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CIAT's Action Plan

UNIDAD DE INFORMACION Y DOCUMENTACION

Positioning the Center to Deal With a Changing Environment (1994-1998)

Supplement E: A Preliminary Assessment of the Expected Impacts of Project Outputs

CIAT
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TABLE OF CONTENTS

Page

PART I. Executive Summary 1
- Introduction 1
- Summary of Preliminary Assessment 1

PART II. Study Methodology 7
- Acknowledgements 7
- Purpose 8
- Dimensions of Impact 8
- Process 8
- Conceptual Model 9
- Economic Model 10
- Units of Analysis 12
- Model Parameters 14
- Differences With Previous CIAT Planning Studies 16
- Limitations 17
- Sustainability Score: Natural Resource Preservation 18
- Benefits to the Poor 19
- Institutional Strengthening Benefits 19
- Model Performance 21
- Project Costs 24

REFERENCES 25

APPENDIX I: Technical Parameters of Project Outputs 27

APPENDIX II: Sustainability Appraisals of Project Outputs 55

APPENDIX III: Definitions of Project Outputs 63

PART I. **Executive Summary**

Introduction

This is an interim progress report that provides a preliminary assessment of the expected impacts of the outputs of CIAT projects. The results presented here represent a third iteration in an ongoing study that requires further iterations. These preliminary findings are presented now as a point of reference in a wider decision making process of CIAT's 1994-98 action plan. It is not intended that decisions be based mechanically on these results. Rather, these preliminary findings are illustrative of our best current knowledge of the relative contribution of some alternative CIAT outputs with respect to efficiency, equity, and sustainability.

Some of the patterns in these findings have been stable over the initial iterations, and thus have displayed some robustness. Other tendencies in the results have varied, and some features of model performance are seen to require further adjustment which will likely change some of the results. The study methods, limitations, and model performance are discussed in detail in Part II. Study Methodology.

Summary of Preliminary Assessment

Preliminary results of estimated benefit indicators are presented by project output in accompanying tables (project outputs are briefly defined in Appendix III). Table I presents results with outputs rank ordered by internal rate of return. The internal rate of return is an interest rate that is like an annual percentage return on CIAT investment in producing a particular output.

The rate of return thus takes into account the expected research costs to develop an output, and the expected CIAT share of the efficiency benefits anticipated from the output. The efficiency or productivity benefits of project outputs result from reduced per unit costs of production and represent resource savings to society (see Economic

Model Section below). These benefits are discounted for the probability of success in achieving a project output, and the share of benefits attributed to CIAT's effort is 50%, with the other 50% attributed to NARDSs and other partners.

Higher rates of return are, of course, desirable. At a minimum, a project must have an expected rate of return equal to the cost of capital, conventionally taken to be 10%. The vast majority of agricultural research programs earn much higher rates of return, and those estimated here for CIAT, fall within the normal rage reported in the literature (Evenson and Rosegrant 1993).

The second column of Table I presents the present values of CIAT's share of expected net efficiency benefits which are used in the internal rates of return calculations. Table II presents the same list of project outputs rank ordered by expected benefits that accrue to the poor (column 3), to reflect CIAT's goal of contribution to the alleviation of poverty. Table III presents the outputs ranked by mean scores on an evaluation of the contribution of project outputs to sustainability (see section on Sustainability Scores below).

While a few outputs come out consistently high or low on all indicators, other projects emerge high ranked on one indicator, and not another. The relative weights of the efficiency, equity, and sustainability criteria is a policy choice for CIAT decision makers.

During the course of this study, a proposal evolved to group CIAT outputs into 18 mega-projects. Although these mega-projects were not units of analysis in this study, Table IV presents total benefits and benefits to the poor attributed to these proposed mega-projects. Bean and cassava genetic diversity and genetic improvement benefits are presented together, and no estimates are provided for the forest margin mega-project.

Table I. Outputs of CIAT Projects Rank Ordered by Internal Rate of Return.

	Internal Rate of Return (%)	Present Value of CIAT Share of Expected Net Benefits 1994-2028 ($ million 1993) (10% discount)	Present Value of Expected Net Benefits to Poor 1994-2028 ($ million 1993) (10% discount)	Sustainability Contribution (0= neutral or no effect 3= highest possible effect)
Forages. Institutional (a)	126.5	726	160	-
Yuca Institutional	97.9	1062	735	-
Beans Disease (LAM)	95.6	403	157	1.4
Forages: Arachis (a)	93.4	1821	401	1.2
Hillside Institutional	90.4	128	52	-
Yuca G. Pool Humid	88.4	391	271	0.8
Beans Institutional (LAM)	86.4	110	43	-
Hillside Erosion	84.2	459	225	2.2
Savanna: Intensive Systems	84.1	1400	368	0.0
Savanna Institutional	81.8	127	31	-
Beans Disease (AFRICA)	81.1	204	173	1.4
Beans Drought (AFRICA)	79.2	79	67	1.2
Rice Institution	77.5	141	42	-
Forages: Shrub Legumes	76.0	355	121	1.6
Beans Meso Yield (LAM)	75.7	413	161	0.8
Forages: Brachiaria (a)	74.6	1671	368	0
Beans Insect (AFRICA)	74.4	102	87	1.4
Yuca Quality	73.2	566	392	1.6
Beans Insect (LAM)	70.3	99	39	1.4
Forages: Centrosema/Desmodium (a)	70.0	413	91	1.2
Beans Meso G. Pool (AFRICA)	68.6	80	68	0.8
Yuca G. Pool Sub-Tropical	67.5	190	131	1.1
Yuca Product/Process	66.5	119	82	0.7
Yuca G. Pool Sub-Humid	66.4	324	224	0.9
Forages: Stylosanthes (a)	65.9	540	119	1.2
Rice Lowland Yield	65.6	352	106	0
Yuca Pest/Disease Management	65.4	980	678	1.6
Rice Weeds	64.6	192	58	0.6
Yuca Planting Material	63.5	67	46	1.4
Rice Blast	63.4	315	95	0.8
Rice Hoja Blanca Virus	62.8	114	34	0.8
Savanna: Min Input Syst	62.1	398	101	0.2
Yuca G. Pool Semi-Arid	61.9	228	158	1.1
Beans Institutional (AFRICA)	61.6	80	67	-
Beans Phosphorus (AFRICA)	59.4	92	78	0.6
Hillside Land Policy	58.6	163	73	2.6
Beans Phosphorus (LAM)	58.6	171	67	0.6
Yuca G. Pool Highland	57.8	96	66	1.2
Beans Drought (LAM)	54.4	161	63	1.2
Yuca Soils Management	54.1	339	234	1.8
Rice Upland Yield (a)	49.1	161	48	0.8
Beans Andean G. Pool (AFRICA)	48.9	87	74	0.8
Beans Nitrogen (LAM)	48.1	28	11	1.0
Hillside Fallow	48.0	291	98	2.6
Savanna: Low Input System	47.4	159	41	0.6
Beans Nitrogen (AFRICA)	46.1	26	22	1
Rice IPM	43.8	50	15	1.4
Beans Temperature (AFRICA)	41.4	5	4	0.2
Forages: Legume Mixtures	34.5	21	5	1.2
Beans Andean Yield (LAM)	32.3	35	14	0.8
Beans Temperature (LAM)	31.9	12	5	0.2
Beans Al-Ca (LAM)	29.6	8	3	0.6
Beans Al-Ca (AFRICA)	21.2	5	4	0.6

(a) Not include benefits from upland rice or forage area expansion which are attributable to savanna system projects.

