THE WORLD BANK OPERATIONS EVALUATION DEPARTMENT

The CGIAR at 31: An Independent Meta-Evaluation of the Consultative Group on International Agricultural Research

Brazil Country Paper for the CGIAR Meta-Evaluation

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Abbreviations and Acronyms

ASB	Alternatives to Slash and Burn
CGIAR	Consultative Group on International Agriculture Research
CIAT	International Center for Tropical Agriculture
CIFOR	Center for International Forestry Research
CIMMYT	International Maize and Wheat Improvement Center
CIP	International Potato Center
CMDT	Change Design and Management Team
CMRT	Crop Management Regional Training
DGF	Development Grant Facility
Embrapa	Brazilian Agricultural Research Corporation
FAO	Food and Agriculture Organization
GCP	Global Challenge Program
GILB	Global Initiative on Late Blight
IARC	International agricultural research center
ICLARM	World Fish Center
ICRAF	International Centre for Research in Agroforestry
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICT	Information and communication technologies
IFDC	International Fertilizer Development Center
IFPRI	International Food Policy Research Institute
IITA	International Institute of Tropical Agriculture
ILCA	International Livestock Centre for Africa
ILRI	International Livestock Research Institute
INGER	International Network of Germplasm Evaluation of Rice
INIBAP	International Network for the Improvement of Banana and Plantain
IPG	International public good
IRRI	International Rice Research Institute
IRTP	International Rice Test Program
ISNAR	International Service for National Agricultural Research
IWMI	International Water Management Institute
MAS	Managing Acid Soils Consortium.
MIS	Management information system
NARS	National Agricultural Research Systems
OED	Operations Evaluation Department
PALOP	CGIAR Centers for Lusophone Africa
PROCISUR	Cooperative Program of Agricultural Research for the South Cone of South America
PRODETAB	Brazilian Agricultural Technology Development Project
PYVV	Potato yellow vein virus
QPM	Quality protein maize
R&D	Research and development
RIEPT	International Tropical Pasture Evaluation Network
RIH	Reduced-impact harvesting
TAC	Technical Advisory Committee of the CGIAR
TS	True seed
TSR	Third System Review
WARDA	West Africa Rice Development Association

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Preface

This is one of two country working papers by independent scholars prepared as part of the meta-evaluation of the Consultative Group on International Agricultural Research (CGIAR) conducted by the Operations Evaluation Department (OED) of the World Bank. The report, entitled *The CGIAR at 31: An Independent Meta-Evaluation of the Consultative Group on International Agricultural Research*, is available on OED's external Web site: http://www.worldbank.org/oed/gppp/. The country working papers are: "Brazil Country Paper for the CGIAR Meta-Evaluation" by Jamil Macedo, Marcio C.M. Porto, Elisio Contini, and Antonio F.D. Avila and "CGIAR Effectiveness — A NARS Perspective from India" by Dr. J.C. Katyal and Dr. Mruthyunjaya.

The report on the CGIAR is part of a two-phase independent review by OED of the World Bank's involvement in global programs. The first phase has been published: *The World Bank's Approach to Global Programs: An Independent Evaluation, Phase 1 Report* (OED, Washington, D.C., 2002). The second phase, due in fiscal 2004, involves case studies of 26 programs, of which the CGIAR is one. The inclusion of the CGIAR evaluation in the OED review of the Bank's global programs was requested by the Development Grant Facility (DGF) and Bank Management in June 2001, and endorsed by OED's global program advisory committee.

While the focus of the meta-evaluation is on the Bank and the strategic role it has played and ideally will continue to play in the future in ensuring the CGIAR's development effectiveness, five thematic working papers and four country case studies focus on the different components of CGIAR activities that determine impact. In addition to informing a broader understanding of the policy and technical context of CGIAR implementation, the papers provide a tool for assessing the performance and impact of the whole CGIAR partnership; this, in turn, provides a critical context for gauging the impact and value added of the Bank's participation in the program, the primary objective of the CGIAR meta-evaluation.

The four country case studies — on Brazil, India, Colombia, and Kenya — provide developing country perspectives on the CGIAR. The Brazil and India reports are being issued as country working papers. Two country background papers — C. Ndiritu, "CGIAR-NARS Partnership: The Case of Kenya" and L. Romano, "Colombia Country Paper for the CGIAR Meta-Evaluation" — are available on request. The complete list of working and background papers and peer reviewers for the working papers is provided in Annex 3.

The CGIAR was the first program providing global public goods to receive grants from the Bank's net income. Although the program has an impressive tradition of self-assessments, System-level evaluations have been few and far between. An exception, the Third System Review (TSR), was carried out in 1998, 17 years after the previous System-level review. OED determined that a meta-evaluation would most effectively assess CGIAR performance and inform OED's overall review of the Bank's involvement in global programs. In brief, the objectives of the meta-evaluation were three-fold:

- Evaluate implementation of recommendations in the 1998 TSR review
- Identify issues confronting the CGIAR from a forward-looking perspective
- Draw lessons for overall Bank strategy on global public policies and programs

The meta-evaluation report is in three volumes. *The Overview Report (Volume 1)* addresses strategic questions regarding the organization, financing, and management of the CGIAR as these have affected research choices, science quality, and the Bank's relationship to the CGIAR. *The Technical Report (Volume 2)* explores the nature, scope, and quality of the System's scientific work, assesses the scope and results of the reviews, and analyzes the governance, finance, and management in the CGIAR. *The Annexes (Volume 3)* provide supporting materials and are available on request.

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1. Introduction

1.1 This country working paper's main objective is to contribute to the OED Evaluation of Global Policies and Programs, addressing: the impact of the CGIAR in Brazilian research; the ideal partnership between CGIAR and the National Agricultural Research Systems in Brazil and; the future role of CGIAR in Brazil, as seen by Embrapa.

Embrapa

1.2 By the end of the 1960s, the Brazilian population was growing at increasing rates, accompanied by strong rural-urban migration. The agricultural frontier of fertile soils in the south of the country was being depleted. The movement of economic activities inland was mainly driven by changing the country's capital to the Central Highlands (Brasilia), which saw rapid building of rural infrastructure such as a road web, electrification, etc.

1.3 The first attempts at agricultural occupation of the Central region were frustrated by the limitations imposed by soils conditions. Most soils there belong to the class Dystrophic Latosols which are highly weathered, acidic and lack the essential nutrients for the cultivation of cereals and grasslands. Responding to these conditions required a new agricultural research model in Brazil, one based on the development of innovative technologies, capable of addressing the specific problems and challenges of the Cerrados and, with enough flexibility to manage existing resources.

1.4 One answer to those challenging conditions was the creation of the Brazilian Agricultural Research Corporation — Embrapa, in 1972, a private-law public institution with administrative and financial autonomy linked to the Brazilian Ministry of Agriculture. In the three following decades, Embrapa played a key role in the development of the Brazilian agricultural sector through the enhancement of plant and animal productivity. This resulted in falling prices paid by the consumers of agricultural products, and greater competitiveness in supplying the national and international markets. Today, Embrapa is considered one of the most important research institutions in the tropics.

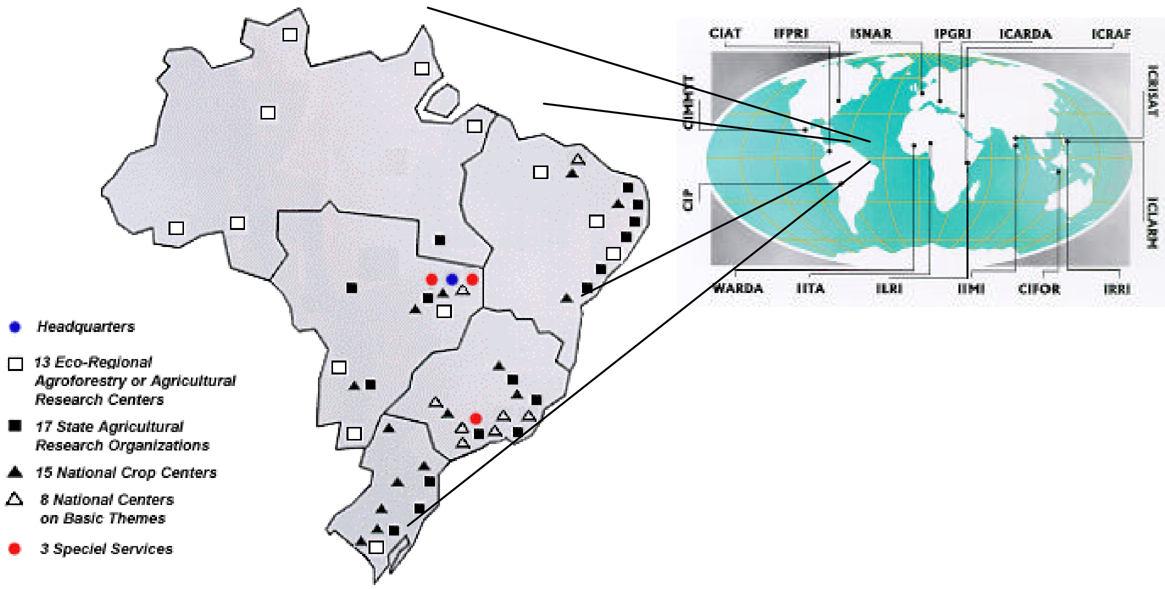
1.5 In order to fulfill its mission of "seeking and implementing sustainable development solutions for Brazilian agribusiness by generating, adapting and transferring knowledge and technology to benefit the whole society," Embrapa aims to: (a) develop a competitive agribusiness in a global economy; (b) promote sustainability of the economic activities while ensuring environmental balance; (c) reduce social imbalances; and (d) supply food that promotes health and improves the nutritional status and the quality of life of the population (Embrapa, 1998).

