:

Less

- Finished breeding products
- Work on favorable environments
- Packaged technology for cultural practices
- On-farm research

More

- Specifically characterized segregating & parent materials (advanced germplasm)
- Biotech applications for nonconventional breeding
- Methodology development
- Postharvest and commercialization technology
- Natural resource management studies for sustainable agriculture in stressed, unfavorable environments

With regard to activities related to institution building, there will be a move from "receivers" to suppliers," as well as an increased demand from other sectors of the NARDS.

Less	More
- Production & general research training	- Training of other NARDS
- In-country training	- Specialized and higher degree training
- On-farm research training	- Methodologies for training trainers
	- Research management training
	- Financial support for regional activities

Less-Advanced NARDS

In the scientific field, it is expected that there will be a general move from the demand for adaptive to applied research as follows:

Less	More
- Variety testing	- Parental materials
- Crop orientation	- Production systems management
	- Integrated crop management strategies
	- Soil conservation and sustainability of yield (Africa and Asia)
	- Processing and managing scientific data
	- Scientific information and training materials

With regard to institution building, there will be a gradual move toward regional linkages, which will increase the demand for information and for supporting commodity-oriented networks.

Less	More
	- Production training
	- Information exchange
	- Leadership in integrating regional cooperation
	- Promotional activities with national leaders (use IARC's institutional clout)
	- Support of development projects
	- Financial support for regional and operational activities

Internal Considerations

Comparative Advantage

In the scientific fields related to its mandate, CIAT has the following comparative advantages:

1. State-of-the-art knowledge on beans, cassava, rice, tropical pastures and seed technology.

2. Germplasm collection and characterization.

3. Development of methodologies for R & D activities and scientific principles for location-specific research.

4. Information and documentation services.

With respect to institution-building, the Center has the following comparative advantages:

1. Exposure of NARDS scientists to multiple disciplines and technology generation and transfer situations.

2. Role model for NARDS leaders and scientists; potential for influencing their attitudes.

3. Role of institutional convener, given its scientific credibility and institutional neutrality.

Strategies for the Nineties

To devise strategies for the next decade, it is necessary to estimate the growth potential of the countries and the NARDS with which CIAT works and to bear in mind that the Center's resources are reaching the upper limit of expansion--that is, a no growth or limited growth situation vis-à-vis the expected broader spectrum of support demands. The following strategies with regard to technology generation are recommended:

1. Support the move to regional integration of NARDS with division of research responsibilities based on comparative advantages; a coordinating role for CIAT.

2. Stimulate the evolution from a simple radial-hub networking model to a multinodal network based on horizontal interactions among all members with more sharing and specialization of responsibilities.

3. Promote the development of upstream research networks, linking scientists from developed and developing countries around specific research problems and opportunities.

4. Work more with those less-advanced programs that have the greatest potential for "takeoff," based on an institutional diagnosis vis-à-vis CIAT's comparative advantages.

With regard to technology transfer activities, emphasis will be on the following strategies:

1. Develop methodologies to strengthen the NARDS technology generation and transfer linkages.

2. Provide opportunities for graduate thesis research to be conducted under the guidance of experienced senior staff at CIAT headquarters and in the regions.

3. Conduct more individualized training for NARI scientists.

4. Train NARDS personnel to collaborate with in-country production and on-farm research courses, as well as certain regional training activities.

5. Play a catalytic role in the promotion of development-oriented pilot activities, gradually transferring the methodologies to regional and national bodies.

6. Develop training materials on CIAT commodities at different levels and in different languages.

To facilitate an effective partnership, it is also envisaged that CIAT may have to assume a managerial role in channeling external funds for regional activities, expediting their allocation and disbursement, while ensuring their specific use.

Appendix E

SUMMARY OF RESPONSES TO SURVEY ON DRAFT STRATEGIC PLAN[1]

1. Trends for the Nineties: Assumptions for Latin America

		SA	A	D	SD[2]
1.1	The current economic crises will continue for the next decade.	3	15	4	0
1.2	The continued devaluation of domestic currencies will lead to reduced food and feed imports.	5	16	1	0
1.3	Economic growth will stem from increased trade and technological development in the agricultural sector.	7	15	0	0
1.4	Given serious economic crises, national governments will tend to curtail services.	4	15	3	1
1.5	Despite the potential for agriculture as a driving force in development, there will be limited funds for agricultural research and development activities.	7	13	2	1
1.6	Infrastructure development for frontiers will be limited.	1	19	2	0
1.7	Agricultural growth will have to be primarily through intensification of land use.	10	8	4	1
1.8	Environmental degradation will accelerate unless programs that impact on increasing rural incomes are developed.	10	9	3	1
1.9	There will be more of a market orientation toward agriculture.	5	14	1	0
1.10	There will be increased globalization of the agricultural market.	3	13	3	0
1.11	The reduction of food imports will lead to decreased food security among the poor.	0	10	10	3
1.12	The increased potential for nontraditional	0	5	14	2

[1] Raw scores, based on 24 respondents of 64 receiving survey.

[2] SA=Strongly agree; A=Agree; D=Disagree; SD=Strongly disagree

		SA	A	D	SD[3]
	exports will lead to decreased food security among the poor.				
1.13	The trend toward increased urbanization will continue.	5	16	1	0
1.14	There will be increased political pressures to increase production of low—cost staples to improve the nutritional status of the growing low-income urban population.	5	15	1	0
1.15	There will be increased demand from the middle- and high-income urban strata for more diversified produce, as well as more processed foods for quick preparation.	6	15	1	0

2. National Agricultural Research & Development Systems (NARDS)

		SA	A	D	SD
2.1	Given the projected limited public resources, agricultural research will have to be market driven, emphasizing short-term benefits.	3	18	3	0
2.2	The NARS will focus more on export and other income-generating crops.	1	16	6	0
2.3	To promote broad-based economic development, the NARDS will focus more on commercially oriented farmers.	2	13	9	0
2.4	Given the globalization of the market, there will be a demand for research on nontraditional export crops.	4	19	0	0
2.5	The increased demand for intensive research on export-oriented crops will stimulate the formation of more producer associations.	4	16	2	0
2.6	There will be more private companies and foundations involved in agroindustrial research related to export-oriented crops.	8	13	1	0
2.7	Given the greater number of actors, there will be more complex interinstitutional interfaces.	5	14	3	0