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Table II. Outputs of CIAT Projects Rank Ordered by Benefits to Poor, 1994-2028.

	Internal Rate of Return (%)	Present Value of CIAT Share of Expected Net Benefits 1994-2028 ($ million 1993) (10% discount)	Present Value of Expected Net Benefits to Poor 1994-2028 ($ million 1993) (10% discount)	Sustainability Contribution (0= neutral or no effect 3= highest possible effect)
Yuca Institutional	97.9	1062	735	-
Yuca Pest/Disease Management	65.4	980	678	1.6
Forages: Arachis (a)	93.4	1821	401	1.2
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Forages: Institutional (a)	126.5	726	160	-
Yuca G. Pool Semi-Arid	61.9	228	158	1.1
Beans Disease (LAM)	95.6	403	157	1.4
Yuca G. Pool Sub-Tropical	67.5	190	131	1.1
Forages: Shrub Legumes	76.0	355	121	1.6
Forages: Stylosanthes (a)	65.9	540	119	1.2
Rice Lowland Yield	65.6	352	106	0
Savanna: Min Input Syst	62.1	398	101	0.2
Hillside Fallow	48.0	291	98	2.6
Rice Blast	63.4	315	95	0.8
Forages: Centrosema/Desmodium (a)	70.0	413	91	1.2
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Beans Phosphorus (AFRICA)	59.4	92	78	0.6
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Hillside Land Policy	58.6	163	73	2.6
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Beans Phosphorus (LAM)	58.6	171	67	0.6
Beans Institutional (AFRICA)	61.6	80	67	-
Beans Drought (AFRICA)	79.2	79	67	1.2
Yuca G. Pool Highland	57.8	96	66	1.2
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Rice Weeds	64.6	192	58	0.6
Hillside Institutional	90.4	128	52	-
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Beans Insect (LAM)	70.3	99	39	1.4
Rice Hoja Blanca Virus	62.8	114	34	0.8
Savanna Institutional	81.8	127	31	-
Beans Nitrogen (AFRICA)	46.1	26	22	1
Rice IPM	43.8	50	15	1.4
Beans Andean Yield (LAM)	32.3	35	14	0.8
Beans Nitrogen (LAM)	48.1	28	11	1.0
Forages: Legume Mixtures	34.5	21	5	1.2
Beans Temperature (LAM)	31.9	12	5	0.2
Beans Temperature (AFRICA)	41.4	5	4	0.2
Beans Al-Ca (AFRICA)	21.2	5	4	0.6
Beans Al-Ca (LAM)	29.6	8	3	0.6

(a) Not include benefits from upland rice or forage area expansion which are attributable to savanna system projects.

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Table III. Outputs of CIAT Projects Rank Ordered by Sustainability Scores.

	Internal Rate of Return (%)	Present Value of CIAT Share of Expected Net Benefits 1994-2028 ($ million 1993) (10% discount)	Present Value of Expected Net Benefits to Poor 1994-2028 ($ million 1993) (10% discount)	Sustainability Contribution (0= neutral or no effect 3= highest possible effect)
Hillside Fallow	48,0	291	98	2,6
Hillside Land Policy	58,6	163	73	2,6
Hillside Erosion	84,2	459	225	2,2
Yuca Soils Management	54,1	339	234	1,8
Yuca Pest/Disease Management	65,4	980	678	1,6
Forages: Shrub Legumes	76,0	355	121	1,6
Yuca Quality	73,2	566	392	1,6
Beans Insect (AFRICA)	74,4	102	87	1,4
Beans Disease (LAM)	95,6	403	157	1,4
Beans Insect (LAM)	70,3	99	39	1,4
Beans Disease (AFRICA)	81,1	204	173	1,4
Yuca Planting Material	63,5	67	46	1,4
Rice IPM	43,8	50	15	1,4
Beans Drought (AFRICA)	79,2	79	67	1,2
Yuca G. Pool Highland	57,8	96	66	1,2
Forages: Centrosema/Desmodium (a)	70,0	413	91	1,2
Beans Drought (LAM)	54,4	161	63	1,2
Forages: Stylosanthes (a)	65,9	540	119	1,2
Forages: Legume Mixtures	34,5	21	5	1,2
Forages: Arachis (a)	93,4	1821	401	1,2
Yuca G. Pool Semi-Arid	61,9	228	158	1,1
Yuca G. Pool Sub-Tropical	67,5	190	131	1,1
Beans Nitrogen (AFRICA)	46,1	26	22	1
Beans Nitrogen (LAM)	48,1	28	11	1,0
Yuca G. Pool Sub-Humid	66,4	324	224	0,9
Beans Meso Yield (LAM)	75,7	413	161	0,8
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Rice Hoja Blanca Virus	62,8	114	34	0,8
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Rice Blast	63,4	315	95	0,8
Rice Upland Yield (a)	49,1	161	48	0,8
Yuca Product/Process	66,5	119	82	0,7
Beans Al-Ca (AFRICA)	21,2	5	4	0,6
Savanna: Low Input System	47,4	159	41	0,6
Beans Al-Ca (LAM)	29,6	8	3	0,6
Beans Phosphorus (AFRICA)	59,4	92	78	0,6
Rice Weeds	64,6	192	58	0,6
Beans Phosphorus (LAM)	58,6	171	67	0,6
Beans Temperature (AFRICA)	41,4	5	4	0,2
Beans Temperature (LAM)	31,9	12	5	0,2
Savanna: Min Input Syst	62,1	398	101	0,2
Savanna: Intensive Systems	84,1	1400	366	0,0
Rice Lowland Yield	65,6	352	106	0
Forages: Brachiaria (a)	74,6	1671	368	0
Hillside Institutional	90,4	128	52	-
Forages: Institutional (a)	126,5	726	160	-
Beans Institutional (LAM)	86,4	110	43	-
Savanna Institutional	81,8	127	31	-
Beans Institutional (AFRICA)	61,6	80	67	-
Rice Institution	77,5	141	42	-
Yuca Institutional	97,9	1062	735	-

(a) Not include benefits from upland rice or forage area expansion which are attributable to savanna system projects.

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Table IV. Net Present Value of Total Benefits and Benefits to Poor of CIAT Outputs by Mega-Project Clusters.

		Present Value of CIAT Share of Expected Net Benefits 1994-2028 ($ million 1993) (10% discount)	Present Value of CIAT Share of Expected Net Benefits to Poor 1994-2028 ($ million 1993) (10% discount)
Cassava:	Manihot Diversity & Improved Gene Pools	1229	850
Cassava:	Integrated Crop Management	1386	959
Cassava:	Markets	685	474
Subtotal Cassava		**3300**	**2283**
Beans:	*Phaseolus* Diversity & Yield Stability	1472	762
Beans:	Productivity in Latin America and the Caribbean	376	147
Beans:	Productivity in Sub-Saharan Africa	352	299
Subtotal Beans		**2200**	**1208**
Forages:	Diversity	912*	201*
Forages:	For Acid Soils	2313*	509*
Forages:	Improvement	1592*	350*
Subtotal Forages		**4817***	**1060***
Hillside:	Andean	434	190
Hillside:	Central American	479	211
Subtotal Hillsides		**913**	**401**
Rice:	Lowland in Latin America and the Caribbean	855	257
Rice:	Upland in Latin America and the Caribbean	329*	99*
Subtotal Rice		**1184***	**356***
Savanna:	Brazilian Cerrados	1789	463
Savanna:	Colombian Llanos	168	45
Subtotal Savanna		**1957**	**508**

* Not include benefits from upland rice or forage area expansion which are attributable to savanna projects.