1.6 Headquartered in Brasília the corporation has 40 decentralized units strategically located in all regions and ecosystems. Embrapa's decentralized units are classified in three types, namely 15 product centers, addressing key crops and animals; 9 thematic centers, addressing specific areas of knowledge; and 13 agroforestry or ecoregional centers, which cover the different ecosystems in the

Brazilian territory. Three special services are also available, addressing key areas that cut across products, themes, and regions.

1.7 Embrapa coordinates the National Agricultural Research System of 7,000 researchers and technicians, with the participation of State research agencies, universities, foundations, technical support, and rural extension groups, cooperatives, farmers associations and private companies. Figure 1 shows the network of research units and institutions making up the Brazilian NARS, with linkages to the CGIAR Centers.

Figure 1: Brazilian National Agricultural Research System and CGIAR Centers



1.8 Embrapa has invested heavily in strengthening its human resources. Currently Embrapa has 2,108 researchers, 48 percent with a Ph.D. degree with the balance holding a M.Sc. degree. The remaining staff is distributed between support (4,147) and administrative (2,180) staff, with a total of 8,435 employees (Embrapa, 2001).

1.9 Its annual financial resources of around U.S. $ 300 million come from the federal government (91 percent), self financing (6 percent), and external resources (3 percent). It is estimated that about U.S. $ 16 billion were invested since the creation of the corporation. With the support of the World Bank, Embrapa is implementing the Brazilian Agricultural Technology Development Project — PRODETAB — whose main component is a competitive grant system for research and development (R&D) projects. The project enabled Embrapa to increase its multi-institutional cooperative action and partnerships in strategic areas of agricultural development.

The Importance of International Cooperation

1.10 In addressing issues of importance for development of the Brazilian agricultural sector, Embrapa found itself deeply involved in international cooperation, especially in the last decade. While Embrapa collaborates with institutions located in developed countries a way to follow new advances and opportunities in science and technology, the corporation is also being seen as a natural partner for developing countries located in the tropical and subtropical areas.

1.11 As a result, the demand for cooperation with countries located in the South Hemisphere has reached levels comparable to those experienced by formal international research institutions. Embrapa has formally developed scientific and technological cooperation and exchange activities with more than 150 institutions and international organizations, including research centers, universities, laboratories, and private companies, located in more than 50 different countries.

1.12 In Latin America, the Caribbean, and Africa, Embrapa has provided assistance and technical support to governmental institutions from several countries. While in South America, Embrapa also participates in cooperative sub-regional programs dealing with natural and genetic resources, biotechnology, agribusiness, and institutional development, in partnership with countries of the Southern Cone (PROCISUR) and the South American Tropics (PROCITROPICOS). Other collaborative activities include professional training, technical assistance and the design and implementation of development programs and projects.

1.13 A pioneering action aimed at increasing institutional cooperation and the opportunities of technological development was the creation of the Labex-Embrapa Virtual Laboratories Abroad. Labex is a mechanism that allows for tracking scientific and technological progress, as well engaging in R&D projects by placing senior Brazilian scientists in selected advanced laboratories in the United States of America and Europe. A virtual laboratory is already at work in association with the Agricultural Research Service — ARS/USDA in the United States and a similar facility is been implemented in association at AGROPOLIS, in Montpellier, France.

1.14 A vast program of technical and scientific cooperation has been developed with the research centers that constitute the Consultative Group on International Agricultural Research, acting in America, Africa, Asia, and Europe. A detailed analysis of the Embrapa-CGIAR cooperation will be done in the next chapters of this paper.

CGIAR/Embrapa Cooperation

1.15 Informal Embrapa/CGIAR cooperation started in the early seventies, after the creation of the Brazilian Corporation and the first international agricultural research centers, namely CIAT, CIMMYT, IRRI, and IITA. In its beginning the partnership was based on more informal mechanisms, including training of Brazilian researchers at CGIAR centers; germplasm exchange and testing; and participation of Brazilian researchers in meetings organized by the CGIAR.

1.16 The cooperation was intensified in the eighties, with the placement of several CGIAR scientists at Embrapa research centers and the joint implementation of research projects funded by third parties and coordinated by CGIAR centers. Successful examples of this partnership are soil management projects at Embrapa Cerrados; forage breeding projects at Embrapa Beef Cattle; projects covering cassava

IPM and cassava breeding at Embrapa Cassava and Fruits; beans breeding at Embrapa Rice and Beans; and potato breeding at Embrapa Vegetables. These joint research activities were considerably reduced in the nineties, when key scientists returned to their research centers. Additionally, the number of visits of researchers from both sides was reduced.

1.17 Brazil formally joined the CGIAR in 1984, when a contribution of one million dollars was made in support of the centers located in Latin America. In the period between 1985 and 1995 Brazilian contributions were sporadic. In 1996 Embrapa started contributing to the CGIAR, on behalf of Brazil and using its own funds, initiating a period of close involvement with the System, participating in all regular meetings and even organizing a Mid-Term Meeting in Brasilia, in 1997.

1.18 After 1996, Brazil held a seat on the Executive Council and was represented in several committees and task forces of the CGIAR, especially those dealing with changes in the System's structure and governance. Several Embrapa scientists have been acting as board members of international centers and in the CGIAR Secretariat.

2. The Impact on Brazilian Agricultural Research

2.1 Key CGIAR centers, such as CIAT, CIMMYT, and CIP were of crucial importance for the establishment of some of Embrapa's centers, especially those with shared research areas. Where several years this collaboration was done without a formal written agreement, mostly on personal basis. Key results of the Embrapa and CGIAR collaboration are presented in this section. Annexes I and II also show the existing links between Embrapa and CGIAR centers, as well as activities shared by the two systems in 2001.

Genetic Resources and Germplasm Enhancement

Rice and Beans

2.2 The collaboration between Embrapa Rice and Beans, CIAT and IRRI began in the early seventies. The first activities were focused on germplasm exchange and training of Brazilian researchers in CGIAR centers.

2.3 The exchange of germplasm followed the international Center strategy of organizing a global system for distribution and evaluation of rice and beans germplasm. In 1975, IRRI created the International Rice Test Program (IRTP), now called International Network of Germplasm Evaluation of Rice (INGER). This network allowed the National Agricultural Research Systems (NARS) to access rice germplasm through trials designed to solve particular agriculture and nutritional problems of the countries.

2.4 In the case of Brazil, especially in the beginning of the process, these trials resulted in very low efficiency as direct sources for obtaining new cultivars.

However, after the regionalization of the program, under the coordination of CIAT, several lines were used as parents in the Brazilian breeding program and delivered directly as cultivars. Good examples of beans cultivars are Emgopa 201-Ouro, Empasc 201-Chapecó, Capixaba Precoce, BR-1 Xodó, Emcapa 404-Serrano, Emcapa 405-Goytacases, Ouro Branco e Vermelho 2157. Irrigated rice cultivars released include Cica 8, Empasc 101, Empasc 102, Empasc 105, Metica 1, Javaé, MG 1, MG 2, among others.

2.5 With the evolution of the process, national institutes began to use germplasm developed by IRRI and CIAT as parents for specific problems and as sources of potential new varieties. In Latin America the cooperation was directed, for both rice and beans, to exchange of materials in segregation stages. This strategy was highly productive for Brazil, where most varieties planted under irrigation in the South, such as BR-IRGA 409 and its derived varieties were derived from this collaboration. In the case of beans, important cultivars, such as Aporé, Diamante Negro, Rudá, and Safira were introduced. For upland rice, cultivars Progresso, Maravilha, and Canastra, and, more recently, Bonança, were developed and selected.

Maize, Millet, and Sorghum

2.6 An active exchange of maize germplasm between Brazilian institutions, including both the public and private sectors and CIMMYT has characterized the collaboration with the CGIAR. Under a recent agreement for lineage evaluation more than 2000 lineages were evaluated. Maize germplasm received included entries with tolerance to acid soils, resistance to biotic stresses -several economically important diseases, and quality protein maize (QPM). In cooperation with ICRISAT Embrapa Maize and Sorghum implemented a project on germplasm evaluation, with the introduction of over 2,600 lines of sorghum and over 2,200 lines of millet. Embrapa also collaborated in the project addressing tolerance to aluminum, financed by IDB.

2.7 From CIMMYT regional office, germplasm dispatched to Brazilian institutions consisted of nurseries and trials including entries to be screened and evaluated for tolerance to acid soils, and to biotic stresses such as fall army worm and maize stem borer, corn stunt, sugarcane mosaic virus, phaeosphaeria leaf spot, and polysora and physopella rusts. Additionally, germplasm transferred from Brazil has been selected and merged into the corresponding base populations being improved at CIMMYT either for tolerance to acid soils or to different biotic stresses. In addition, plants showing resistance to acid soils or the different biotic stresses were selected. Progenies derived from these resistant entries are to be utilized in their breeding program.

2.8 With information received from the various locations where nurseries were established throughout Brazil, eight experimental varieties with resistance to specific stresses have been generated. These entries, along with those generated using data from other locations, have been included in acid soils trials and delivered to interested collaborators in many countries. Brazilian institutions are also actively participating in evaluating this new germplasm.

2.9 More recently, under the joint coordination of Embrapa and CIMMYT, a workshop on acid soils and tolerance to aluminum toxicity and efficiency on phosphorus acquisition took place in March 2001, in Harare, Zimbabwe.