[3] SA=Strongly agree; A=Agree; D=Disagree; SD=Strongly disagree

		SA	A	D	SD[4]
2.8	There is a general lack of managerial capacity in national agricultural research institutions (NARIs), which affects their research productivity.	6	9	7	1
2.9	There are more qualified and experienced human resources in the NARDS.	2	9	8	1
2.10	Given limited funds for operational activities, there will be continued turnover and underutilization of the human resource base.	6	12	5	0
2.11	There will be a diminished capacity for in-country human resource development in both technology generation and transfer at the undergraduate level.	0	10	11	0
2.12	There will be a diminished capacity for human resource development in both technology generation and transfer at the graduate level.	0	11	9	1
2.13	The national agricultural research systems (NARS) are concerned about developed country institutions controlling new technology through patents.	5	12	5	1
2.14	The more advanced NARS will conduct more basic and applied research in an effort to stay at the forefront of scientific and technological developments.	5	15	1	1
2.15	The NARS will place more emphasis on biological forms of pest control.	7	16	1	0
2.16	The NARS will place more emphasis on enhancement of soil fertility; e.g., a plant's biological nitrogen fixation ability.	9	13	1	0
2.17	The NARS will place more emphasis on policy research, particularly as related to agroindustrial development.	3	12	8	0
2.18	In relation to CIAT commodities, NARI scientists have acquired more knowledge and experience.	8	12	4	0

[4] SA=Strongly agree; A=Agree; D=Disagree; SD=Strongly disagree

		SA	A	D	SD[5]
2.19	In relation to CIAT commodities, the NARIs will assume more responsibility for conventional breeding.	2	14	6	2
2.20	In relation to genetic materials of CIAT commodities produced by a NARI, these will be interchanged freely among the countries of the region.	7	14	2	0
2.21	In relation to CIAT commodities, the NARIs will assume more responsibility for developing cultural practices.	4	18	0	0
2.22	The NARS will place more emphasis on technology transfer activities.	7	13	2	1
2.23	The stronger NARDS will engage in more on-farm research.	7	15	0	1
2.24	The traditional gap between research and extension will be narrowed in stronger NARDS as a result of greater on-farm research activities.	9	14	0	1
2.25	As concerns CIAT commodities, the stronger NARS will prefer to invest their limited funds in more favored areas and leave CIAT to work in the less-favored areas.	2	9	7	3
2.26	As concerns CIAT commodities, the stronger NARS will assume more responsibility for in-country training activities, especially general production courses and on-farm research methodologies.	4	17	2	0
2.27	The NARDS have sufficient access to publications and other information services related to CIAT commodities.	2	13	9	0
2.28	Commodity-oriented research networks will become a more important strategic tool to bring about regional collaboration.	8	16	0	0
2.29	The NARIs will not be able to fund regional activities out of their budgets.	13	7	2	1
2.30	The NARS will place pressure on the donors to continue their support of	10	11	0	1

[5] SA=Strongly agree; A=Agree; D=Disagree; SD=Strongly disagree

		SA	A	D	SD[6]
	regional network activities.				
2.31	To increase efficiency in the use of scarce resources, smaller NARDS will integrate their R&D efforts in a regionally oriented division of labor.	4	14	4	0

3. CIAT

		SA	A	D	SD
3.1	CIAT's current commodity mix is the right one.	0	19	1	0
3.2	The Center should increase its research efforts to improve agricultural productivity and develop production technology that is sustainable over time and that will not lead to environmental degradation.	14	10	0	0
3.3	CIAT should act as a catalyst in fostering appropriate policies for agricultural development.	5	15	3	0
3.4	CIAT should continue to emphasize a genetic approach to solving production problems.	4	18	2	0
3.5	The Center should concentrate on characterizing and documenting the vast germplasm collections for use by the NARS.	6	14	3	0
3.6	Genetic materials of CIAT commodities produced by a NARI should be made available to other NARIs through CIAT's regional programs or where none exists, from headquarters.	13	11	0	0
3.7	CIAT should continue to emphasize a low-input philosophy with regard to agricultural production technology.	9	13	1	0
3.8	CIAT should help NARDS identify funds for formal graduate training.	10	13	0	0
3.9	CIAT should provide less technical backstopping assistance for the NARIs.	0	6	11	5

[6] SA=Strongly agree; A=Agree; D=Disagree; SD=Strongly disagree

	SA	A	D	SD[7]
3.10 CIAT should provide more methodological support to the NARDS.	6	17	0	0
3.11 CIAT should reduce its training efforts related to the general production of its commodities, which can be handled by the NARIs themselves.	2	13	6	1
3.12 CIAT should increase specialized training and internships for NARDS personnel.	10	14	0	0
3.13 CIAT should organize more commodity-focused workshops to improve communication among regional network researchers.	9	14	0	0
3.14 CIAT should organize courses for preparing NARDS trainers.	10	12	2	0
3.15 CIAT should increase its research efforts in the area of integrated crop management.	10	14	0	0
3.16 CIAT should increase its research efforts in the area of postharvest technology.	8	12	3	0
3.17 CIAT should decrease its research efforts in conventional breeding.	2	10	9	2
3.18 CIAT should decrease its research efforts in on-farm research.	1	11	9	2
3.19 CIAT should continue its work on methodology development and training materials related to on-farm research.	7	16	1	0
3.20 CIAT should decrease its research efforts in developing cultural practices.	1	9	14	0
3.21 CIAT should continue to emphasize applied research.	6	15	2	0
3.22 CIAT should expand its efforts in strategic research, which is problem-solving and mission oriented at whatever level of sophistication is required to overcome important production constraints.	9	14	0	0
3.23 CIAT should increase its strategic research efforts in order to take	10	13	0	1

[7] SA=Strongly agree; A=Agree; D=Disagree; SD=Strongly disagree

		SA	A	D	SD[8]
	advantage of scientific developments in the areas of tissue culture, molecular biology and genetic engineering.				
3.24	CIAT should increase its strategic research efforts to characterize germplasm and to identify gene pools and recombinant ability to facilitate more accurate identification of progenitors for CIAT and NARI plant breeding activities.	11	13	0	0
3.25	The Center should increase its strategic research efforts in order to understand better the biology, natural control mechanisms and epidemiology of the causal organisms of important diseases and pests of its mandated commodities.	11	12	1	0
3.26	CIAT should increase its strategic research efforts in order to understand better the plant mechanisms related to yield, photosynthetic efficiency, drought tolerance and nutrient utilization.	10	11	3	0
3.27	The Center should increase its strategic research efforts in order to obtain a better understanding of plant/soil/ microorganism relationships.	7	16	1	0
3.28	CIAT should expand research activities in small farmer seed production.	3	12	7	1
3.29	The Center should expand research activities in integrated production, postharvest utilization and marketing of commodities on a pilot scale.	4	13	4	1
3.30	CIAT should expand research activities in key areas such as farmer participation in research design and testing.	2	8	12	0
3.31	CIAT has a comparative advantage in doing strategic research on natural resource management in Latin America.	4	10	4	0
3.32	CIAT should place emphasis on the enhancement of natural resources and increased productivity on less fragile,	6	14	1	0