PART II. Study Methodology

Acknowledgements

This progress report is the product of the contribution of many at CIAT. The Program Leaders were responsible for the initial definitions of projects and outputs, and they worked hard with their scientists to develop the technical parameters (Appendix I). While all programs took this task seriously, the Cassava Program treated it with most commitment through a week long program planning seminar. The Program Leaders also provided information on sustainability consequences and research costs. Drs. Carlos Lascano and Oswaldo Voysest deserve special mention for their efforts as Acting Leaders of the Forage and Bean Programs. All the Program Leaders deserve credit for their professionalism in this challenging exercise.

The initial results of each model are largely the responsibility of each program economist. Dr. Luis Sanint was employed as a consultant by the Rice Program, and Ruben Dario Estrada as a consultant for the Hillside Program. Dr. Guy Henry of the Cassava Program ably assisted by Veronica Gottret, developed a particularly detailed model incorporating the Cassava Program's needs to look at different markets in different continents. Libardo Rivas, Associate Economist in the Forage Program, was responsible for the meat and milk models, and also ran the soybean and maize models included in the savanna projects. Norha Ruíz de Londoño was responsible for the bean models for Africa and Latin America. Dr. Alvaro Ramírez, Associate Economist in the Rice Program, provided some crucial input, and Carolina Correa, Assistant Economist in the Impact Assessment Unit, was tireless in her help re-running the rice, Hillsides, and cassava models. The study is being coordinated by Douglas Pachico who is responsible for any errors or omissions committed in the assembly of this document.

Purpose

This report presents estimates of some impacts that would result from successful achievement of outputs produced by CIAT projects. These estimates of impact have been calculated so that they may serve as an element in decision making as CIAT revises its Medium Term Plan.

Dimensions of Impact

This exercise follows the criteria for decision making set down in CIAT's strategic plan:

- **Efficiency** or contribution to economic growth.

- **Equity** or alleviation of poverty

- **Sustainability** or contribution to the preservation of the natural resource base.

Impacts are thus measured at the level of final social objectives rather than intermediate impacts, like improved knowledge. The effects of intermediate outputs are captured to the degree that they contribute to the final objectives of efficiency, equity, and sustainability.

Process

Based on discussions in the CIAT Management Committee, it was decided that all Programs should recast their strategies and activities into a project framework, with clearly defined outputs.

From the projects and outputs thus specified, concrete final outputs were identified. For each output, the Programs provided their best estimate of the technical impact of the project output (e.g. how much yields would increase or costs reduce); the time and resources required to achieve the proposed project output; the target area for which the output is destined; and the probability of successfully producing the output in the given time frame and resources. All these data were generated by CIAT biological scientists, and are contained in Appendix I.

Based on these data, CIAT economists used a formal economic model to estimate the efficiency and equity consequences of the proposed CIAT outputs.

Conceptual Model

The Strategic Plan defines CIAT mission as "... applying science to the generation of technology that will lead to lasting increases in agricultural output...", while CIAT's strategy statement focuses on germplasm development research to increase output; resource management research to make agricultural production sustainable; and interinstitutional cooperation to enhance national agricultural research and development system (NARDS) effectiveness.

Consequently, the conceptual model used in this exercise sees CIAT as principally conducting research to generate outputs of technology or technology components (e.g. information or methods). These outputs are used by NARDS to generate final outputs which are suitable for use by farmers. CIAT's interinstitutional cooperation activities assist NARDS through training and information exchange as they generate final outputs.

Thus, over time there is a phase of strategic research on which CIAT concentrates its efforts; followed by applied and adaptive research for which NARDS have a comparative advantage; followed finally by a process of adoption of technology by farmers. The benefits from agricultural research result from this final use of new technology by farmers.

Economic Model

The analytical model used in this exercise follows the standard economic approach to assessing the impact of agricultural research (Norton et al. 1992; Lindner and Jarrett 1978; Akino and Hayami 1975). The particular version utilized, was developed at CIAT and was used in past CIAT planning exercises (Pachico et al. 1987; Janssen et al. 1991; Rivas et al. 1992).

The model simulates the effect on the market for a product (e.g. rice) of a new technology that increases productivity, reduces costs, or raises the value of the product. In general, new technologies reduce unit costs of production, increase the availability of goods, and lower market prices to consumers. Producers gain from reduced costs, and consumers gain from lower prices. Social benefits are the sum of the benefits to members of society, i.e. producers and consumers.

The particular model used looks at changes over time as different technologies are adopted by distinct groups of farmers at varying times; as populations and incomes grow, thus increasing demand; and as factors other than agricultural research affect production (e.g. increased mechanization or improved education of farmers). This model is appropriate for appraising the contribution of new technology to efficiency and equity.

Natural resource enhancement and preservation can also be included in this model to the degree that resource preservation permits agricultural production to be sustained at a higher level than would otherwise have occurred. Thus, new crop/pasture systems for the savannas, and improved erosion control in the hillsides and in cassava growing areas are examples of natural resource enhancements that contribute directly to agricultural productivity and thus can be measured through the model. However, where there are effects external to the agricultural sector, a different approach has to be taken. This occurred, for example, in the off farm effects of hillside soil erosion on downstream water resources (Estrada 1993).

A separate economic model was built by CIAT economists for rice, beans, cassava, milk, meat, maize and soybeans. The economic parameters used in these models are reported below, while as noted above, the technology parameters used in the models were developed by CIAT biological scientists and are reported in Appendix I. The model for each product is distinct, tailored to the particular characteristics of each market. The initial models were constructed by participating program economists, while the Rice and Hillside programs employed consultants to assist in the process. The Impact Assessment Unit harmonized the process and made some final adjustments in several of the models. The model is based on a supply function

$$S_o = c\ (P\text{-}m)^d \qquad (1)$$

Where S_o is the initial supply, P the market price for the product, and m the minimum price below which no production occurs. c and d are constants.

$$d = (s(P_o\text{-}m))/P_o \qquad (2)$$

$$c = Q_o/(P_o\text{-}m)^d \qquad (3)$$

Where P_o and Q_o are initial equilibrium price and quantities, and s the supply elasticity. The supply function is shifted due to technical change through a divergent vertical shift in the supply function that reduces marginal costs proportionally.

$$S_1 = c(K(P\text{-}m))^d \qquad (4)$$

Where $K = (Q_1\text{-}Q_o)/Q_o$ and Q_1 is the quantity of the good that would be supplied after technical change at the initial equilibrium price P_o.

In order to simulate the process of technology diffusion, K for any given period, t, is calculated from a logistic function

$$K_t = A/(1+e)^{a+bt} \qquad (5)$$

Where e is the mathematical constant, and A the maximum level of anticipated adoption. In addition, the model incorporates the possibility that the supply may change over time even in the absence of CIAT research outputs. Thus,

$$S_t = c(1+x)^t \, (K_t(P-m))^d \qquad (6)$$

Where x is the autonomous rate of change in supply. The demand function is defined

$$D_t = B(1+y)^t \, P^n \qquad (7)$$

Where n is the own price elasticity of demand, y the growth rate in demand over time, and B a constant.

$$B = Q_o/P_o^{\,n} \qquad (8)$$

The model uses a conventional marshellian economic surplus approach to measure the returns to research from a rightward shift in the supply function induced by a change in technology. The area under the supply curve shift is measured by mathematical integration from the price axis (Pachico et al. 1987; Rivas et al. 1992)

Units of Analysis

The unit of analysis in this report is the final output of projects. The analysis is not by program or unit as many project outputs are the product of inter-program/unit effort. For example, rice and forage germplasm are essential for the new savanna systems;

the VRU and Cassava Program work together on viral diseases of cassava; the GRU and Forages Program both conserve and characterize genetic resources which are used in different germplasm improvement outputs.