Wheat, Triticale, and Barley

2.10 In terms of germplasm development CIMMYT maintains extensive collaboration with Embrapa's centers such as Embrapa Wheat, Embrapa Soybeans, Embrapa Western Agriculture, Embrapa Cerrados, and Embrapa Genetic Resources and Biotechnology. In addition, there are close ties with other regional centers such as IAPAR, IAC, EPAMIG, FUNDACEP, and CODETEC. Germplasm needs are met from Mexico as well as from CIMMYT´s regional base in Uruguay. During the last years over 160 international nurseries representing bread wheat, durum wheat, triticale, and barley were sent to Brazil and evaluated in collaboration with national counterparts.

2.11 Specific germplasm development actions for industrial quality characters have been implemented using Brazilian wheat varieties. This germplasm intends to cover the needs for high quality wheat in acid soils of subtropical and tropical areas. The result of Brazil/CIMMYT collaboration has lead to the release of at least 11 wheat cultivars originated from direct introductions or crosses with CIMMYT germplasm. At present several of these cultivars are being multiplied.

2.12 Beginning 2000, CIMMYT is participating in the Embrapa Wheat coordinated rust trap nursery. The objective is to determine the variability in the rust fungus over the region and develop strategies for deployment of durable resistance progenitors in the wheat improvement program.

Cassava

2.13 An extensive cassava research program has been implemented by Embrapa Cassava and Fruits with CIAT and IITA. The program includes: (a) collection, characterization and use of exotic germplasm; (b) genetic analysis of drought resistance; (c) transfer of medium and large scale cassava production and processing technologies to sub-Saharan Africa; and (d) assessment of genetic diversity of land races from Brazil. A more recent initiative deals with the improvement of nutritional characteristics of cassava storage roots, with major emphasis on carotene content.

2.14 Cassava improvement in sub-Saharan Africa continues to benefit from the introduction of germplasm from Latin America through CIAT, and in collaboration with IITA. This effort, initiated in the early eighties, has provided unique sources of variability not currently available in Africa. Genes from Latin American materials, especially those related to drought resistance and tolerance, are incorporated into the breeding populations with resistance to the African cassava mosaic virus and distributed to national programs for testing and selection under local environmental conditions.

2.15 To efficiently utilize this germplasm IITA continues to strengthen the capability of African research institutes to undertake cassava research and development through a series of training, workshops, exchange visits, and information exchange with Embrapa as a key partner.

Potato, Sweet Potato, and White Carrot

2.16 The major contribution of CIP to Brazil is characterized by the supply of improved germplasm for the national potato breeding program. In the last 10 years Embrapa Vegetables has received over 100 thousand genotypes of seeds containing resistance to diseases and pests of importance in Brazil.

2.17 Activities have been directed to (a) evaluate diagnostic techniques developed at CIP and to assess the situation of virus infection in the collections of sweet potato and Peruvian carrot maintained by Embrapa Vegetables; (b) evaluate the occurrence and the dispersal of PVY in the Southwest and South Regions of Brazil; (c) evaluate the adaptation and the potential of novel root crops such as *yacon* and *mashua* in Brazil; (d) maintain the exchange of genotypes and information on crops and technologies of mutual interest for CIP and Brazil and (e) train Brazilian researchers in molecular techniques being developed at CIP as a tool to characterize populations of *Phytophthora infestans.*

2.18 The major achievements in transference and utilization of genetic resources were (a) introduction of potato progenitors multiplex for resistance to PVX, PVY, *Ralstonia solanacearum*, *Alternaria solani, Phytophthora infestans*, *Meloidogyne* spp, and *Phthorimaea opercullela*, in cooperation with Embrapa Temperate Agriculture. CIP prepared and send the material as true seed (TS) of 25 families, 200 genotypes each; (b) introduction of *arracacha* accessions from the University of Cuzco in cooperation with Embrapa Vegetables in Brasilia; (c) morphological characterization of 178 *arracacha* accessions maintained at the Embrapa Germplasm Bank (161 Fl hybrids, 10 native cultivars from the Ecuadorian Andes, and 7 Brazilian varieties widely cultivated in Brazil), which was conducted in two stages, grouped into 49 morphotypes according to visible morphological similarities, and eight qualitative characters of the upper part of the plants; (d) introduction of true potato seed (TPS) families in cooperation with Embrapa Vegetables. Regarding sweet potato, a consulting botanist from CIP characterized more than 500 lines, thus reducing the number of duplicates in the collection, thus increasing the efficiency of germplasm utilization.

2.19 In addition, the following analytical materials were transferred to Embrapa: (a) probe of Potato Yellow Vein Virus (PYVV) and a control nucleic acid sample CIP; (b) primers for specific detection of PVY-NTN; (c) Plasmid p ST-PE1 gem for PSTVd detection as well as protocols for sample preparation, plasmid extraction and hybridization techniques. (The same material were sent to the University of Lavras in Minas Gerais); (d) probes for detection of PSTVd, PLIRV, and PVX were sent to Brasilia and Canoinhas (Santa Catarina); (e) serological kits for detection of sweet potato viruses in membranes (NCM-ELISA) were carried to Brazil for validation at laboratories in Brasilia and Pelotas (Rio Grande do Sul); and (f) positive controls for white carrot viruses were sent to Brasilia.

2.20 Three Latin American workshops on sweet potato cultivation, bacterial disease of potato, and breeding of potato were organized with direct support of CIP. Several Embrapa and CIP joint publications were prepared, covering issues such as bacterial disease in potato, cultivation of sweet potato, cultivation of white carrot, and a catalog of sweet potato, among others.

Forages

2.21 In the past two decades, with the support from IPGRI, a remarkable effort by international and national organizations including Australia (CSIRO), Colombia (CIAT), and Ethiopia (ILRI), has resulted in the assemblage of representative collections of tropical germplasm.

2.22 These collections are and will continue to be a valuable resource to future pasture improvement in the tropics. Yet despite intensive exchange and evaluation in network trials such as those carried out in the now-extinct International Tropical Pasture Evaluation Network (RIEPT), they are, by no means complete or fully exploited

2.23 Major forage legume species include genera such as *Stylosanthes*, *Arachis*, *Centrosema*, *Macroptilium*, *Desmodium*, *Leucaena*, *Zornia*, *Calopogonium*, many originally from the American continent but now in widespread use in the tropics. Success of legume adoption in the Americas has been less impressive than grasses, probably due to constraints of indigenous diseases and also use of traditionally abusive management practices that impair legume(s) more than the aggressively growing C4 grasses associated with them. It is interesting to observe the overall predominance of forage legume genera and species in germplasm collections, when grasses are, in fact, much more ubiquitous in nature and thus play a major role in sustaining livestock production systems worldwide.

2.24 Major tropical forage grasses belong to fewer genera when compared to the legumes (*Panicum, Pennisetum, Brachiaria, Andropogon,* and *Paspalum*) and come mostly from the savannas of Africa. Introduced accessions of several of these have shown remarkable adaptation to other tropical ecosystems and cover even more environments than legumes — millions of hectares — attesting to their larger genotypic plasticity.

2.25 Due to the high demand for new grass varieties, the expected adoption is comparatively much faster and widespread than with legumes, and the tendency is to utilize those even outside their range of adaptation as has been the case for Brachiaria brizantha cv. Marandu in Brazil: released by Embrapa, for soils of medium fertility and good drainage in 1984, it has spread to low fertility and wet soils of the southern Amazon region because of its resistance to a major pest — spittlebugs (Homoptera: Cercopidea). Despite this thousands of hectares are now dying as resistance to the pest has been broken–a result of the monoculture of this cultivar.

2.26 To summarize achievements and perspectives concerning genetic resources for tropical areas, the following points should be highlighted: (a) significant progress has been made in terms of assembling, characterizing, exchanging and evaluating the most widespread tropical forages, there are still untapped resources to be identified, specially if trees and shrubs are considered; (b) the scenario for funding germplasm collection and maintenance is not auspicious, therefore it is imperative that international organizations coordinate efforts to at least maintain the resources already gathered with data banks organized and accessible worldwide; (c) animal production in the tropics is heavily dependent on pastures and improved forages have had a major impact on productivity, meat quality and the seed market, especially concerning grasses (Valle, C.B.do, 2001). The potential for new improved cultivars resulting from germplasm selection in the short term and to bred cultivars in a longer term is very large, particularly as new techniques such as molecular markers, tissue culture, or assisted selection using QTLs' become available; and (d) there is still much to be done but each step is a giant one toward narrowing the gap between the temperate and tropical world as far as forage resources are concerned. Straining the cooperation of Embrapa with CGIAR Centers is paramount to improving animal production in Brazil.

Development and Management of Production Systems

2.27 The cooperation with CIFOR and Embrapa is mainly related to forest management. CIFOR maintains an office at the Embrapa Eastern Amazon Center, in Belém. Two joint projects are being implemented.

2.28 The project Management of Secondary Forests by Small-Scale Farmers in Northeastern Pará focuses mainly on the generation of baseline socioeconomic and biophysical information on farmer's production systems and the status and role of secondary forests within their properties. As result of evaluating the first period of this project, the need for a more participatory process in the design, implementation, and evaluation of the project in its second phase became evident. A more active involvement of the direct beneficiaries -the small-scale farmers — and their organizations was considered a key element in the validation process of selected management options for secondary forests in farmers' lands.