[8] SA=Strongly agree; A=Agree; D=Disagree; SD=Strongly disagree

		SA	A	D	SD[9]
	underutilized lands such as the highly acid, low fertility South American savannas with sufficient rainfall.				
3.33	CIAT should develop cropping systems to deter erosion of the steep Andean hillsides and mountain slopes.	5	14	2	0
3.34	CIAT should develop technology for reclaiming deforested areas in the humid tropics that are already degraded.	8	10	3	0
3.35	CIAT has a comparative advantage in creating a new development-oriented entity dedicated to activities related to its mandated commodities.	3	12	2	0
3.36	CIAT should maintain its traditional emphasis on low-resource farmers.	10	11	1	1
3.37	CIAT should also orient technologies toward farmers with a capability of producing marketable surpluses in medium- to high-potential areas.	6	16	1	1
3.38	CIAT should not work for marginal farmers in marginal areas.	1	7	11	1
3.39	CIAT should base its research investments on the highest social rate of return.	9	9	4	0
3.40	As the Center does not have a comparative advantage in basic research, this should be done through cooperative efforts with highly specialized research institutions that have the expertise and equipment.	12	12	0	0
3.41	CIAT will be less called upon to fill gaps for the NARDS.	0	3	11	3
3.42	CIAT should analyze its relationships with the NARDS on the basis of a more collaborative, partnership mode--i.e., complementarity, in which its comparative advantage is reviewed.	11	12	0	0
3.43	CIAT should work with all the actors at the national level, including the	8	13	1	1

[9] SA=Strongly agree; A=Agree; D=Disagree; SD=Strongly disagree

		SA	A	D	SD
	universities.				
3.44	CIAT should work with all the actors at the national level, including the private sector.	4	12	6	1
3.45	CIAT should serve as a link between agricultural research institutions in developed and developing countries.	10	12	1	0
3.46	CIAT should serve as a facilitator of scientific cooperation at the regional level.	11	13	0	0
3.47	CIAT should help NARDS identify funds for regional research activities.	12	12	0	0
3.48	CIAT should serve as a facilitator of scientific cooperation at the national level.	4	8	12	0

RESPONDENTS TO NARDS SURVEY

LATIN AMERICA

Country	Institution
Belize	MAG
Bolivia	IBTA
Brazil	CNPAF
Chile	INIA
Colombia	Universidad Nacional
Costa Rica	MAG
Costa Rica	IICA
Cuba	MAG
Dominican Republic	SEA
Ecuador	INIAP
Ecuador	FUNDAGRO
Guatemala	ICTA
Guayana	NARI
Panama	IDIAP
Panama	Universidad de Panamá
Trinidad & Tobago	MAG

AFRICA

Burundi	ISABU
Swaziland	MAG
Zaire	INERA
Zimbabwe	DRSS

ASIA

Malaysia	MARDI
PRC	SCATC
Thailand	Kasetsart University
Vietnam	Institute of Agricultural Technology

Appendix F

Task Force Report: NATURAL RESOURCE MANAGEMENT FOR SUSTAINABLE AGRICULTURE[1]

1. Background

Agricultural development needs to be considered within the broader context of the environment (i.e., physical resources, man's relationships with new technology and the environment, and agricultural policy environment). Therefore, a task force on natural resources was created as part of the exercise to develop a sound Centerwide strategy for the coming decade.

Within this context, the task force addressed five main questions:

- Given the existing mandate of CIAT and areas of expertise, what are the main environmental concerns in relation to natural resource use, now and in the future?

- What is CIAT doing about these concerns at present?

- Are changes in research focus required?

- If so, what are the related strategic issues?

- What would be the organizational implications for CIAT?

The task force prepared an issues paper looking at environment-crop relationships, environmental concerns by commodity, and potential research strategies. The paper was first presented to a think tank whose members included soil scientists (physical and chemical), an ecologist, a systems specialist, economists and an environmentalist. The think tank discussed research strategies for the different environmental concerns, the potential role of CIAT and other international centers working in this area, and the possible implications for CIAT in the coming decade.

2. Concerns on the Use of Natural Resources for Agriculture

Agriculture makes use of natural resources for the benefit of society. The task force considered that the overriding concern in dealing with the task at hand was how new technologies could affect the conservation of natural resources and the sustainability of agriculture.

1/ Task force members: F. Torres, R. Zeigler, P. Jones, J. Spain, J. White and T. Brekelbaum.

2.1 Conservation of Natural Resources

The task force concluded that there were four major areas of concern for agricultural development. These were genetic erosion of species, biotic factors related to noxious organisms, abiotic factors related to soil degradation and loss, and deforestation, which leads to general environmental degradation.

2.1.1 **Genetic diversity** includes concerns related to the narrowing genetic base of improved cultivars as farmers plant a few, similar varieties over large areas; the loss of natural variability an landraces (future genetic resources); and the restricted flow of "genes." The risk of genetic vulnerability to biological and climatic shock increases as the resilience of crop species is lost. This resilience is due to genetic diversity.

To diversify materials, breeders must have access to a crop's full genetic range, including wild relatives. A prerequisite for this capability is a well-characterized, well-preserved, pathogen-free germplasm bank. Destruction of natural habitats of wild members of the crop species and its relatives is another serious concern.

2.1.2 **Noxious organisms.** Improved varieties of crops may prove susceptible to previously unimportant diseases and pests. Intensification of cropping, particularly in monoculture, can favor evolution of new biotypes of existing noxious organisms. Increased international shipments of seed or vegetative propagules can result in accidental introduction of new diseases and pests. This applies not only to research institutions but also to commercial enterprises. Misuse of agrochemicals will increase unless effective integrated pest and disease control measures are developed.

2.1.3 **Soil degradation** includes soil erosion, deterioration of structure, loss of nutrients, and buildup of toxic elements, and can be associated with off-site problems such as sedimentation.

- Current status: hills and mountain slopes. Most of the Andean hills and mountain slopes have been deforested to establish crops or pastures. The pastures are overgrazed and sometimes burned as a means of controlling weeds and burning off dry pasture. Mountain soils are susceptible to erosion due to their geologic instability and the steepness of the slopes. Climatic conditions exacerbate the tendency to erode (e.g. intense storms even in regions of relatively low rainfall). Resource-poor farmers on marginal lands with precarious land tenure cannot be expected to adopt complex and costly conservation measures, no matter how effective, unless there is a visible short-term benefit. Consequently, identifying technical solutions to the problem of soil degradation in the highlands, compatible with the socioeconomic conditions of the region, will be a challenge. Unless there are major policy changes with respect to land tenure, credit availability, subsidized conservation conservation practices and technical assistance, implementation of solutions will be difficult.