Similarly, because of the way projects have been structured so far, there is not a one-to-one correspondence between outputs and projects. For example, the outputs of the proposed Bean Germplasm Improvement Project cannot be fully separated from the outputs of the proposed Africa or Latin America projects. Likewise, hillside outputs of improved fallow systems or improved erosion control, run across the two proposed projects, one for Cauca, Colombia, the other for Central America. The approach taken here, then, is to focus on the final outputs, leaving organizational issues aside.

Many activities of CIAT produce intermediate outputs, e.g. nutrient cycling models, a land use typology, knowledge of the inheritance of a trait. This analysis accepts as a working hypothesis the proposed set of research activities that Program Leaders have specified as essential to produce projected outputs by the target dates. These projected activities form the basis for calculating the costs of producing the project outputs.

As noted above, this analysis operates at the level of final outputs. Thus, activities such as land use studies, germplasm conservation, biometry, are not analyzed separately, but are incorporated into the analysis as inputs or resources required to produce intermediate outputs that are necessary to achieve the specified final outputs.

Forest Margin outputs are not explicitly included in this analysis. This is due to the current vacancy in leadership for Forest Margin projects that left a gap in the definition of expected outputs, etc. In principle, this analysis could be conducted in the future.

Model Parameters

Values of several parameters are essential to conduct simulations of the market impact of new technologies. These parameters are presented in Table V. Initial product prices for rice, beans, and meat, are 10 year averages of FAO International price series 1982-91 expressed in constant 1991 $US. These prices are a proxy for border prices and approach the opportunity cost of the commodities in question in the sense that the international prices represent what an additional amount of the commodity would cost at the margin, or conversely, the price at which surplus could be sold. Cassava, though, is much less tradable than other CIAT commodities, except for that share of cassava which is sold as pellets for animal feed. The 10 year fresh weight equivalent price for cassava pellets is $ 40/ton, but this price substantially underestimates the value of cassava in many markets. Consequently, price data provided by the Cassava Program economist that is equal to a weighted average of $ 70/ton were used. The milk price is the same as used in the previous exercise. The minimum cost of production is an estimate of minimum variable costs of production and are essentially estimates of the respective Program economists, as are the elasticities of supply and demand, though some references exist to support some of these parameters.

The rate of demand growth is calculated from the following sources: Population growth rate projections are derived from World Resources 1992-93; real income growth is taken from the IMF 1992; incomes elasticities of demand are from Musgrove (1988), Gray (1982), Ferroni (1982), and Sanint et al. (1984). The autonomous supply growth parameters are taken from the 1993 CIAT Trend Highlights analyses of FAO data as are the initial quantities of production.

Rice technology is assumed to diffuse most rapidly due to the relatively strong institutions serving the sector, while cassava and forage (meat and milk) technology is assumed to take the longest to diffuse due to weaker institutions and greater difficulties

Table V. Economic Parameters Used in MODEXC Model to Estimate Benefits of CIAT Project Outputs. Draft - November 6, 1993.

	Rice Model	Beans[b] Model	Beef Model	Milk Model	Cassava Model
Initial Price ($US/ton)	286	555	1490	300	71[a]
Minimum Cost of Production ($US/ton)	150	200	500	100	50[a]
Demand Growth (%/yr)	2.0	1.6	2.2	2.2	2.1[a]
Autonomous Supply Growth (%/yr)	1.8	1.0	1.8	1.9	1.5[a]
Demand Elasticity	-0.45	-0.6	-0.7	-0.8	-0.9[a]
Supply Elasticity	0.8	0.45	0.5	0.7	0.45[a]
Years from Release to Adoption Ceiling	8	9	10 to 15	10 to 15	10
Supply Shift	1.74	1.98	1.70	1.54	1.32[a]

[a] Weighted average of different markets.

[b] Latin America only.

in propagation of planting material. (See discussion below on institutional strengthening).

The supply shifts are calculated from the technical parameters provided by the respective Program Leaders. The supply shifts indicate the additional amount of production that would occur at constant prices if success was met in reaching all the target outputs for a particular commodity. In this context, the cassava outputs are most conservative in projections of the supply shift, while those of beans are the greatest. These supply shift parameters can be interpreted in the following manner. If all the outputs for beans and cassava were developed in the projected time frame, achieved the expected levels of adoption, and had the anticipated impact on productivity (all as specified in Appendix I), then at constant prices, an additional 98% of beans would be supplied to the market, and an additional 32% of cassava.

Comparing the supply shift parameters used in the 1991 and 1993 exercises, the projected supply shift for rice is considerably less than previously estimated. The current supply shift has been rigorously built up from technical estimate of yield increases and cost reductions. The previous estimate seems to have been inflated by inclusion of the continued adoption of technology already developed, which is an irrelevant consideration with respect to the returns to future investment in research.

For all the other commodities, the projected supply shift is greater in the current exercise than in the previous. In principle the current estimates have a more rigorous technical basis, having been developed by the Program biological scientists.

Differences With Previous CIAT Planning Studies

This analysis builds upon and has several advantages over the study conducted during the 1991 CIAT strategic planning process.

- Analysis is by output of projects rather than by program.

- Benefits estimates are included for agroecosystem projects, while previous analysis only treated commodity outputs.

- Technical consequences of project outputs have been specified by biological scientists, not economists.

- Research costs are taken into account and rates of return on investment calculated.

- Sustainability scores are related to project outputs.

- Institutional strengthening benefits are estimated.

- Consolidated quantitative estimate of benefits to poor included.

- Benefits can be broken down cross-wise commodity by agroecosystem.

- Sustainability scores compiled from five key dimensions of natural resource preservation.

Limitations

There are several areas in which further work need to be done to provide more reliable information for decision making.

- Expected consequences of project outputs provided by involved scientists and need to be subjected to external review.

- Forest Margin outputs not defined or analyzed.

- More effort could be made to include analysis of potential land use policy impacts and impacts of germplasm conservation, biodiversity, and externalities.

- Technical parameters for bean outputs in Africa not yet reviewed by Africa based staff.

Sustainability Score: Natural Resource Preservation

Preservation of the natural resource base for the purpose of making agricultural production more sustainable is set out in the CIAT Strategic Plan as a major criterion for CIAT decisions. The impact of CIAT's efforts to sustain agricultural production by reducing decapitalization of the natural resource base, can in principle be assessed through economic modeling. This has been done in the cases of cassava and hillside erosion projects, and the rice IPM project. However, some impacts of natural resource degradation occur outside the agricultural sector, and some aspects of resource degradation are in practice difficult to quantify.

This exercise has, therefore, like the previous CIAT planning exercise, included an explicit qualitative evaluation of the effects of project outputs on the natural resource base. This both highlights the importance that CIAT gives to the sustainability criterion as an explicit objective in itself, and also provides a tools for addressing consequences that do not occur within the agricultural sector.

Each project output has been appraised on a scale of +3 to -3 with respect to the effect that successful production of a project output would have on the natural resource base. Plus 3 indicates a very great positive contribution; +2 a significant positive contribution; +1 a minor contribution; 0 is no effect; while minus numbers indicate increasingly deleterious effects of a project output on the natural resource base.