2.29 The second Embrapa-CIFOR Project, Sustainable Management of Production Forests at the Commercial-Scale in the Brazilian Amazon, has as a major objective the application of well planned and -implemented harvesting operations by timber enterprises in order to reduce environmental damage, increase working efficiency, and reduce waste, thereby increasing the potential for future harvesting. As an instrument for validation, a set of basic guidelines for reduced-impact harvesting (RIH) is needed. Based on relevant experiences with RIH in the Brazilian Amazon (i.e., from FAO/PRODEPEF/SUDAM, EMBRAPA, IMAZON, FFT, and the timber enterprise Mil Madeireira), the FAO Model Code of Forest Harvesting Practices, and CIFOR's RIH Guidelines for Indonesia, a set of interim guidelines were prepared. The draft document considered the minimum necessary guidelines to be applied in timber harvesting operations with some possible variations or options which may be adapted by a timber enterprise at the level of individual operations in the pre-harvesting, harvesting, and post-harvesting phases.

Natural Resource and Policy Issues

2.30 In cooperation with CIAT, Embrapa participated in the Managing Acid Soils (MAS) Consortium. Activities dealt initially with recuperation and replacement of degraded acid soils in the Central Plateau of Brazil by productivity-enhancing and resource-conserving agropastoral and/or silvoagropastoral systems. The driving forces behind land use changes were identified, as well as indicators for the successful transformation of these areas. Successful prototype systems or components and technologies for the sustainable management of acid soils were also defined.

2.31 As a result of the collaboration between CIAT and Embrapa Cerrados, as well as other partners such as Universidade Federal de Uberlandia and Bayreuth University, several research projects were implemented to generate knowledge on the dynamics of soil organic matter and physical processes in different agricultural systems currently operating in the Cerrados of Brazil. A summary of the results of this work has been published by CIAT as "Sustainable Land Management for the Oxisols of the Latin America Savannas, Dynamics of Soil Organic Matter and Indicators of Soil Quality" (Thomas, R. and Ayarza, M.A.1999).

2.32 The cooperation with ICRAF in the field of agro-forestry production systems in the Amazon was undertaken in direct support of Embrapa activities in the Alternatives to Slash and Burn (ASB) program, including: (a) support to participate in the third ASB Synthesis and Linkages workshop, essential for continuing the involvement of Embrapa in the ASB program, and assisting the Brazilian team with planning for Phase III proposal writing; (b) travel of Global ASB Coordinator and Latin America Regional ASB Coordinator to Rio Branco and Porto Velho to discuss technical report for Phase II and proposal writing for Phase III. (c) support for travel of Embrapa-Acre/Rondonia scientists to participate in the ASB Global Synthesis symposium at the American Society of Agronomy Meetings in Salt Lake City, Utah. U.S., among others.

2.33 As part of cooperating with IFPRI in addressing policy issues, Embrapa has established a comprehensive set of procedures to monitor the management and performance of its various research centers and national programs. This joint program focuses on the development of procedures to undertake and interpret technology assessments for economic evaluation of institutional, programmatic, and agency-wide R&D investments. The primary clients of this research are senior Embrapa managers and policymakers, while the methodological advances will be of more direct use to those within and beyond Embrapa who are responsible for research evaluation and analysis.

2.34 Through the information and methods developed as part of this project, Embrapa will be in a better position to make more informed resource allocation decisions in ways that improve the overall efficiency and effectiveness of research applications. The project's emphasis on economic implications of R&D will help link the within-Center, across-Center, and programmatic decisions taken by Embrapa to the likely social consequences of those decisions. This not only provides evidence of effectiveness of past and present R&D investments, but also gives guidance as to the appropriate levels of sources of future funding.

2.35 A set of appropriate methodologies and case studies was developed to assess the institutional and programmatic contributions to the economic impact of varietal improvements in soybean, upland rice, maize, and edible beans. The studies not only trace the overall stream of varietal technologies and breeding pedigrees, but also provide estimates of associated research costs and estimate measures of social benefits.

2.36 The work encompasses the following specific products: (a) a methodological framework for comparable economic assessment of R&D centers and programs within Embrapa having a major focus on varietal improvement and directly related technologies; (b) a compilation of necessary technology generation and flow, R&D cost, market, biophysical and other data required to support the economic evaluation; (c) a pilot assessment of economic consequences of R&D for varietal material developed by Embrapa Maize and Sorghum, Embrapa Soybean, and Embrapa Rice and Beans; (d) recommendations for further national and international application of the findings of the study in both.

2.37 Two seminars were held, one for the president of Embrapa and its board and the other targeted to Embrapa staff and various invitees outside Embrapa. These seminars highlighted the economic evaluation and benefits from methodologies being adapted for and applied in this project. The final report of this project is been jointly prepared by Embrapa and IFPRI.

Capacity Building and Institutional Strengthening

2.38 The cooperation with CGIAR centers is recognized as particularly successful in the area of capacity building and institutional strengthening, more specifically in training Brazilian researchers, extension workers, and farmers. EMBRAPA researchers participated in several training events useful for developing joint research projects that were carried out by EMBRAPA and the CGIAR Centers.

2.39 Table 1, below, shows that, in the last 30 years, a total of 875 Brazilian nationals participated in training events organized by CIAT, CIP and CIMMYT, the three CGIAR centers that have developed closer collaboration with Embrapa in the period.

2.40 In the case of CIAT, a total of 684 Brazilian nationals benefited from several modalities of training, ranging from short-term courses to post-graduate thesis work. Of this total, 521 were Embrapa researchers. A total of 101 Brazilians attended courses organized exclusively by CIP or jointly with Embrapa. The information provided by CIMMYT shows that 90 Brazilian researchers participated in training events organized by that Center. These totals do not include participation of Brazilians in conferences, seminars, symposia, and workshops.

2.41 An interesting point that should be stressed is the reduction of the total number of Brazilian nationals trained after 1990, as shown in Table 1. This tendency is clear in the case of CIAT, where the number of trainees that received training in the period 1991-1995 and 1996-2000 represents 28 percent and 12 percent, respectively of the total number of trainees in the period 1986-1990. In the case of CIP, although the table shows a considerable increase in the number of trainees in the last five years, this is a result of the participation of Brazilian technicians in courses jointly organized by CIP and Embrapa, in Brazil. Some examples of specific training activities involving selected crops and technical areas are given below.

Table 1: Number of Brazilian Nationals Trained at Selected CGIAR Centers, 1971-2000

Period	*CGIAR Centers*			*Total*
	CIAT	*CIP*	*CIMMYT*	
1971-1975	72	1	13	86
1976-1980	184	7	5	196
1981-1985	145	15	3	163
1986-1990	201	10	12	223
1991-1995	57	22	29	108
1996-2000	25	46 [a]	28	99
Total	684	101	90	875

Source: training databases provided by CIAT, CIP, and CIMMYT.

a. Includes 33 training participants in the III International Training Course on Mathematical Models for Simulation of Crop Growth, held in Brazil in 1999.

Training: Rice and Beans

2.42 More than 200 Brazilian researchers received training on different aspects of rice and bean production and utilization from the CGIAR centers. The first training activities concentrated in general aspects of the two crops and were followed by more specialized training covering specific areas of interest of Embrapa and included thesis research work by CIAR scientists, especially from CIAT. The evolution of this relationship allowed the development and implementation of joint projects of mutual interest and with common objectives by the two organizations.

Training: Maize and Wheat

2.43 A considerable number of Brazilian scientists received training at CIMMYT over the last three decades. Recent training activities organized in cooperation with the CGIAR include: (a) participation of national maize research coordinators from the corresponding South American countries in the 17th Latin American Maize Research Meeting, held in Cerete and Cartagena, Colombia. Some of the above scientists could later participate in the International Symposium on Genetics and Exploitation of Heterosis in Crops, organized in CIMMYT, Mexico; (b) since 1995 an annual course in “Use, management and trial with maize” has been offered to over 75 researchers from Latin America and Africa in collaboration with CIMMYT; (c) with funds provided by IFAD, the second Crop Management Regional Training (CMRT) Course was held at the CNPMS/EMBRAPA facilities at Sete Lagoas, M.G.

2.44 A total of ten students from South American countries participated in this course; (d) personnel from CIMMYT HQ traveled to Brazil to participate in the teaching of specific courses taught at the CMRT; (e) Brazilian scientists visited

CIMMYT-HQ and participated in various activities related to maize breeding and germplasm development; (f) Brazil has assisted, through CIMMYT, in funding 10 Brazilian scientists, to attend a Regional workshop on Wheat Biotechnology held in collaboration with INIA, Uruguay. Two additional scientists were funded by CIMMYT; (g) Brazilian scientist and research administration had an opportunity to visit CIMMYT in Mexico to further explore the possibility of enhancing research collaboration.

Training: Potato

2.45 Several training activities were conducted in cooperation with CIP, involving more than 20 researchers from Embrapa and other Brazilian institutes and universities, as follows: (a) a scientist from Embrapa participated as an instructor in a workshop on Management of white carrot. Trainees came from Ecuador, Peru, and Bolivia. The course was held at San Juan de Minas; (b) consultancies and technical visits of a scientist from CIP on characterization of white carrot; (c) a scientist from CIP visited several research units of Embrapa and Brazilian universities, with the objective of evaluating the importance of potato and sweet potato viruses in the country; (d) Support from CIP to Embrapa Vegetables in Brasilia with the purpose of assisting local researchers on the morphological characterization of the Brazilian sweet potato collection.

2.46 The collaboration with CIP has contributed to a substantial improvement in the procedures and care of the collection. Losses of accessions and mixtures have been greatly reduced. Several joint papers were published in Brazilian scientific journals; (e) Visit of a professor from the University of Lavras in Minas Gerais to CIP headquarters to participate in a workshop on “Simulation studies on Late Blight” and “L.B. Pathogen Studies” to review progress, prepare an action plan and identify areas for cooperation with CIPs Project 1 and the Global Initiative on Late Blight (GILB).