On steep sites, reforestation may be the only practicable way to control runoff and erosion. On hillsides, agro-silvo and agro-silvo-pastoral systems could be developed to protect the soil continually by tree cover with an understory of annual or perennial crops. Not only will soil physical conditions be improved, but also organic matter, nitrogen fertility, and the availability of other essential mineral elements will be increased.

There is a danger in attempting to import ready-made solutions from temperate zones. In the case of the extreme, irregular slopes of the Andes, contour farming is seldom practical, even when combined with terraces. Crop and soil husbandry on these slopes is complex. Good drainage, but with adequate moisture, is critical. Excess water must be conducted down the slope carefully to avoid gully and sheet erosion while protecting the surface from the impact of heavy rainfall.

Possibilities for controlling erosion include combinations of reduced or zero tillage and the use of erosion-control structures. The use of barrier strips of perennial plants rather than erosion control structures has been successful in arresting both runoff and erosion on steep sites.

- <u>Current Status: lowlands</u>. Problems of soil erosion, compaction and soil fertility degradation are growing in importance. Chemical impoverishment of the soil is a problem, especially in the humid forests. There, much of the nutrient stock, found in the forest biomass, is released when the forest is cleared an burned. Soil erosion is serious in both forest and savanna ecosystems, even on gentle slopes of less than 2%. Many savanna Oxisols have stable microstructures but weak macrostructures. They are thus susceptible to surface sealing and subsequent sheet and gully erosion if they are unprotected, even though potential infiltration rates are high. Savanna climates are highly erosive with 1500-2500 mm of annual rainfall, concentrated in 6-8 month rainy seasons with frequent high-intensity storms.

Fortunately, most Oxisols and Ultisols are rather deep, and the slopes on which they are found are gentle enough for effective, mechanized conservation practices. These include no-till planting, minimum tillage, mulch farming, strip planting, alley cropping, contour rows and terraces. Little progress has been made in applying conservation practices in the rapidly expanding frontiers of Latin America. These frontier regions are particularly important in Brazil, Colombia, Venezuela, Peru and Bolivia. Here loss of soil fertility and erosion are now among the most serious, although often unacknowledged, problems.

2.1.4 Deforestation. CIAT recognizes the importance of preserving the tropical forest. Increasing atmospheric CO_2, loss of species diversity and soil degradation are clearly major concerns. The first two issues depend heavily on policy decisions, and the research components fall outside the mandate of CIAT. The Center does have the capacity to address the problem of soil degradation. Although a more local concern compared with the global implications of increased CO_2 and loss of species diversity, a solution to the problem of soil degradation should slow forest clearing.

2.2 Sustainability of Agriculture

Sustainability refers to the capacity of an agricultural system to maintain productivity in the face of stress without degrading the environment. The stresses may include drought, pest and disease buildup or decreasing soil fertility. The effects of stress may be exacerbated by socioeconomic factors such as inadequate credit, agrarian policies or lack of infrastructure for education, health or transport.

The cumulative effect of withstanding continuous stresses or discontinuous shocks can be critical. A major event such as a new pest or a large increase in input prices would constitute a shock. Depending upon the intensity of the shock, productivity of an agricultural system may remain unaffected. It may fall and gradually return to the previous level, it may settle to a low level, or it may collapse altogether. The principal stress on an agricultural production system is the declining quantity and quality of the natural resources that are the basis of agriculture.

Many determinants of agricultural sustainability cannot be dealt with at the farm level. Demographic pressure is an example of this and is a major reason why present agricultural practices are often not sustainable. This pressure is a result of various socioeconomic factors which include land tenure patterns and intersectorial—development policies.

2.3 Socioeconomic Factors

Natural resource concerns cannot be dealt with in isolation from critical socioeconomic constraints. Strategies for developing natural resources have been successful where technology and socio-economics have been adequately integrated. Nevertheless, the task is not easy as there are significant differences in value systems. In the case of land degradation, the decline in soil quality is the outcome of several factors, both proximate and underlying. The latter are not only difficult to identify but even more difficult to address. Developing agricultural technology that farmers can use must consider both types of factors. Among the most important socioeconomic factors that need to be taken into account are:

- Development and land use policies
- Land tenure
- International and domestic markets
- Infrastructure
- Demographic pressures
- Land availability
- Resource availability (financial and human)
- Traditional agricultural practices
- Farmers' level of education and management skills
- Farmer and consumer preferences

3. CIAT's Approach to Sustainability

3.1 Research Structure

The basic research structure of CIAT is organized along commodity lines with multidisciplinary teams of scientists. Originally, activities were restricted to Latin America; but given the Center's international mandate for beans and cassava, work has been extended to Africa and Asia.

From the onset, the commodity programs have emphasized the development of technologies appropriate for farmers with limited resources. Genetic solutions have been sought in preference to those requiring chemical inputs. This discourages the use of pesticides and other inputs often associated with loss of sustainability. As a primary strategy, CIAT has therefore emphasized breeding for resistance to diseases and pests and for tolerance to edaphic and climatic stresses. This in turn has generated concerns over loss of genetic diversity and possible introduction of noxious organisms through international networks of germplasm exchange. The latter is basically a quarantine issue.

3.2 Environmental Concerns

In consultation with CIAT program scientists the task force identified a list of environmental concerns connected with the development of sustainable systems. It also identified a range of socioeconomic constraints to solutions. It was recognized that it is vitally important to study and understand these constraints while assuming that they can only be influenced indirectly. As many concerns are expected to shift in importance over time, the task force found it useful to rate them based on their present and expected future importance (Table 3.2).

3.3 Conceptual Framework

The task force recognized the complexity of natural resources concerns. To simplify analysis, the task force followed a conceptual framework based on possible levels of intervention. These varied along a continuum from the gene level through increasing levels of system complexity, up to the level of geographic region. Table 3.3 develops this framework.

3.4 Sustainability Issues

Many of the environmental concerns identified in Section 3.2 have been effectively addressed by CIAT's interdisciplinary teams within a commodity framework. Nevertheless, the task force felt that certain concerns cut across commodity programs, thus requiring intervention of a higher level of integration. Table 3.4 shows the classification of CIAT's activities.