Each project was appraised on five different dimensions of the natural resource base: biodiversity, soil quality, water resources, pollution, and pest ecology. These full evaluations are presented in Appendix II. In the summary results, Tables I-III, mean scores of the sustainability appraisal are reported. Although taking simple means across dimensions of a scale is not without methodological short-comings, these figures are presented as an illustrative first approximation guide.

Benefits to the Poor

Equity or poverty alleviation is, along with economic growth and sustainability, a key decision making criterion for CIAT. The model used to estimate the efficiency benefits of CIAT outputs, also generates information about which proportion of these benefits go to consumers, and which to producers. With a knowledge of the shares of commodities that are either consumed or produced by the poor, the shares of the total benefits that go to the poor can be calculated. Data on the distribution of consumption by income classes is calculated by weighing equally data from a study of Brazil, which is the single greatest consumer of all CIAT commodities (Grey 1982) and data from a study of Colombia which represents the rest of the region (Sanint et al. 1984). Data on the shares of poor farmers in production, is taken from previous CIAT planning exercises (Janssen et al. 1991).

Institutional Strengthening Benefits

CIAT has always committed resources to institution building, training, information exchange and networking. These activities are designed to improve the capacity of NARDSs to achieve their objectives. As discussed above in the section on the conceptual model, NARDSs are seen as playing a crucial role in applied and adaptive research as well as in extension. NARDSs effectiveness in undertaking these tasks is a necessary condition for the achievement of benefits from agricultural research.

CIAT's efforts to strengthen NARDS could have several benefits: acceleration of the process in which NARDS' applied and adoptive research converts strategic technology components into final technologies for farmers; increase of the probability of NARDS' success in this activity; more rapid diffusion of technology; and diffusion of technology to a larger group of users.

The approach used in this study focus solely on the first of these possible effects - acceleration of the research activities of NARDSs. This places emphasis on research rather than extension activities. The analysis used here estimates the benefits that would accrue from a more rapid conversion by NARSs of strategic components into final technologies.

The contribution that CIAT can make to NARDS' effectiveness depends on the inherent strength of NARDSs, and on the difficulties of making progress in a specific research area. For example, since NARDSs are relatively strong in the Latin America rice sector, it is assumed that CIAT institutional strengthening activities can accelerate technology generation by one year. Bean programs are less strong in Latin America, so it is assumed that CIAT could make a greater contribution through institutional strengthening so that technology generation could be accelerated two years. Cassava and forages research in NARDSs are least developed, and the problems of multiplication of planting material are more complex and require greater intervention. Thus, successful CIAT institutional strengthening activities in these areas could accelerate technology generation by three years.

While the specific magnitudes of these differences cannot be substantiated, this approach does allow for the simulation of some relative differences that appear logical. Looking at Tables I and II in the executive summary, it can be seen that instititutional strengthening outputs have consistently high impacts. Two points should be taken into account. First, these institutional benefits occur in this model solely through the acceleration of the technology generation process. It is like having an extra year of benefits. Second, as a consequence, these institutional strengthening benefits occur only indirectly. They only occur in the presence of successful technological change and would not otherwise occur.

Model Performance

In addition to providing estimates of the impact of technical change due to CIAT project outputs, the model also necessarily produces projections of future equilibrium price and quantity in the market. These projections can in turn be analyzed as an indicator of the overall plausibility of the model results.

These indicators for the models are presented in Table VI. In the case of beans in Latin America, little change is forecast either in per capita consumption or in prices. Thus, the benefits results emerge from a scenario that is essentially similar to that of today. This would be a conservative or prudent base scenario unless the view was taken that the trend of declining per capita bean consumption over the last twenty years would continue. It would seem plausible that per capita bean consumption may continue to fall in Brazil with increasing urbanization and dietary diversification. Elsewhere, though, the previous fall in per capita consumption appears to have ceased, and consumption leveled off (Pachico 1993). Nonetheless, consumption has not yet stabilized in Brazil which accounts for about half of bean consumption in the region. Thus, it might be slightly more realistic for bean consumption to fall further. In Africa, bean consumption per capita does indeed drop slightly, due largely to upward pressure on prices as even with technical change prices are projected to increase slightly.

Looking at the rice projections, per capita consumption is projected to grow about 20%. While per capita rice consumption did increase substantially in Colombia and Venezuela in the decades of the 1960's and 1970's (CIAT Trends 1985), per capita rice production remained flat during the 1980's (CIAT Trends 1993). Thus, the rice benefits are emerging from a scenario that includes an increase in per capita consumption for

Table VI. Ccmparison of MODEXC Model Projections for 2028 with Current Prices and Consumption.

	Per Capita Consumption (kg/yr) 1993	Per Capita Consumption (kg/yr) 2028	Total Change (%)	Price 1993 ($ 1991/ton)	Price 2028 ($ 1991/ton)	Total Change (%)
Beans: Latin America	11.7	12.0	2.6	555	541	-2.5
Beans: Africa	18.8	17.3	-8.0	555	572	3.1
Rice	31.2	37.4	19.9	286	247	-13.6
Beef	14.5	18.5	27.6	1490	1358	-8.9
Milk	76.7	101.4	32.2	300	265	-11.7
Cassava: Latin America[a]	84.2[b]	76.2[b]	-9.5	85[b]	150[a]	76.2
Cassava: Asia[a]	16.5[b]	18.6[b]	12.7	64[b]	68[a]	6.1
Cassava: Africa	185.3	174.5	-5.8	70	79	12.6

[a] Includes direct and indirect consumption (e.g. animal feed).

[b] Weighted averages of different markets.

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which there may be no compelling prospect, unless rice were to begin to partially displace maize in the diet in Mexico or Central America north of Nicaragua. The increase in per capita rice consumption is supported to some degree by its positive income elasticity of demand. The projected change of a 13.6% decline in the real price or rice is consistent with secular trends of declining real prices for major food staples (Pinstrup Andersen 1993).

The models for both milk and beef project a moderate decline in price (11.7% and 8.9%, respectively) and a significant increase in per capita consumption (32.2% and 27.6%, respectively). While both are products with strong consumer preferences, whose consumption could well rise with increasing incomes, recent trends appear less favorable, particularly in the case of beef. Trends in beef consumption and prospects of beef demand in the face of competition from poultry, have been the subject of differing analyses (Lynam 1987; Seré and Jarvis 1989). Without daring to attempt to resolve this polemic, suffice it to say that significant increases in per capita beef consumption would represent a reversal of recent trends in Latin America, and may not be a fully appropriate context for benefits estimates.

The cassava models are the most complex, needing to deal with different markets (e.g. fresh, farinha, animal feed) in three continents. Moreover, as noted above, international price series are not fully appropriate in markets where cassava is a non-tradable due to its high perishability. Sensitivity analysis was done with different price regimes - $55/ton and a weighted average of $70/ton. The results are highly sensitive to price changes. The results presented in Tables I-IV are based on the higher prices. At the lower price cassava benefits would be about 1/3 less. Moreover, the model for Latin America projects a 76% increase in cassava prices. There is little doubt that cassava would price itself out of many uses at such prices. Sensitivity analysis indicates that this anomalous result largely dissipates with more conservative projections of demand growth, and this leads to a slight decline in the benefits estimate. Clearly there is an opportunity for further iterations with the cassava as well as the other models.

Project Costs

It is, of course, essential to take into account projected costs in analyzing alternative opportunities for investment in agricultural research. All cost estimates were provided by the Program Leaders. Accounting units used were senior staff equivalents (port-docs and visiting scientists are costed at 1/2 of a senior scientist).