Training: Cassava

2.47 During the seventies and the eighties numerous training activities benefited a large number of researchers from the Embrapa Cassava and Fruits, from state research and development institutions, including short term training, medium term training and Ph.D. thesis orientation by CIAT.

2.48 An example of partnership was the organization of a four-week training workshop on cassava breeding, jointly financed by IITA, the International Fund for Agricultural Development, and the Office of Foreign Disaster Assistance (OFDA) of USAID, at IITA, Ibadan, Nigeria, in 1999. The workshop provided an opportunity for NARS scientists from several African NARS to update and strengthen their knowledge and skills in breeding and selection of cassava. Fourteen participants drawn from nine African countries (Gambia, Ghana, Niger, Nigeria, Rwanda, Sierra Leone, Chad, Togo, and Zimbabwe) participated in the workshop. The workshop covered breeding for specific agroecological zones; collection, evaluation, characterization and utilization of germplasm; screening and selection for quality traits, resistance to pests and diseases and adaptation to abiotic stresses; use of appropriate biotechnologies in breeding, micropropagation; and data management and statistical analyses of breeding data.

Training: Forestry

2.49 In cooperation with CIFOR and Faculdade de Ciências Agrárias do Pará — FCAP were organized two local seminars to present main results of the first phase of the Project on the "Management of Secondary Forests by Small-Scale Farmers in Northeastern Para". The meetings were held in Bragança and Capitão Poço in 1998. The audience consisted of farmers, extensionists, practitioners, and local authorities. A booklet presenting the results of the studies in a very simple, readable way to facilitate understanding by the target project beneficiaries was published by Embrapa.

2.50 A workshop was held in December 1998 to discuss a set of basic guidelines for reduced-impact harvesting (RIH) with some 20 local specialists and from abroad Brazil. During 1999 the resulting version was further reviewed by a small group of specialists from Embrapa, FFT, Imazon, and CIFOR. The final draft is being published by Embrapa. The main aim of the discussions was to update the guidelines on the basis of their validation in real conditions, and to incorporate them in the Brazilian forest legislation. Among the recommendations made particular emphasis to include a section with considerations for commercial timber species occurring at low-densities in the forest. The RIH guidelines were also published in Portuguese.

The CGIAR's Contribution to the Impact on Brazilian Agricultural Research

2.51 A large number of impact assessment studies have been developed worldwide showing the contributions made by agricultural research in improving the productivity, profitability, and sustainability of the agricultural sector. Brazil has been the subject of such studies, with Embrapa responsible for the majority of the impact assessment studies conducted in the country (Avila & Ayres, 1987; Avila, 2001).

2.52 The importance of agricultural research for technological development has been systematically shown through a diversified set of impact assessment studies aggregated by commodity, international loans (IDB and World Bank), training programs, etc. Selected studies developed by Embrapa are presented on Table 2. Note: For more complete information on Embrapa impact assessment studies, see Ayres & Avila (1987) and Avila (2001).

Table 2: Rates of Return Found by Selected Impact Assessments by Embrapa*

Authors	*Subject of Study*	*Period*	*Rate of Return (%)*
Cruz, Palma & Avila (1982)	Embrapa research: aggregate	1974/92	22
Cruz & Avila (1983)	World Bank Project I	1977/91	20-38
Avila, Andrade, Irias & Quirino (1984)	Embrapa training program	1974/96	22-30
Ambrosi & Cruz (1984)	Wheat Research Center	1974/82	59-74
Avila, Irias & Veloso (1985)	IDB Project I:		
	Embrapa research	1977/96	27
	Southern Brazil	1974/96	38
Barbosa, Cruz & Avila (1988)	Embrapa research: aggregate	1974/96	34-41
Barbosa, Avila & Motta (1988)	World Bank Project II	1982/87	43
Barbosa & Cruz (1993)	IDB Project II	1985/90	43
Avila & Evenson (1995)	Embrapa Research (TFP): National Research Programs	1970/85	56
Evenson & Avila (1995)	Embrapa Grain Program:	1978/92	
	Maize		58
	Rice		37
	Wheat		40
Almeida, Avila & Wetzel (1999)	Soybeans breeding program	1986/97	69
Ambrosi (2000)	Wheat Research Center	1986/97	88-143
Yokoyama & Almeida (2001)	Upland rice breeding program	1977/95	88-143

* Avila (2001).

2.53 Among the studies showed on Table 2 it is important to point out the good results of the impact evaluations of research programs involving CGIAR commodities, such as rice, wheat, and maize. The internal rates of return (IRR) of the agricultural research investments calculated for these commodities were higher than 30 percent, demonstrating the profitability of these investments, and confirming other impact assessment studies developed for Brazil (Table 3).

2.54 Some of the published studies on the impact of research are strongly linked with CGIAR commodities. A good example is the evaluation of the role of genetic improvement on agricultural productivity in Brazil, published by Almeida et al., 1999, and Yokoyama & Almeida, 2001, who also estimated high rates of return (69 to 143 percent) for this specific kind of agricultural research investment. This subject was also highlighted in a pilot study developed by IFPRI, University of California-Davis, and Embrapa that evaluated the impact of the genetic improvement program on soybeans, upland rice, and beans. The benefit-costs ratios calculated in this study varied from 10 to 74, showing that the investments in this program were also very profitable for Brazilian society (Alston et. al., 2001).

Table 3: Rates of Return Found by Other Brazilian Impact Assessments

Authors	*Area/Region*	*Product*	*Period*	*Rate of Return (%)*
Avila (1981)	Rio Grande do Sul State	Irrigated rice	1959/78	87-119
Ribeiro (1982)	Minas Gerais State	Rice Cotton Soybeans	1974/81	69 48 36
Gonçalves, Souza & Rezende (1989)	São Paulo State	Rice	1876/88	85-95
Evenson & Cruz (1989a)	Brazil	Wheat Maize Soybeans	1966/88	39 30 50
Evenson & Cruz (1989b)	PROCISUR Region*	Wheat Maize Soybeans	1969/88	110 191 179
Evenson (1990a)	Brazil	Field crops	70/75/80	41-141
Evenson (1990b)	Brazil: Center-South	Field crops	70/75/80	68-75

Source: Avila (2001)

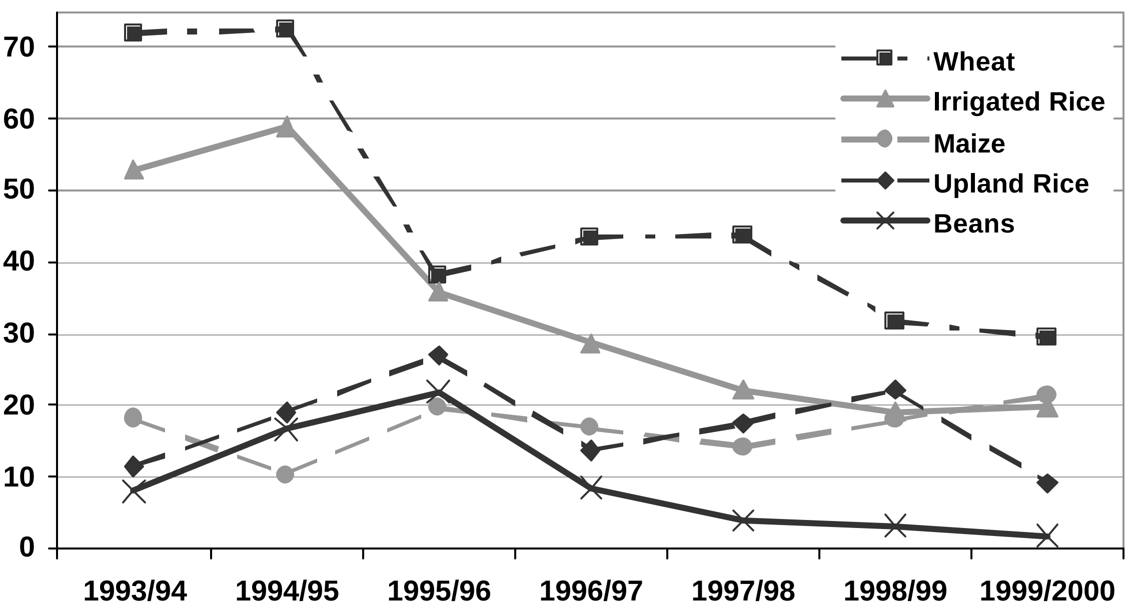
*Cooperative Program in Agricultural Research for the South Cone of South America, including the national institutions for agricultural research of Brazil, Argentina, Uruguay, Paraguay, Bolivia and Chile.

2.55 Another study, developed by Avila et al. (2001) showed the importance of the role of improved varieties on the average productivity of wheat, irrigated rice, maize, cotton, beans, soybeans, potatoes, and upland rice in Brazil. The study focused on a central part of the research program, the crop genetic improvement, and showed that these programs contributed roughly with 40 percent of the realized yield gains over the period of the study (1990s). Estimates of genetic improvement impacts by crop showed some variations in the contributions. However, all crops benefited from genetic improvement which represented a major part of productivity gains.

2.56 The results presented by Avila et al. (2000) also reflect the importance of the varieties originated from CGIAR genetic material on the increase of commercial agricultural productivity in Brazil. In order to estimate the contribution of CGIAR genetic material, breeders of institutions responsible for the generation of the main commercial wheat, rice and beans varieties in the nineties were asked to provide information on the participation of varieties developed by the international centers in their respective breeding programs. The provision of parental material from CGIAR centers showed positive effects on the increase in average yields of rice, beans, and wheat, but not of maize, where private suppliers dominate the Brazilian market.