Table 3.2. Ratings of environmental concerns by commodity program.*

CONCERNS		IMPORTANCE OF PROBLEM BEANS	CASSAVA	PASTURES	RICE
BIOLOGICAL					
Impact of commodity through genetic erosion of:	- Commodity germplasm	0++	0++	0++	00+++
	- Other plants			0++	0+
	- Other organisms			+	+
Impact of commodity by introduction of:	- Weeds			0++	0+
	- Pests	+	0++	+	0+
	- Diseases	00++	00++	0++	0+
Impact of commodity by increasing:	- Pest resistance	0++	0+	0++	00+++
	- Disease incidence	000++	+	0++	00+++
	- Weed competition	+	00++	0++	00+++
PHYSICAL					
Impact of commodity on:	- Soil erosion	00+++	000+++	0++	0++
	- Soil fertility/ nutrient availability	0++	000+++	0++	0+
	- Soil physical characteristics	+	0+	0+++	00+++
	- Chemical pollution of the soil	+	0+	+	
	- Water availability				00+++
	- Water quality	+			00+++
	- CO_2 effects			+	
OTHER					
Impact of the commodity on:	- Pesticide poisoning/ pollution	+	+	+	0++
	- Agricultural diversity	+		0++	00++
	- Clearing of native vegetation			++	

* Ratings	Present	Future
Low	0	+
Medium	00	++
High	000	+++

Table 3.3. Relation between level of intervention and type of biotic and physical constraints or socioeconomic concerns.

LEVEL	CONCERNS/CONSTRAINTS BIOTIC/PHYSICAL*	SOCIOECONOMIC**
Gene	A, B, C	1
Plant	B, C, D	1, 2, 3, 4
Crop	B, C, D	1, 2, 3, 4
Farm	C, D	4, 5, 6, 7
Ecosystem	D, E-Z	4, 5, 6, 7, 8, 9-n
Region	D, E-Z	8, 9-n

* Biotic/Physical Concerns:

A = Genetic diversity
B = Noxious organisms
C = Decline in soil fertility
D = Soil erosion
E-Z = Deforestation, greenhouse effect, etc.

** Socioeconomic Constraints:

1 = Farmer and consumer preferences
2 = Farmers' traditional agricultural practices & management skills
3 = Human and financial resource availability
4 = Land tenure
5 = Markets
6 = Infrastructure
7 = Land allocation
8 = Development and land use policies
9-n = International trade, foreign debt, etc.

Table 3.4. Activities of CIAT commodity programs and support units related to sustainability issues, grouped by implied level of intervention along a continuum from the gene to agroecological region.

LEVEL OF INTERVENTION	ACTIVITIES OF COMMODITY PROGRAMS AND SUPPORT UNITS
Gene	- Collection and maintenance of major germplasm collections for bean, cassava and tropical pasture species
	- Phenotypic evaluation of germplasm bank accessions for agronomic performance and disease resistance
	- Gene pool characterization using biotechnology*
Plant	- Incorporation of resistance to major pests and diseases into new lines of beans, cassava and rice
	- Selection of pasture legumes and grasses resistant to major insects and diseases
	- Enhancement of nitrogen-fixation capacity in beans
	- Research on drought tolerance in beans and cassava
	- Selection for efficiency in nutrient use and tolerance to acid, infertile soils in beans
	- Studies on the effect of mycorrhizal associations on nutrient-use efficiency*
	- Development of rice lines with deep roots and tolerance to acid soils of savanna regions*
	- Development of pasture grasses and legumes tolerant to acid, infertile soils of savanna regions
	- Selection of well-adapted, deep-rooted grasses and legumes for reclaiming degraded, deforested lands in the humid tropics*
Crop	- Research on varietal mixtures of beans to reduce disease and insect damage*
	- Studies on soil fertility maintenance and erosion control in cassava and bean production systems

Table 3.4 continued.

LEVEL OF INTERVENTION	ACTIVITIES OF COMMODITY PROGRAMS AND SUPPORT UNITS
	- Development and promotion of integrated pest management practices for cassava and rice*
Farm	- Studies on plant/soil/animal interrelationships in nutrient cycling in pastures
	- Studies of use of shade-tolerant pasture species as potential components of silvopastoral systems*
	- Development of pasture/rice rotation systems for acid savanna soils*
	- Studies on agroforestry systems for enhancing soil fertility and reducing soil erosion in bean crops*
Ecosystem	- Anthropological studies of the land use practices of settlers in the Amazon Basin, with emphasis on social benefits of the use of better-adapted pastures to reclaim degraded, abandoned land*
	- Development of sustainable intensified pasture/crop systems for the acid savannas to provide a viable alternative to deforestation in frontier expansion*
	- Characterization of cassava-growing microregions in specific ecosystems in support of integrated cassava development projects
Region	- Agroecological classification for cassava, bean and rice environments to identify homologues within and between continents
	- Collection, biological studies and shipment to Africa of natural enemies of cassava pests (mealybugs and green mites)*
	- Agronomic study of cassava production, processing and marketing in Africa*

* Recent initiatives.

3.5 Geographic Focus

Notwithstanding the diversity of environments where CIAT's commodities are grown, there is considerable geographic overlap of production regions:

Northeast Brazil	Beans-Cassava
Amazon Basin	Pastures-Cassava-Rice
Eastern Andean Piedmont	Pastures-Cassava-Rice
Llanos of Colombia and Venezuela	Pastures-Cassava-Rice
Brazilian Cerrados	Pastures-Rice

While at present the commodity programs may not be working for the same clients, there is obvious potential for combined intervention to address natural resource concerns.

4. Research Challenges

4.1 Conserving Genetic Diversity

The task force concluded that most of the components required for conducting research activities in this area are in place. Given the germplasm banks, the Programs can address the concerns of preserving and maintaining the diversity of their commodities. It is envisaged that there will be a progressive move from germplasm improvement strategy to one of germplasm management. The task force felt this could be best accomplished by an internal reorganization to ensure the coordination of efforts currently dispersed across several programs and units. This issue that should be addressed during the next phase of strategic planning.

4.2 Managing Noxious Organisms

The task force felt that problems of diseases and pests are generally well in hand at the program level. There may be a need for increased input into integrated pest management as part of integrated crop management strategies, particularly in beans and rice. The problem of weed management is not being adequately addressed. Additional resources will be required. These may be deployed at the program level, or if deemed appropriate, to help in interprogram initiatives.

4.3 Conserving Soil Resources

Short-term soil fertility concerns are being handled by the commodity programs, some of which are also addressing soil erosion on a limited scale. The task force recommended that the programs dedicate additional efforts to this area. Solutions to soil degradation begin on the farm, but this problem must eventually be dealt with at higher levels of intervention, where CIAT is not involved at present.