The current full cost per senior research scientist in 1992 was $US 469,000 (CIAT 1993 Funding Request). This includes full direct costs, research support, information, capital, institutional development, management and administration, but is slightly exaggerated for not having taken into account the presence of post-doctorals and visiting scientist which would increase the denominator and lower the average cost. Taking this into account, and the scope for some cost savings, average unit costs of $US 400,000 were used.

Program Leaders included both core and non-core resource requirements in their cost estimates. No distinction is made between core and non-core resources in this analysis which is based on total program costs. While some programs do make important changes in time in their resource requirements, for brevity the average assumed level of resources for 1994-98, in senior scientist equivalents, is presented by research area.

	Senior Scientist Equivalents
Beans: Latin America & HQ	10.8
Beans: Africa	7.4
Cassava	20.5
Forages	11.3
Hillsides	7.0
Rice	12.6
Savanna	7.0

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APPENDIX I:

Technical Parameters of Project Outputs

Technical Parameters for Rice Project Outputs

Project Output	Yield Increase (%)	Target Area (000 ha)	Adoption Ceiling (%)	Probability of Research Success (%)	Year Available to NARS	Year Available to Farmers	Year Adoption Ceiling Reached
Lowland Yield 1	21	2,925	90	80	1998	2001	2008
Lowland Yield 2	6	2,925	90	80	2004	2007	2014
Upland Yield 1	41	3,475	67	67	1998	2001	2007
Upland Yield 2	6	3,475	67	67	2004	2007	2014
Blast: Lowland	16	2,925	90	67	1998	2001	2008
Blast: Upland	29	3,475	90	67	1998	2001	2008
Weed Interference: Lowland	16	2,925	90	50	1998	2001	2008
Weed Interference: Upland	12	3,475	67	50	1998	2001	2008
Hoja Blanca Virus: Lowland	10	2,925	33	90	1996	1999	2006
Hoja Blanca Virus: Upland	3	3,475	33	90	1996	1999	2006
Integrated Pest Management 1	10	290	75	90	1995	1997	2004
Integrated Pest Management 2	10	290	75	90	1998	2001	2008
Integrated Pest Management 3	10	290	75	90	2004	2007	2014

Technical Parameters for Cassava Project Outputs

Research Area Crop Management
Agroecosystem Lowland Humid Tropics

Continent/ Constraint	Actual Average Yield t/ha	Estimated Potential Yield t/ha	Potential Increase due to Varietal Effect %	Potential Increase due to Crop Management Effect %	Probability of Success %	Year Available to NARS	Year First Diffusion	Target Area (ha)	Adoption After 10 Years %
L. America									
Root rots	11 8	23 9	12	14	100	1996	2002	109 000	20
Frogskin			2	16	50	1999	2000	116 000	25
Hornworm			-	11	100	1997	1996	20 000	50
Asia									
Low Soil Fert	13 3	26 0	15	15	60	1999	2004	552 000	50
Soil erosion			5	10	70	1999	2004	345 000	10

Technical Parameters for Cassava Project Outputs

Constraint Category Crop Management
Agroecosystem Sub-humid Tropics

Continent/ Constraint	Actual Average Yield t/ha	Estimated Potential Yield t/ha	Potential Increase due to Varietal Effect %	Potential Increase due to Crop Management Effect %	Probability of Success %	Year Available to NARS	Year First Diffusion	Target Area (ha)	Adoption After 10 Years %
L. America									
Root rots	10.0	20.0	15	18	85	1998	1999	214 000	20
CBB									
Anthracnose			18	5	100	1995	1996	257 000	20
Super-elongation			7	3	100	1995	1996	60 000	20
Mycoplasm			2	1	85	1997	1998	86 000	10
Vein mosaic			1	4	80	1999	2000	69 000	20
Spider mite			7	8	80	2004	2005	514 000	50
Mealybug			1	4	80	1998	1999	171 000	75
Whitefly			4	1	50	2004	2005	514 000	40
Lacebug			4	1	50	2004	2005	428 000	40
Hornworm			-	15	100	1997	1998	128 000	50
Burrowing bug			3	12	75	2004	2006	43 000	50
Low soil fert			14	16	50	1997	2002	514 000	50
Soil erosion			8	12	80	1999	2004	428 000	10
Pl material				10	100	1998	2000	616 000	10
Asia									
Low soil fert	12.0	25.0	14	11	75	1999	2001	1 058 000	60
Soil erosion			8	12	80	1999	2001	1 123 000	16
Africa Spider mite	10.0	21.0	7	23	80	2004	2005	2 712 000	25

Technical Parameters for Cassava Project Outputs

Constraint Category Crop Management
Agroecosystem Semi Arid Tropics

Continent/ Constraint	Actual Average Yield t/ha	Estimated Potential Yield t/ha	Potential Increase due to Varietal Effect %	Crop Management Effect %	Probability of Success %	Year Available to NARS	Year First Diffusion	Target Area (ha)	Adoption After 10 Years %
L America									
Root rots	7 0	15 0	8	6	90	1997	1999	56 000	15
Vein mosaic			2	8	80	1999	2000	62 000	25
Spider mite			11	12	80	2004	2005	166 000	50
Mealybug			1	4	80	1998	1999	41 000	75
Whitefly			4	1	50	2004	2005	104 000	40
Lacebug			6	1	50	2004	2005	104 000	40
Hornworm			0	15	100	1997	1998	10 000	50
Soil fert			6	13	70	2004	2009	145 000	30
Soil erosion			8	12	70	2004	2009	104 000	7
Pl material			-	15	80	1999	2001	207 000	10
Asia									
Soil fert	13 0	10 0	7	13	75	1999	2001	514 000	40
Soil erosion			4	6	60	1999	2001	514 000	12
Africa									
Spider mite	6 0	15 0	5	5	80	2004	2005	214 000	25

Technical Parameters for Cassava Project Outputs

Constraint Category Crop Management
Agroecosystem Highlands

Continent/ Constraint	Actual Average Yield t/ha	Estimated Potential Yield t/ha	Potential Increase due to Varietal Effect %	Potential Increase due to Crop Management Effect %	Probability of Success %	Year Available to NARS	Year First Diffusion	Target Area (ha)	Adoption After 10 Years %
L America									
Root rots	10 0	20 0	6	6	90	1998	2000	66 000	15
CBB +									
Anthracnose			14	6	90	1997	1999	136 000	15
Mycoplasm			8	5	90	1997	1999	27 000	20
Frogskin			5	20	50	1999	2000	39 000	30
Vein mosaic			2	8	80	1998	1999	27 000	25
Hornworm			-	15	100	1997	1998	20 000	50
Burrowing									
bug			2	10	75	2004	2006	58 000	50
Soil fert			18	19	60	1997	2002	195 000	30
Soil erosion			5	20	90	1999	2004	233 000	15
Pl material			-	8	100	1998	2000	206 000	10

Technical Parameters for Cassava Project Outputs

Constraint Category Crop Management

Agroecosystem Subtropics

Continent/ Constraint	Actual Average Yield t/ha	Estimated Potential Yield t/ha	Potential Increase due to Varietal Effect %	Potential Increase due to Crop Management Effect %	Probability of Success %	Year Available to NARS	Year First Diffusion	Target Area (ha)	Adoption After 10 Years %
L America									
Root rots	14 0	24 0	5	6	90	1998	2000	248 000	15
CBB + Anthracnose			16	7	70	1998	2000	541 000	20
Common mosaic virus			0	10	50	1997	1998	75 000	25
Hornworm			0	15	100	1997	1998	150 000	70
Subterranean mealybug			-	5	50	2004	2005	301 000	75
Pl material			-	8	70	1998	2000	301 000	20
Asia									
Soil fert			11	17	70	1999	2001	478 000	50
Soil erosion			5	20	70	1999	2001	359 000	15