2.57 Using the database built for the impact study covering improved varieties developed by Avila et al. (2001), and new information obtained from Embrapa centers, it was possible to identify the participation of CGIAR varieties in the Brazilian seed market of wheat, beans, irrigated and upland rice (Figure 2). This database includes the most important varieties developed by Embrapa centers, State research institutes (IRGA, IPA, IAPAR and IAC), as well as private foundations linked to the cooperative agricultural research system (FUNDACEP and COODETEC).

Figure 2: Participation of CGIAR Genetic Material in the Brazilian Seed Market (%)



2.58 The participation of CGIAR genetic material in the Brazilian seed market, during the nineties, was, in average, 25 percent. Among the commodities analyzed, wheat was the product that benefited most from the participation of the CGIAR genetic resources, followed by irrigated rice. It is important to note that this relative participation in the seed market is at a minimum range, given the lack of information for some recent varieties released in the market, especially in the case of wheat and irrigated rice.

2.59 These results, combined with the impact assessment studies listed in Tables 2 and 3 confirm the importance of the role of the CGIAR genetic material on the Brazilian agriculture, especially in the first half of the 1990s. If the varieties with CGIAR material are largely used in the seed market, we assume that part of the amount of benefits calculated in these impact studies are due to the introduction of CGIAR material. However, beginning in the second half of the 1990s, there are tendencies of decreasing the participation of genetic material originated from CGIAR centers in the Brazilian market. This fact corroborates the overall slow down of collaboration between Embrapa and CGIAR centers which will be further analyzed in the next chapters of this paper.

3. The Ideal Partnership

3.1 A proposal for strengthening the partnership between the CGIAR and a national agricultural research system such as Embrapa must be focused on the generation of technologies and innovative systems, as well as its applications as a tool for agricultural development. Such a partnership includes the participation of several

Brazilian institutions, including universities, the State research organizations, and the private sector, as well as Embrapa itself.

The Context for Cooperation

3.2 Due to the peculiarities typical of a country with continental dimensions, with a broad diversity in climate, soil, cultural values and the heterogeneity of its agricultural sector, Brazil should be considered by the CGIAR as a unique partner and should be treated as such. The dynamic character of the economy and its productive structure, and the existence of several agricultural frontiers in the country are factors that justify the existence of a flexible and multifaceted approach of cooperation.

3.3 From the viewpoint of degree of development Brazil has regions that can be classified as having a highly developed agricultural sector, as is the case in the Southern region. On the other extreme, most areas of the Northeast may be classified as having a poor agricultural sector, and others still are underexploited, with unknown potential, as in many areas of the Amazon tropical forest.

3.4 To examine the Northeast as a typical case, the region, and especially its rural areas, has the highest concentration of poverty in Latin America. Recent studies indicate that a large portion of the population living in this region is ready to migrate to other areas of the country, such as the Southeast and the South, where salaries are higher both in the rural and urban areas. The CGIAR, having poverty alleviation as an important component of its mission, cannot forget that Northeastern Brazil should receive the same priority given to Asian and African countries.

3.5 Another important characteristic of Brazil is enormous productive potential of the agricultural sector. Data collected by Embrapa Cerrados show that this continental region has an agricultural area of 80 million hectares, with the potential to produce 240 million metric tons of grain and to double beef production. The record harvest of grain in 2001 that reached over 98 million metric tons was a result of productivity increases, and an increase in planted area. This increase in area has, as a natural consequence, the appearance of new problems that will have to be addressed by both natural resource and agricultural research together.

3.6 The CGIAR and its research centers have technological and scientific cooperation as a strong component of their mission, involving several countries, specifically those belonging to the developing world. As a result of cooperation significant multiplier effects are created, with implications for the process of building national capacity at different levels. In the specific case of Brazil several positive results were obtained from a strong collaboration with the national system, as shown in previous sections of this paper.

Cooperation with Brazil

3.7 As indicated earlier in this paper, the history of collaboration between the CGIAR and Embrapa has occurred for over 30 years. In this period three distinct phases can be identified. During Phase 1, which covers the beginning of both institutions, Embrapa was benefited by the training of its researchers in several CG centers, with special contributions provided by CIAT, CIP, CIMMYT, and IRRI, which provided short-term training on specific commodities such as cassava, rice, maize, and beans. A few Embrapa researchers received medium and long-term training, including thesis work, in association with Brazilian and foreign universities.

3.8 The second phase, initiated in the mid-eighties, was characterized by the existence of joint research work in Brazil and at selected centers and even in third countries. A number of joint projects funded by external donors were implemented, putting together the capabilities of scientists belonging to CGIAR and Embrapa. Some specific cases deserve special emphasis for their good results, such as those covering different aspects of cassava research. A joint project involving CIAT, IITA and Embrapa solved the threat of the cassava mealy bug in Africa, by introducing natural enemies of the pest, collected in Brazil, into African countries, following a classical biological control approach. As a result of this work CIAT and IITA won the King Baudoin Award. A similar project looking for natural enemies of the cassava green mite in South America, with particular emphasis in Brazil was implemented by the same partners. A number of phitoseid mites native to Brazil are contributing to the control of the cassava green mite in Africa.

3.9 The collaboration is in its third phase, characterized by the participation of Embrapa as a shareholder of the System, being present in committees and task forces and, lately, as a member of the Executive Council. This new status reflects the progress of Embrapa in the past three decades and the recognition, by the CGIAR, of the increased importance of Embrapa as an equal partner in agricultural research. However, and unlike what happened in phase 2, joint research activities are at its lowest level since the beginning of the two institutions.

3.10 A recent internal evaluation of the joint activities of the two systems has shown that there are very few initiatives being implemented by CGIAR and Embrapa centers. The number of training events involving Embrapa trainees has significantly decreased (see Table 1) and most present activities can be characterized as mutual visits and participation in technical meetings. Very few joint research projects funded by external agents are underway although, with the creation of the Challenge Programs, Embrapa has been involved in some initiatives that could generate new joint projects.

3.11 The reasons for this decrease in collaborative research projects are still unknown, although there are some factors that can help explain the current status. What is known is that a new mode of collaboration will have to be implemented, taking into consideration the situation of Embrapa as a mature and capable research institution and the comparative advantage of Brazil in providing technical assistance and expertise to other countries, especially those at a lower level of developments in the tropical areas of the world.

3.12 In these 30 years of existence the progress undergone by Embrapa and the CGIAR centers followed a distinct path. The international centers were established with enough resources to purchase and install cutting-edge equipment and laboratories and to contract highly qualified international scientists. The CGIAR

Centers followed the new paradigms and advances in agricultural science, keeping up to date and accompanying the evolution of science.

3.13 On the other hand, Embrapa was created with the human resources available in Brazil in the seventies, the vast majority of them without an advanced degree and using installations belonging to a research system that was decades old. Contrary to the CGIAR centers, Embrapa grew at a higher rate, due to heavy investments in infrastructure and on a comprehensive graduate-training program for its researchers within Brazil and in foreign universities in North America and Europe. Presently half of the scientific staff of Embrapa holds a Ph.D. degree and the majority of the researchers have at least a Masters degree. In terms of scientific capacity Embrapa has more scientific staff when compared to the CGIAR. In addition the changes undergone on research and communication facilities places the corporation in a position to share with CGIAR centers the development and implementation of upstream research.

3.14 The above should be taken into account when proposing a new mode of cooperation to be implemented by the two institutions. Embrapa is ready to work together with the CGIAR and even to assist the System in its work to help agricultural production in developing countries as a way to alleviate poverty and hunger. This will enhance the System's efforts by augmenting its capacity to play its role of lead agricultural research system in the development world.

3.15 The cooperation between the CGIAR and Brazil should be considered as a partnership involving mature institutions, using the resources and knowledge for solving problems faced by farmers in developing countries. In spite of the amount of knowledge accumulated in the past three decades by both partners, the number and extent of constraints that limit tropical agricultural production are still large. Especially on tropical agriculture, the cooperation is crucial to maximize the limited available resources.

3.16 We believe that the opportunity for the CGIAR to collaborate with a number of advanced Brazilian institutions is one way to maximize results by facilitating technology transfer to other regions of the world, through joint cooperation with third countries. Therefore, cooperation with Brazil should be seen as a win-win partnership, with potential benefits to both partners and many other countries in the developing world.

Ideal Cooperation

3.17 A number of assumptions must be adopted in order to start a new mode of cooperation between the CGIAR and Brazil. The most important are:

- Embrapa has grown into a mature research institution in the developing world and should be considered as an equal partner by CGIAR centers;
- Embrapa and its partners in Brazil have developed technologies that can be used in the tropics, as proven by the impact of agricultural technologies in the Brazilian agricultural sector;

- Embrapa has a cadre of scientists with academic level and knowledge comparable with the best international scientists and not limited by language barriers, as most of them are fluent in at least two languages;
- Embrapa has gained the respect of leading advanced institutions and national programs as a partner who can work hand in hand with scientists and institutions from both the North and the South.
- Embrapa is willing to interact with the CGIAR as a true and interested partner and is ready to contribute to the development of the agricultural sectors of the developing world.
- Embrapa has established partnerships with institutions from both developed and developing countries and is in a unique position to use these links to connect North and South.

3.18 The cooperation agenda must address themes of common interest for both the international research centers and Embrapa. In general, from the Brazilian side, agricultural research focuses on four broad themes: (i) competition; (ii) sustainability; (iii) equity, and; (iv) life quality.

3.19 Beyond this macro context, Brazilian agribusiness faces big challenges. In order to progress, it needs to be competitive in a globalized world at both the internal and external level. From the technological point of view, competition demands quality of products and services, reliability in the delivery of products, and competitive prices. Thus, it is necessary to take advantage of opportunities for innovation, support decision making by farmers and entrepreneurs, organize production chains, and protect knowledge.