4.4 Implications

4.4.1 The task force concluded that management and preservation of soil resources is the principal concern requiring additional research efforts. Crucial questions include:

- Should CIAT expand its activities to cover research issues at the ecosystem level?

- If the response is affirmative, what should be the geographic target(s); and what approach should CIAT take from an organizational standpoint?

- If CIAT is to be a role model for the national agricultural research and development systems, how should the sustainability of a system where various crops are being put together be studied?

- In entering this new area of research, how can CIAT benefit most effectively from the experience and expertise of sister IARCs and other institutions involved in the management and preservation of soil resources?

- How can "success" be evaluated in natural resources? Agricultural production technologies can be assessed in terms of crop productivity. In resource management the key concept is "damage reduction" rather than increased production. Although this can be measured, the gains in reducing damage to the environment and increasing agricultural sustainability cannot be expressed in terms of production alone.

- Is a new, independent unit/program needed to focus specifically on the management and preservation of soil resources at the level?

- If the Center expands its research to management and preservation of soil resources activities at higher system levels, it is proposed that criteria for selecting ecosystem target(s) and their application to mandated areas be developed by a special task force during the forthcoming stage of the strategic planning exercise.

4.4.2 **Geographical targets.** The high-priority ecosystems to be considered could be the following:

- Fragile and eroding tropical hills and mountain slopes. Many Latin American farmers are found on the hilly lands of the Andes and Central America, where the soils are more fertile than in the flatlands. Deforestation in these areas is almost complete, with only small patches of the original deciduous broadleaved and montane forests remaining. Erosion control is of paramount necessity, but there is no simple nor unique solution for these highly diverse regions. Reforestation may be the only viable alternative in some areas; sustainable crop/pasture or agroforestry production systems could be the solution in others. Care must be taken to choose areas where prospects for positive results are good. Particular emphasis should be given to the probable payoff and the policy environment needed for success.

- The underpopulated and underutilized savannas, which are generally used for extensive grazing although rice, and recently soybeans, are grown in the Cerrados of Brazil. Emphasis is still on extensive production. Erosion risks exist in most areas. Genetic erosion of savanna species will also occur as areas planted to improved pastures and crops increase.

  CIAT now has good prospects for releasing well-adapted varieties of rice and cassava for these acid soil areas. With these new developments it may be possible to design stable and intensified systems rotating pastures with crops. If socio-political pressures permit, then these could provide attractive alternatives to colonizing forest ecosystems.

- The humid tropical forests, which are under increasing threat of deforestation. Up to 15 percent of the global annual increase in atmospheric carbon dioxide is believed to be due to this cause. The loss of natural genetic diversity is also worrying as forest lands are replaced by crops and pastures. The cleared land is typically used for a few cycles of cropping and then put into pasture as weeds increase and fertility declines. The pastures then degrade due to nutrient deficiencies and weed encroachment. The nutrient depletion is primarily in phosphorus and nitrogen much of which was originally in the biomass of the forest stand.

  There might be two solutions for these areas. The first of these would be to reclaim the presently degraded pastures and develop a production system which would allow colonists to remain on their cleared land without further felling of virgin forest. The second solution would be to reduce the pressure of colonists moving into the forests by providing alternatives elsewhere.

4.4.3 Comparative advantage. These is evidently a need for expansion to include activities in the management and preservation of soil resources. This should emphasize research at the farm or ecosystem level. The task force has therefore analyzed the comparative advantages and disadvantages in CIAT undertaking this expanded role, see Table 4.4.

Table 4.4. CIAT's comparative advantages and disadvantages in undertaking activities related to management and preservation of soil resources.

ADVANTAGES	DISADVANTAGES
Continuity	Dilution of effort
Record of achievements	Technical and institutional complexity.
Credibility	Location specificity
Role model	High-risk venture
Networking experience	Traditional commodity and germplasm focus
Agroecological Studies Unit	

5. CONCLUSIONS

Assuring sustainable agricultural production involves not only the physical environment, but also important biotic problems, including loss of genetic diversity and buildup of noxious organisms.

CIAT's traditional commodity approach with emphasis on genetic improvement has confronted most aspects of the biotic concerns affecting the individual commodities. These efforts should be continued and reinforced. Deterioration of the physical environment has been addressed to some extent within the commodity framework. This work has been slanted towards prevention of erosion. Further initiatives are needed at a higher level of intervention to ensure that the practices conform with a reasonable system of farming. This will require a collaboration between commodity teams within CIAT and with other agricultural research and development institutes.

There are three major regions where soil degradation is a severe threat to sustainable agricultural production and where CIAT has a comparative advantage.

In tropical highlands, demographic pressures have led to the breakdown of traditional farming systems and resulted in severe soil degradation. CIAT has expertise in commodities highly appropriate to the development of stable productive systems for these areas.

Development of stable intensified production systems for the underutilized acid savannas would present opportunities for relieving demographic pressures in other regions.

Rehabilitation of previously degraded tropical forest areas would reduce the pressure for continued clearing and help in the preservation of virgin forest.

Appendix G

Task Force Report: SCIENCE AND TECHNOLOGY RESEARCH TRENDS[1]

Introduction

Agricultural research is a dynamic process that must evolve in order to meet the challenge of providing food for the world's growing population. Recent advances in the biological sciences add a new dimension to traditional research by permitting detailed analyses of the fundamental bases of plant processes. These advances are providing new tools that will increasingly find applications in germplasm characterization, evaluation and genetic improvement.

Research at CIAT is organized to provide solutions to problems that constrain crop production and postharvest use in tropical and subtropical regions of the world. Improved technological components, including improved germplasm and management methodologies, are the main products of CIAT's commodity programs. Without doubt traditional approaches have contributed to significant progress in a wide range of relevant research areas. There are, however, needs for better characterization of mechanisms underlying the responses of plants to biotic and abiotic factors in order to provide information regarding the inheritance of important characters, their location on the plant's genome, and their distribution among genetic stocks. Such knowledge will facilitate the speed with which many useful traits can be selected, transferred to other genotypes and utilized in crop improvement.