Technical Parameters for Cassava Project Outputs

Research Area Varietal Improvement

Agro-ecosystem	Actual Average Yield t/ha	Estimated Potential Yield With all Constraints Removed (t/ha)	Potential Yield Increase due to Component %	Probability of Success (%)	Year Available to NARS[1]	Year First Diffusion[1]	Target Area (ha)	Adoption After 10 Years[1] (%)
Lowland humid tropics								
Latin America	11 8	23 9	45	80	2011	2014	311 000	30
Asia	13 3	26 0	45	80	2008	2011	621 000	50
Africa	8 7	24 0	45	70	2020	2025	2 580 000	30
Lowland Subhumid tropics								
Latin America	10 0	20 0	50	70	2011	2014	692 000	25
Asia	12 0	25 0	50	70	2008	2011	1 444 000	20
Africa	10 0	21 0	55	60	2011	2016	2 882 000	15
Semiarid tropics								
Latin America	7 0	15 0	55	80	2008	2011	207 000	25
Asia	13 0	19 0	55	80	2008	2011	1 029 000	40
Africa	6 0	15 0	70	60	2018	2023	714 000	25
Highlands								
Latin America	10 0	20 0	50	80	2008	2011	311 000	30
Africa	8 0	18 0	60	70	2016	2021	803 000	25
Subtropics								
Latin America	14 0	24 0	60	80	2008	2013	451 000	25
Asia	11 0	20 0	65	80	2008	2013	761 000	25
Africa	10 0	22 0	65	70	2013	2018	714 000	25

Varietal

* Favourable semi-arid conditions in N E Thailand, where the length of the dry season corresponds to semiarid conditions but rainfall is higher than 700 mm

[1] Taking into account the "average" strength of NARDS to adapt, validate and diffuse the technology component in question

NOTE (a) Biotech research, improvements in conventional breeding methodology, use of wild species etc are considered as means of either reducing the time to reach the potential yield or increasing the probability of success

(b) Farmer participatory research, networking, information exchange and training are considered as means of either reducing the time until first diffusion or increasing the adoption after 10 years

[2] Cassava varietal improvement actually modeled to occur in two steps An initial release of improved material by 1998, with a second generation of further improved material in 2005

Technical Parameters for Cassava Project Outputs

Research Area: Post Harvest Processing, Marketing and Utilization
Agroecosystem: Lowland Humid Tropics

Continent/	Market Type	Constraint	Cost Reduction/ Price Premium	Probability of Success %	Year Available to NARS	Year First Diffusion	Target Area (ha)	Adoption After 10 Years %
Latin America	Traditional	Raw material quality (processing)						
		- Perishability	ΔC=15	75	2008	2011	208 500	15
		- Dry matter	ΔC=20	100	2003	2006	208 500	25
		Process improvement	ΔC=15	100	1998	2000	208 500	20
		New product development	ΔP=20	100	1996	1998	125 000	40
Asia	Traditional	Raw material quality (processing)						
		- Perishability	ΔC=15	75	2008	2011	165 000	20
		- Dry matter	ΔC=20	100	2001	2004	165 000	25
	Diversified	Raw material quality (processing)						
		- Perishability	ΔC=15	75	2008	2011	180 000	30
		- Dry matter	ΔC=20	100	2001	2004	180 000	30
	Traditional	Process improvement	ΔC=15	100	1996	1998	60 000	15
		New product development	ΔP=20	100	1996	1998	75 000	15
Africa	Traditional	Raw material quality (processing)						
		- Perishability	ΔC=20	75	2008	2011	340 000	5
		- Dry matter	ΔC=10	100	2005	2010	340 000	5
		- Cyanide	ΔP=15	60	2005	2010	340 000	5

Technical Parameters for Cassava Project Outputs

Research area: Post Harvest Processing, Marketing and Utilization
Agroecosystem: Subhumid Tropics

Continent/	Market Type	Constraint	Cost Reduction/ Price Premium	Probability of Success %	Year Available to NARS	Year First Diffusion	Target Area (ha)	Adoption After 10 Years %
Latin America	Traditional	Raw material quality (fresh and processed)						
		- Perishability	ΔC=20	75	2008	2011	250 000	15
		- Dry matter	ΔC=15	75	2008	2011	500 000	15
	Diversified	Raw material quality (processed)						
		- Perishability	ΔC=15	75	2008	2011	50 000	25
		- Dry matter	ΔC=20	75	2008	2011	50 000	25
	Traditional	Process improvement	ΔC=15	100	1998	2004	100 000	10
		New product development	ΔP=20	100	1996	1998	100 000	10
Asia	Traditional	Raw material quality (processed)						
		- Perishability	ΔC=15	75	2008	2011	380 000	20
		- Dry matter	ΔC=20	100	2001	2004	300 000	25
	Diversified	Raw material quality (processed)						
		- Perishability	ΔC=15	75	2008	2011	500 000	40
		- Dry matter	ΔC=20	100	2001	2004	500 000	50
	Traditional	Process improvement	ΔC=15	100	1998	2001	70 000	15
		New product development	ΔP=20	80	1999	2003	80 000	15
Africa	Traditional	Raw material quality (processed)						
		- Perishability	ΔC=20	75	2008	2011	380 000	5
		- Dry matter	ΔC=10	100	2006	2010	380 000	5
		- Cyanide	ΔP=15	60	2005	2010	380 000	5

Technical Parameters for Cassava Project Outputs

Research Area   Post Harvest Processing, Marketing and Utilization
Agroecosystem   Semiarid Tropics

Continent/	Market Type	Constraint	Cost Reduction/ Price Premium	Probability of Success %	Year Available to NARS	Year First Diffusion	Target Area (ha)	Adoption After 10 Years %
Latin America	Traditional	Raw material quality (processed)						
		- Perishability	ΔC=10	75	2008	2014	200 000	20
		- Dry matter	ΔC=20	100	1996	2000	80 000	20
		New product development	ΔP=20	100	1996	1998	100 000	25
Asia	Traditional	Raw material quality (processed)						
		- Perishability	ΔC=15	75	2008	2011	50 000	25
		- Dry matter	ΔC=20	100	2001	2004	50 000	25
	Diversified	Raw material quality (processed)						
		- Perishability	ΔC=15	75	2008	2011	400 000	40
		- Dry matter	ΔC=20	100	2001	2004	400 000	40
	Traditional	Process improvement	ΔC=15	100	1999	2001	30 000	20
		New product development	ΔP=20	100	1996	1998	50 000	20
Africa	Traditional	Raw material quality (processed)						
		- Perishability	ΔC=20	75	2008	2011	80 000	5
		- Dry matter	ΔC=10	100	2005	2010	80 000	5
		- Cyanide	ΔP=15	60	2005	2010	80 000	5

Technical Parameters for Cassava Project Outputs

Research Area: Post Harvest Processing, Marketing and Utilization
Agroecosystem: Highland Tropics