3.20 A second challenge for the Brazilian agribusiness is the sustainability of both the economy and the environment. This implies that knowledge and technologies are able to promote the sustainable use of the natural resources base and strong intervention in the dynamics of the agricultural and natural systems. The basic purpose remains of reducing risks to the sustainability of overall economic and ecological activities, while pursuing scientific validation of traditional knowledge.

3.21 The third challenge is promotion of health and improvement of the quality of life, through significant improvement of the nutritional level of the Brazilian population. In order to achieve the expected results it is necessary that (functional quality of foods and raw materials), diet diversification, consumers' security, and products and information on technologies of the interest to the consumer be available.

3.22 The agribusiness and its supporting technologies must also contribute to overcome the fourth challenge, represented by a significant reduction in social imbalance. Important areas are the organization of farmers and production chains, exchange of knowledge and technologies, identification of new market opportunities and technologies for small enterprises.

3.23 The strategy used by the CGIAR to find solutions for agricultural problems is, in a way, different from that adopted by Embrapa, although the emphasis on high productivity, sustainable agriculture, and concern for the maintenance and utilization of natural resources is shared by the two organizations. With the responsibility to address issues of a global nature in developing countries, spread over a broad range of ecosystems and cultures, the CGIAR has a broader mandate when compared with Embrapa.

3.24 However, and due to the large extension of Brazil, its variability in ecological conditions, the natural links of the country with several of its partners in the developing world, and the characteristics of Embrapa as a national research institution with close link with the international community, a stronger and more focused collaboration between the two organizations will certainly benefit other developing countries.

How to Cooperate

3.25 There are various ways to improve the cooperation between the CGIAR and the Brazilian National Agricultural Research System as led by Embrapa. The first area to be considered deals with the development and implementation of joint research and development projects that may include other developing countries. A critical factor to be considered in the selection of themes for joint research is the importance of selected themes for all partners involved in the collaboration. As proved in the past, the implementation of research projects by CGIAR centers in Brazil without the effective consultation and participation of Brazilian counterparts is not a good strategy. Joint identification of problems and opportunities for the development of research projects is mandatory for a profitable and successful collaboration.

3.26 The Embrapa's long experience in addressing the complex subject of agriculture in Brazil represents a strong comparative advantage in the tropical world. While generating technologies for the benefit of Brazilian farmers, with special attention to small landowners, Embrapa has also contributed to the expansion of commercial plantations that can easily be compared with the agriculture practiced in developed countries.

3.27 The utilization, by the CGIAR, of the Brazilian experience in agriculture would introduce new technologies especially in areas prioritized by the CGIAR centers such as precision agriculture, satellite monitoring and agriculture instrumentation. Embrapa is already working with partners in the USA and Europe in these areas, and is willing to share the knowledge with the CGIAR System. The strategy to be followed consider the expansion of Brazilian teams leaded by Embrapa, by accepting CGIAR scientists as part of the teams working both in Brazil and at selected CGIAR centers.

3.28 A particular area of concern expressed by Embrapa is the contribution made by CGIAR centers to the lusophone community in Africa (PALOP) and East Timor. Due to language barriers, technicians and farmers there prevented from benefiting from the technologies generated by the international community in the agricultural sector. Brazil, as a member of the PALOP group, retains most of the available technical literature in agriculture, from technical papers to technical manuals and books. Embrapa has been supporting lusophone countries by offering its many publications to these countries.

3.29 Embrapa is already working together with lusophone African countries through bilateral agreements and tripartite actions funded by the Brazilian government and foreign agencies, such as JICA, the Japanese International Cooperation Agency. The most important area being emphasized is the training of lusophone Africans by Embrapa scientists in specific areas of agricultural research and development.

3.30 Embrapa is ready to share its experience with CGIAR in centers by working together to promote the development of agricultural science and technology in lusophone countries. Possible actions would be the implementation of joint research projects, training of technicians and farmers, as well as information and communication.

3.31 In the area of training of researchers and technicians, a strong joint training program focusing on traditional areas of the agricultural sciences and especially on new areas such as genetic engineering, precision agriculture, ecology and other interdisciplinary areas is needed. By taking advantage of the accumulated knowledge available in Brazil, the CGIAR would increase its capacity to transfer technologies and knowledge if Brazilian scientists work hand in hand with CGIAR counterparts in the organization and conduction of formal training events. In the service training of national and international staff should also be encouraged as a line of cooperation between the CGIAR centers and Embrapa.

3.32 Historically, one of the most important functions of the CGIAR centers is the preservation, maintenance, and utilization of genetic resources. As previously shown, Brazil itself was greatly benefited from this work, especially in crops such as beans, maize, cassava, rice and tropical forages, among others. This was of crucial importance to increase both the production and the productivity of Brazilian agriculture. The availability of genetic resources to other partners is indeed one of the strong areas of the CGIAR/Embrapa cooperation, now realized by the recent opportunities offered by advanced biology, with particular emphasis on genetic engineering.

Types of Technologies

3.33 It is important to analyze what types of technologies are needed as part of a strong collaboration in order to meet the objectives and to overcome the challenges faced by tropical agriculture. We believe that there are four basic groups of technologies that will have a strong impact on the future of the agricultural sector: those which modifying comparative advantages; those able to reduce risks; those which can aggregate value to primary products; and those which can facilitate the dissemination of information.

3.34 The first group is related to modern biotechnology, and particularly genetic engineering. It has the capability of changing live organisms — plants and animals — by introducing characteristics, which are distinct from the original organisms. They may contribute to the increase of productivity, resistance to biotic and abiotic stresses, to reduction of costs, and to the possible development of production systems, which are both productive and environmentally sustainable, and the production of biomaterials and molecules of interest to industry.

3.35 The second group of technologies is closely related to risk reduction, caused by both the inadequate use of inputs and environmental contamination. Precision agriculture, which uses satellite images, GPS, informatics, sensors, and climate, agronomic, and edaphic information, is a tool to optimize the use of fertilizers, chemicals, and water. These new technologies would encourage the optimal allocation of inputs according to the specific exigencies of crops and soil types. Sophisticated machines will reduce crop losses to insignificant levels, while information technologies will help reduce the risks of crop failures, especially when used to monitor irrigation. It is important to note that significant work remains to be done in this area.

3.36 The third group is linked to value aggregation and diversification of agricultural products. These technologies are closed associated with food processing, packaging, quality, and new uses. Value aggregation to primary products would increase income of farmers and small processors, generate new jobs, and, therefore, contribute to the development of rural areas in developing countries.

3.37 The development of the agricultural sector is also dependent of a fourth type of technology capable of accelerating the access and exchange of information. With the help of information and communication technologies (ICT) farmers would have better and faster access to market information which could be used for planning farming activities. In addition, information will be used as a tool for making decisions on what to plant and how to commercialize products.

3.38 The definition of what technologies to produce in order to address the real problems faced by farmers in developing countries should also be an important step when planning a better mode of collaboration between the CGIAR centers and the Brazilian agricultural research system. Comparative advantages of both sides must be taken into consideration when planning joint research and development activities, which could benefit users in Brazil and other tropical countries.

4. The Future Role of the CGIAR

4.1 Embrapa understands that any strategy to be adopted by research institutions when designing new ways of cooperation must be based on joint action. The existence of areas of common interest and complementary objectives make possible a fruitful collaboration that can be implemented and attract the necessary funds. This strategy should be taken into account by potential or existing partners and even considered as a goal to be met by administrators and researchers in national and international institutions.

4.2 International research centers of the CGIAR need to adjust future activities in view of the growing scientific capacity of NARS, as it is the case of Brazil. Although the demand expressed by less developed countries should be taken into consideration; new strategies such as those presented above must be developed in order to use, in the best possible way, the resources available at a national level.

4.3 Training should be continued on a more specific basis and focused on areas concerning upstream research and regional/national strategies. In planning training activities international centers should take advantage of the existence of national experts working not only in research institutions, but also in universities and the private sector, as a way to strengthen Centers' capacity and explore the existing capacity of strong NARS for the benefit of less developed ones. Strategic areas, such as those related to the use of biotechnologies (genomics and transformation), informatics, and natural resource conservation and utilization, among others, should be given priority by the international Centers.

4.4 In summary, given that national research institutions have grown in the last 30 years, international research centers should prioritize problems that cannot be addressed by the former or that are not part of the NARS mandate. We believe that this approach, coupled with a continued emphasis on the conservation and utilization of genetic resources, would be the most relevant contribution of the CGIAR to humanity.