The emphasis to be given to this area of strategic research has been considered at CIAT in relation to its continuing mandate in applied and adaptive research in its commodities. As part of the CIAT strategic planning exercise, a task force was created to provide points of reference in this debate and establish the major concerns, which would then lead to an analysis of what would be the implications for CIAT in planning its future research activities; i.e. both biological and nonbiological. For this purpose developments in the next decade were studied from the standpoint of four broad topics: (1) biotic constraints to productivity, (2) microbial associations and plant productivity, (3) physiological and environmental aspects of plant productivity, and (4) product development and quality. A series of meetings were held with CIAT staff, after which discussion papers were prepared for each of the areas, describing the current research focus in CIAT commodities. In addition, advantage was taken of a workshop held to establish an advanced

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1/ Task force members: D.R. Laing, W. Roca, J. Cock, M. Fisher, M. El-Sharkawy.

cassava research network to invite participants to interact with some of CIAT's staff in an informal brainstorming regarding the wider strategic planning exercise at CIAT. A think tank was then held at CIAT with consultants who are at the forefront of their respective fields, as well as CIAT scientists from a range of relevant disciplines, to discuss a series of research issues in the four topics in order to identify the probable new science and technology developments and what could be their expected impact on CIAT's work.

This report summarizes the major conclusions regarding the future trends in biological and agricultural research in the next decade and their implications for CIAT as seen by members of the Science and Technology Task Force. The recommendations provided by the think tank were taken into account in its preparation.

Advanced Biological Research

The rapid rate at which new knowledge is emerging from the biological sciences makes it essential for an institution such as CIAT to monitor developments in this field continuously in order to identify those innovations most likely to benefit its research, as well as to help NARS maintain an awareness of new possibilities. It is anticipated that these modern approaches based on cellular, biochemical and molecular genetic knowledge will be followed in specific research problems. These approaches will be supported and/or be complementary to more basic research in areas such as plant physiology, microbiology and plant biochemistry, which will uncover new insights, thus providing biotechnological as well as traditional approaches with new and exciting applications for plant improvement.

The concept of comparative advantage in conducting such advanced research dictates that CIAT should maintain a problem-oriented approach; i.e. priority constraints that are amenable to modern research solutions would be identified within CIAT's commodities. The task force felt there are major activities in which CIAT should be actively involved:

1. <u>Monitoring and evaluation of new applications</u> and approaches to assess their potential effectiveness and to identify problems that are appropriate for more advanced approaches.

2. <u>Identification of key research areas</u> for collaborative projects through networks of advanced researchers working in developed and developing countries.

3. <u>Development of sufficient in-house capability</u> in the cellular and molecular biology research areas for the application of new biotechnological developments to CIAT commodities. Strengthening of biochemical and cytogenetical research at headquarters is essential to CIAT's role in advanced research and biotechnology, especially in issues relating

pathogen/insect - host plant resistance and germplasm characterization, genome analysis and gene mapping.

Future Research Trends Across CIAT Commodities

Research in CIAT's four mandated commodities (beans, cassava, rice and tropical pastures), which is conducted by multidisciplinary teams, is germplasm oriented. Development of low-input, cost-effective production technology is a major research concern at CIAT in order to increase food production and also to conserve natural resources for future generations. This section first summarizes the current research focus in the areas of biotic constraints, microbial associations, physiological and environmental aspects of plant productivity, and product quality and then outlines possible areas for future advanced biological research.

Biotic Constraints

CIAT programs are engaged in breeding and/or selection for host plant resistance to pests and pathogens, and this research will continue in the future. Notable successes have already been obtained in the identification and development of appropriate resistance. The following are some high priority areas where advanced biological research is expected to make a contribution.

1. Genetic base. Broadening the genetic base through expanding access to primary and secondary gene pools and through identification and introgression of key traits where more adequate genetic resistance is required (e.g., bean leafhopper, cassava mealybug, bean common bacterial blight, rice blast and *Stegasta* in *Stylosanthes*) would strengthen CIAT's role in providing NARS with improved germplasm.

2. Understanding basic mechanisms. Understanding the basic mechanisms of host plant resistance to pathogens and pests would enhance the process of plant improvement and provide a sound scientific basis for both traditional and modern genetic manipulation. This is particularly important in cases where resistance seems to be conferred by specific plant chemical substances (e.g., spittle bug in tropical pastures; bacterial blight, mites and mealybugs in cassava; rust and pod weevil in beans). A case in point is the discovery of the unique protein "arcelin," which effectively reduces postharvest damage by common bean beetles.

3. Gene transfer. The technology of gene transfer, through sexual and asexual means, from related species and microorganisms has improved greatly in recent years. Application of this technology can be envisaged in areas such as: (a) the transfer of R genes from *Phaseolus acutifolius* to *P. vulgaris*, which involves wide crossing and embryo rescue; (b) intrinsic virus resistance through genetic engineering in *P. vulgaris* and cassava; and (c) the transfer of resistance

to spittle bug between apomictic Brachiaria species; (d) gene transfer for bacterial and fungal diseases will be available at a later stage.

Epidemiological studies and behavior of pathogens on the one hand and development of prototype integrated pest management systems will receive more emphasis in order to optimize the useful life of resistant/tolerant cultivars. Modern biological research also offers tools for this activity, e.g. monitoring pathogen/pest genetic variability through biochemical and molecular markers and probes, and genetic mapping.

Microbial Associations

Assessing the role of beneficial microorganisms is important in sustainable production. Biological nitrogen fixation (BNF), the recycling of other major nutrients through the microbial biomass, and potential biocontrol mechanisms can be highlighted. Biological research can contribute in various ways to the control of plant pathogens, both in the phyllosphere and the rhizosphere.

Genetic improvement of beneficial organisms, including natural enemies with pesticide resistance, a broader host range, greater virulence and greater tolerance to factors such as temperature and humidity are important research areas in the nineties. CIAT is expected to be involved in these areas through collaborative networks.

Research is needed on the genetics of BNF components, the physiology of N metabolism and N fixation. In addition work is needed on specific rhizobium traits; e.g., pH tolerance and biochemical efficiency. That work may lead to genetic manipulation of preselected strains of rhizobia.

Impact from research on microbial association is conditioned by innovations in the area of delivery systems, which are essential to assure that results be used by the farmer.

Advanced research and biotechnology will provide promising technologies in microbial (endophytes) manipulation for biocontrol and plant growth promotion and delivery systems. Two general areas that may have impact in the short term are (a) mycorrhizae in cassava, with emphasis on developing practical delivery systems; and (b) development of viable inoculant technology, particularly for microbial inoculants with pastures legumes.

Physiological and Environmental Stresses

To maximize the productivity of CIAT commodities, current research focuses on studying physiological and genetic aspects of plant productivity. Also priority is given to understanding the effects of environmental stresses on plant performances. Research in these aspects includes identification of the limiting climatic and edaphic stresses, and then dealing with them, either by controlling the stresses or by improving plant adaptation to them.

Biomass production and yield potential. In cassava, photosynthesis at leaf level, total biomass and root yield are positively correlated. Screening for variability in photosynthetic capacity and yield is the next step. The potential of true seed propagation for disease control, higher genetic recombination, earliness, ease of multiplication and distribution should be investigated further. In tropical pastures, the rates of leaf senescence and the factors that control it are crucial to understanding biomass accumulation. Understanding the mechanisms of interspecific competition in variable environments is an important area of future research.

Environmental stress. In beans, drought is one of the main constraints limiting productivity. Studies on the basis of drought tolerance of *P. acutifolius* should help develop strategies for transfer to *P. vulgaris*. Drought is also a high priority for cassava, where changes in activities of key photosynthetic enzymes under drought may help identify bottlenecks amenable to genetic manipulation. In rice, the selection of cultivars tolerant to aluminum toxicity through anther culture are being studied. Anther culture is also being used to accelerate the improvement of rice varieties with tolerance to cold.

Other areas of research in this field with high priority for the next ten years include: (a) root biology, especially with emphasis to plant-soil interaction with a range of soil stresses; b) use of biochemical and molecular genetic markers for gene product characterization; (c) plant growth and environmental modeling; and (d) satellite and remote sensing as an aid both to diagnosis and resource inventory development.

Product Development and Quality

Advances in food science and technology, as well as changes in consumption and food industry trends, will affect CIAT commodities over the next decade. CIAT should play an active role in improving quality characteristics of some of its commodities. The work would involve both development of new products and improvement of the quality and convenience of traditional products. The following are areas where major research attention should be given:

1. Determination of consumer acceptability factors. Work is required on the physiochemical basis for quality, including studies on the relationship between chemical composition and structure of the food products in relation to behavior in cooking and processing.

2. Nutritional constraints on product quality. Priority should be given to (a) removing antinutritional factors (the emerging techniques may prove useful here) and (b) conducting biochemical research to understand the mechanisms of post-harvest changes in quality; e.g., physiological deterioration in cassava and hard-to-cook beans. Biotechnological approaches to solving these problems could then be envisaged.

   The areas requiring immediate attention include protein quality and quantity, starch quality and antinutritional factors in beans; and in cassava the elimination of HCN from root parenchyma, as well as starch quality, protein content and root physiological deterioration. These areas are particularly relevant for current biotechnological approaches though gene transfer, selective regulation or inhibition.

Institutional Implications for CIAT

In order for CIAT to maintain an appropriate balance between its current activities in the mid- and downstream areas with newer research initiatives in the areas of advanced biological research suggested in this report, the following guiding principles should be taken into consideration:

1. The work carried out should be problem- and constraint-driven rather than methodology-driven.

2. Prioritization of advanced research problems in CIAT commodities, especially cassava and beans and in tropical pastures as needs become more focussed.

3. Collaboration with advanced institutes through advanced research networks aimed at priority constraint resolution.

4. Development of sufficient in-house capabilities to take advantage of results from the networks.

CIAT has developed good facilities in some areas of biotechnology, physiology and virology. Some additional methodologies and instrumentation required to support future advanced biological research include: (a) novel techniques for understanding genome organization and variability; (b) biochemical and isotope analysis of growth, development and plant nutrition; (c) laboratory techniques for radioisotope work for nutrient and metabolic studies; and (d) electronic instrumentations and data logging.

To assist in these foregoing developments in the programs two additional senior staff in advanced biological research were recommended by the think tank: (a) a plant biochemist with strong background in molecular genetics, as a first priority; and (b) at a later stage, a cytogeneticist with experience in molecular biology. Cell biology/tissue capability, already in place at CIAT, is an essential component of the technological base to ensure that the Center can take advantage of genetic manipulation techniques and provide sufficient strategic research capability.

Strong interdisciplinary interaction among CIAT commodity program scientists and those in support units (BRU, GRU, VRU) needs to continue to be encouraged. The future implications on the work of individual scientists in the commodity programs will depend on the needs for applications to specific constraints and the availability of practical tools. It is expected, however, that there will be a trend for an increased involvement by program scientists in more strategic approaches.

Continuous monitoring of research activities in the upstream networks and in other relevant institutions worldwide is an essential component of CIAT's future directions in advanced research.

Advanced Research Networks

The wide range of potential research areas and projects requiring priority attention from advanced biological research, the minimum attention currently paid by advanced research institutions to CIAT commodities, especially Manihot and Phaseolus, and the increasing involvement of the private sector in funding biotechnology research, dictates the need for the development of collaborative research approaches in the form of networks. A network approach to advanced research can make best use of resources and accelerate progress by encouraging linkages between biotechnology research and specific agricultural constraints so that the results can be translated more directly as benefits for small farmers and consumers.

The role that an institution like CIAT can play in the development of advanced research networks is three fold: (1) The identification of constraints to research on CIAT commodities production and utilization which are more intractable for traditional approaches, (2) the evaluation of research strategies, both basic and biotechnological, which could be implemented to resolve those constraints, and (3) facilitate the establishment of multi-institutional and interdisciplinary collaborative research projects focusing on a CIAT's commodity and dealing with interrelated specific and hihgly prioritized projects. After the networks have been established, CIAT's role will become one of active member and major recipient of information and technologies. Information exchange, sharing and transfer of materials, cooperation training activities, mobility of personnel, and periodic scientific review meetings are the major activities of the network.

A network for advanced cassava research was established in 1988. Research constraints were prioritized in a series of discussions in collaboration with IITA and a range of national and international institutions. The major research areas identified for priority attention include: development of cassava plants free of cyanide, cassava plants resistance to viruses and to selected insect pests, improvement of nutritional quality (starch quality, protein and Vitamin A), improving photosynthetic capacity under stress and greatly reduce or delay root deterioration after harvest. The genetic transformation of cassava and the regeneration of plants from transformed tissue, and the analysis of structure and variability of the cassava genome, were also identified for top priority attention.

The identification of research constraints in <u>Phaseolus</u> beans is underway in 1989. The evaluation and prioritization of various biotechnological approaches for their resolution of constraints will be followed by the establishment of an advanced <u>Phaseolus</u> bean research network before the end of 1989. Some of the advanced research areas requiring attention in common beans include: molecular genetic markers for assessing genomic variability, biochemical and genetic approaches to understand basic mechanisms of pathogen/pest host plant interactions, increasing the genetic base though the introgression of key traits from the primary and secondary gene pools, as well as from other sources, e.g. microorganisms.

In rice, CIAT is an active member of the Rice Biotechnology Network funded by the Rockefeller Foundation. CIAT takes advantage of relevant developments from the network for approaching Latin American rice improvement problems.

Advanced research in tropical pastures will be implemented according to the identification of relevant constraints. The establishment of an advanced network for tropical pastures as is the case of cassava and common beans will then be evaluated.