Annex 1: Acknowledgements

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Annex 2: References

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Annex 3: Cooperation Between CGIAR Centers and Embrapa Decentralized Units in 2001

Embrapa Centers	*CGIAR Centers*														
	CIAT	*CIMMYT*	*CIP*	*IFPRI*	*ICRAF*	*CIFOR*	*ISNAR*	*IPGRI*	*IITA*	*ICRISAT*	*ILRI*	*IRRI*	*WARDA*	*ICLARM*	*IWMI*
CENARGEN	X							X		X		X			
CNPA															
CNPAB															
CNPAF	X											X	X		
CNPAT								X							
CNPC															
CNPDIA															
CNPF					X	X									
CNPGC	X										X				
CNPGL											X				
CNPH			X												
CNPMA															
CNPMF	X							X	X						
CNPMS		X								X					
CNPS															
CNPSA															
CNPSo															
CNPT		X													
CNPTIA															
CNPUV															
CPAA															
CPAC	X									X					
CPACT			X												
CPAF-AC					X										
CPAF-AP															
CPAF-RO					X										
CPAF-RR															
CPAMN															
CPAO															
CPAP															
CPATC															
CPATSA															
CPATU						X									
CPPSE															
CPPSUL															
CTAA															

Annex 4: Cooperation Embrapa-CGIAR in 2001

CGIAR Centers	***Embrapa Centers***	***Joint Activities***			
		Joint Research	***Germplasm Exchange***	***Technical Visits***	***Training***
CIAT	CENARGEN	Molecular analysis of population of *Pyricularia grisea*	-Conservation, breeding of *Phaseolus lunatus* in Brazil -Cassava germplasm catalog -Biology and conservation of Manihot		
CIAT	CPAC	-Evaluation of pasture quality -Biophysical and socio- economic impact of milk production systems -Assessment of pasture degradation by remote sensing		-Consultancy on land use utilization using remote sensing	
CIAT	CNPMF	-Participatory research in cassava breeding	-Exchange of cassava germplasm for semi-arid conditions		
CIAT	CNPAF	-Genetic diversity of isolates of *Pyricularia grisea* in Brazil and Colombia -Research on germplasm disease resistance -Use of molecular markers to select beans cultivars adapted to semi-arid and Cerrados -Development of beans varieties tolerant to biotic and abiotic stress in semi-arid Brazil and Africa -Project proposal on rice quality, submitted to CEE			
CIAT	CNPGL	-Pasture breeding		-Meeting on tropical pastures to evaluate research results	
CIAT	SCI				-Coordination of training for NARS researchers in CGIAR

CGIAR Centers	*Embrapa Centers*	*Joint Activities*			
		Joint Research	***Germplasm Exchange***	***Technical Visits***	***Training***
CIMMYT	CNPMS	-Evaluation of CHTTY/CIMMYT (hybrid Tropical Yellow) and EVT (blight variety) trials -Maize breeding for acid soils -Shipment of Brazilian maize accessions to CIMMYT collection -Regeneration of accessions from CIMMYT collection -Development of maize production systems	-Exchange of maize varieties with resistance to specific diseas es and pests -Joint evaluation of germplasm for acid soils (Embrapa/CIAT/CIMMYT)	-Visit of researchers from Embrapa Maize and Sorghum to discuss plant physiology issues	-Support for training Brazilian researchers in Colombia, Mexico, Uruguay -International course on seeds -Support for creation of reference center for disease and pest diagnosis in Sete Lagoas, MG, with Embrapa Wheat and other institutes -Training of Latin American researchers in crop management, experimentation in Sete Lagoas, MG
CIMMYT	CNPT	-Identification, documentation, introduction of genes with potential tolerance to biotic and abiotic stress -Development of wheat germplasm with high industrial quality -Evaluation of wheat genotypes for bakery -Development of rust-resistant wheat varieties for Southern Brazil -Development of wheat and triticale germplasm with less germination on the ear -Development of giberela-tolerant wheat, triticale -Development of wheat cultivars for Central Brazil -Development of production systems in Paraná State with Embrapa Soybeans, IAPAR, and CODETEC for no-till system -Development of production systems for wheat and other winter crops	-Evaluation and conservation of wheat, triticale, and barley		

CGIAR Centers	***Embrapa Centers***	***Joint Activities***			
		Joint Research	***Germplasm Exchange***	***Technical Visits***	***Training***
CIP	CNPH	-Sexual propagation of potato -Integrated control of bacterial wilt -Introduction of white carrot from U. of Cuzco -Introduction of disease/heat-resistant TPS	-Characterization and conservation of potato, white carrot, and sweet potato germplasm	-Technical visits and consultancies of CIP scientist to Embrapa units for morphological characterization of 178 material of white carrot in Embrapa gene bank; evaluation of virus infection in potato/sweet potato; characterization and maintenance of Embrapa sweet potato collection	-Participation of Embrapa scientis t as trainer in course offered to researchers from Ecuador, Peru, and Bolivia -Training of professor from University of Lavras in potato diseases at CIP
CIP	CPACT	-Introduction of 9 multiplex progenitors of potato seeds (TSP) families (200 genotypes each) with resistance to PVX and PVY	-Transfer to Pelotas, RS, of analytical materials to identify potato virus and nucleic acid samples for control; detection of PVY-ntn; Plasmid p ST-PE1 gen to detect PSTVd; serological kit to detect sweet potato virus and positive control of white carrot		
IFPRI	SEA	Pilot economical evaluation of new varieties developed by Embrapa Maize and Sorghum, Embrapa Soybeans, Embrapa Rice and Beans			
ICRAF	CNPF				International workshop in modeling and simulation of agroforest systems
ICRAF	CPAF-RO CPAF-AC	Implementation of Alternative to Slash and Burn project with Embrapa Rondonia and Embrapa Acre		-Visit of ICRAF scientist to Embrapa HQs, Embrapa Acre, Embrapa Rondonia to discuss joint training -Visit of Embrapa scientist from SCI to ICRAF-Nairobi to discuss cooperation	Organization of training course on research project elaboration, in cooperation with Embrapa Oriental Amazon and FCAP

CGIAR Centers	***Embrapa Centers***	***Joint Activities***			
		Joint Research	***Germplasm Exchange***	***Technical Visits***	***Training***
CIFOR	CPATU	-Joint implementation, Management of Secondary Forests by Smallholders in Northeastern Pará and Development of Secondary Forest by Family Farmers in Brazilian Amazon projects -Participatory research with farmers and farmer organizations in projects to validate selection of management practices for secondary forest -Implementation of low-impact selective timber harvest as part of project on sustainable commercial forest management in the Amazon		-Evaluation of and production of papers on secondary and commercial forests	
CIFOR	CNPF	-Strategies to implement sustainable forest plantations		-Discussion of program on Fellow Visiting Scientist at CIFOR HQs, Bogor, IPR	
ISNAR	SCI	-Discussion of implementation of ISNAR office in Brasilia			
IPGRI	CENARGEN		-Collection, conservation of Arachis, cassava, pineapple germplasm		-Training of African lusophone technicians (PALOPs)
IPGRI	CPATC	Conservation and use of coconut germplasm			
IPGRI	CNPMF	-Research network on training in musa -Micropropagation techniques for pineapple, banana -Identification of pineapple varieties adapted to different regions of Brazil -Identification of banana varieties resistant to Panama and Sigatoka diseases			
IPGRI	SCI			-Training program designed to technicians from Latin America and the Caribbean and PALOP countries.	-Workshop on seed physiology for African researchers in Mozambique. Seen as a pilot for other African countries
IITA	CNPMF	Introduction of cassava germplasm from Brazil and other South American countries into sub-Sahara Africa in cooperation with CIAT			

CGIAR Centers	Embrapa Centers	Joint Activities			
		Joint Research	**Germplasm Exchange**	**Technical Visits**	**Training**
ICRISAT	CENARGEN	Collection, evaluation, conservation, regeneration, dissemination of Arachis germplasm			
ICRISAT	CNPMS	Network of trials for sorghum tolerance to acid soils			
ICRISAT	CPAC	Selection of millet germplasm adapted to long days and high biomass production for no-till systems in the Cerrados			
ILRI	CNPGC	Collaborative research with Embrapa Beef Cattle on primers to detect pathogens			
ILRI	SCI; CNPGL, CNPGC			Visit to Addis and Nairobi to discuss cooperation plan	
IRRI	CNPAF	Germplasm exchange and research for rice breeding			
IRRI	CENARGEN	Gene transference to improve root system of variety IR64 through molecular markers	Characterization and conservation of rice germplasm		
WARDA	CNPAF	Rice germplasm exchange			

Annex 5: List of Working and Background Papers, Authors, and Peer Reviewers

Working Papers

Barrett, Christopher B. 2002. *Natural Resources Management Research in the CGIAR: A Meta-Evaluation.*

> Peer Reviewers: Jock Anderson, Derek Byerlee, Dana Dalrymple, Hans Gregersen, Ted Henzell, John Lynam, Vernon Ruttan, Meredith Soule, Joachim von Braun, Usha Barwale Zehr

Eicher, Carl K. and Mandivamba Rukuni 2002. *The CGIAR in Africa: Past, Present, and Future*.

> Peer Reviewers: Malcolm Blackie, Dana Dalrymple, Bob Herdt, Alain de Janvry, Romano Kiome, John Lynam, Eric Tollens, Geoffrey Mrema, Wilfred Mwangi, Cyrus Ndiritu, Emmy Simmons, Moctar Touré

Gardner, Bruce 2002. *Global Public Goods from the CGIAR: Impact Assessment.*

> Peer Reviewers: Jock Anderson, Dana Dalrymple, Osvaldo Feinstein, Paul William Glewwe, Hans Gregersen, George Norton, Scott Rozelle, Vernon Ruttan, Sara Scherr, Sudhir Wanmali

Lesser, William 2002. *Reviews of Biotechnology, Genetic Resource and Intellectual Property Rights Programs.*

> Peer Reviewers: Ronnie Coffman, John Dodds, Robert Evenson, Brian Ford Lloyd, Anatole Krattiger, Steve Kresovich

Spielman, David 2002. *International Agricultural Research and the Role of the Private Sector.*

Macedo, Jamil, Marcio C. M. Porto, Elisio Contini, and Antonio F. D. Avila 2002. *Brazil Country Paper for the CGIAR Meta-Evaluation.*

Katyal, J.C. and Mruthyunjaya 2002. *CGIAR Effectiveness — A NARS Perspective from India.*

Background Papers (Available upon request)

Ndiritu, Cyrus 2002. *CGIAR-NARS Partnership: The Case of Kenya.*

Romano, Luis 2002. *Colombia Country Paper for the CGIAR Meta-Evaluation.*