Continent/	Market Type	Constraint	Cost Reduction/ Price Premium	Probability of Success %	Year Available to NARS	Year First Diffusion	Target Area (ha)	Adoption After 10 Years %
Latin America	Traditional	Raw material quality (fresh and processed)						
		- Perishability	ΔC=15	75	2008	2012	200 000	20
		- Dry matter	ΔC=15	100	1997	2000	40 000	25
	Diversified	Raw material quality (processed)						
		- Perishability	ΔC=15	75	2008	2011	42 000	30
		- Dry matter	ΔC=15	100	1997	2000	20 000	30
	Traditional	Process improvement	ΔC=10	100	1996	1998	30 000	25
		New product development	ΔP=20	100	1996	1999	30 000	25
Africa	Traditional	Raw material quality (processed)						
		- Perishability	ΔC=20	75	2008	2011	100 000	5
		- Dry matter	ΔC=10	100	2005	2010	100 000	5
		- Cyanide	ΔP=15	60	2005	2010	100 000	5

Technical Parameters for Cassava Project Outputs

Research Area: Post Harvest Processing, Marketing and Utilization
Agroecosystem: Subtropics

Continent/	Market Type	Constraint	Cost Reduction/ Price Premium	Probability of Success %	Year Available to NARS	Year First Diffusion	Target Area (ha)	Adoption After 10 Years %
Latin America	Traditional	Raw material quality (fresh)						
		- Perishability	ΔC=15	75	2008	2013	300 000	20
		Raw material quality (processed)						
		- Perishability	ΔC=15	75	2008	2013	150 000	20
		- Dry matter	ΔC=15	100	1996	2001	150 000	20
	Diversified	Raw material quality (processed)						
		- Perishability	ΔC=15	75	2008	2013	100 000	30
		- Dry matter	ΔC=15	100	1996	2001	50 000	30
	Traditional	Process improvement	ΔC=10	100	1996	1998	50 000	20
		New product development	ΔP=20	100	1996	1998	75 000	20
Asia	Traditional	Raw material quality (processed)						
		- Perishability	ΔC=15	75	2008	2013	100 000	20
		- Dry matter	ΔC=15	100	2000	2005	100 000	20
	Diversified	Raw material quality (processed)						
		- Perishability	ΔC=15	75	2008	2013	200 000	30
		- Dry matter	ΔC=15	100	2000	2005	200 000	30
	Traditional	Process improvement	ΔC=20	100	1998	2001	60 000	25
		New product development	ΔP=20	100	1996	1998	100 000	30
Africa	Traditional	Raw material quality (processed)						
		- Perishability	ΔC=20	75	2008	2011	100 000	5
		- Dry matter	ΔC=10	100	2005	2010	100 000	5
		- Cyanide	ΔP=15	60	2005	2010	100 000	5

Technical Parameters for Forage Project Outputs: Savanna Agroecosystem (Oct. 14/93)

Program Outputs	Expected Productivity (kg/ha meat) (lt/ha milk)	Potential Target Area (million ha)	Probability of Success (%)	Year Technology Available to NARDS for Testing	Year Technology Available to Farmers for Diffusion	Adoption Ceiling (%)	Years to Adoption Ceiling
Baseline: *Brachiaria* Traditional							
Ceba (Beef) S.R.* = 1	110 kg	XX	XX	XX	XX	XX	XX
Dual Purpose (Beef) S.R. = 1	78 kg	XX	XX	XX	XX	XX	XX
(Milk)	900 lt	XX	XX	XX	XX	XX	XX
Brachiaria Mejorada (Pure)							
Ceba (Beef) S.R. = 1.5	200 kg	10	95	1996	2000	90	12
Dual Purpose (Beef) S.R. = 1.4	132 kg	8	80	1996	2000	40	10
(Milk)	1300 lt						
Arachis Based Pastures							
Ceba (Beef) S.R. = 3	400 kg	8	60	1997	2001	50	15
Dual Purpose (Beef) S.R. = 2.2	280 kg	5	60	1997	2001	30	10
(Milk)	2400 lt						
Stylosanthes Based Pastures							
Ceba (Beef) S.R. = 2.0	300 kg	5	80	1998	2002	70	15
Dual Purpose (Beef) S.R. = 1.5	200 kg	3	80	1998	2002	30	10
(Milk)	1800 lt						
Centrosema and *Desmodium*							
Ceba (Beef) S.R. = 2	300 kg	4	80	1998	2002	60	15
Dual Purpose (Beef) S.R. = 1.5	200 kg	3	80	1998	2002	30	10
	1800 kg						

* S.R. = Stocking rate expressed in AU/ha.

[1] These systems additionally produce green manure and soils improvement

Technical Parameters for Forage Project Outputs: Forest Margins (Oct. 14/93)

Program Outputs	Expected Productivity (kg/ha meat) (lt/ha milk)	Potential Target Area (million ha)	Probability of Success (%)	Year Technology Available to NARDS for Testing	Year Technology Available to Farmers for Diffusion	Adoption Ceiling (%)	Years to Adoption Ceiling
Baseline: *Brachiaria* Traditional							
Ceba (Beef) S.R.* = 1.5	127	XX	XX	XX	XX	X	X
Dual Purpose (Beef) S.R. = 1.04	70	XX	XX	XX	XX	X	X
(Milk)	847	XX	XX	XX	XX	X	X
Brachiaria Mejorada (Pure)							
Ceba (Beef) S.R. = 1.5	225	8	70	1996	2000	90	12
Dual Purpose (Beef) S.R. = 1.5	105	5	80	1996	2000	50	10
(Milk)	1300						
Arachis Based Pastures							
Ceba (Beef) S.R. = 3	480	7	80	1997	2001	70	10
Dual Purpose (Beef) S.R. ≐ 2.5	320	5	80	1997	2001	30	10
(Milk)	2600						
Stylosanthes Based Pastures							
Ceba (Beef) S.R. = 2	300	5	50	1998	2002	50	15
Dual Purpose (Beef) S.R. = 1.5	120	5	50	1998	2002	30	10
(Milk)	1600						
Centrosema Based Pastures							
Ceba (Beef) S.R. = 2	300	5	60	1998	2002	50	15
Dual Purpose (Beef) S.R. = 1.5	190	3	60	1998	2002	20	10
(Milk)	1600						
Crop-Pastures[1]							
Ceba (Beef) S.R. = 3	500	2.5	95	1996	2000	80	12
Dual Purpose (Beef) S.R. = 2.5	300	2.5	70	1996	2000	40	10
(Milk)	2500						

*S.R. = Stocking rate expressed in AU/ha.

[1] With legume based pastures reduced follow from 8 to 4 years.

Technical Parameters for Forage Project Outputs: Hillsides (Oct. 14/93)

Program Outputs	Expected Productivity (kg/ha meat) (lt/ha milk)	Potential Target Area (million ha)	Probability of Success (%)	Year Technology Available to NARDS for Testing	Year Technology Available to Farmers for Diffusion	Adoption Ceiling (%)	Years to Adoption Ceiling
Baseline: Native Pasture		X	X	X	X	X	X
Dual Purpose (Beef) S.R.* = .9	94	X	X	X	X	X	X
(Milk)	730	X	X	X	X	X	X
Brachiaria Mejorada (Pura)							
Dual Purpose (Beef) S.R. = 1.5	150	3	80	1996	2000	60	10
(Milk)	1200						
Arachis Based Pasture							
Dual Purpose (Beef) S.R. = 2.0	210	5	50	1997	2001	40	10
(Milk)	2000						
Legumes Based Systems (*Stylosanthes*, *Centrosema*, etc.)							
Dual Purpose (Beef) S.R. = 1.5	140	5	50	1998	2002	30	10
(Milk)	1500						
Mixed Systems of Pastures/Crop Rotations[1]							
Dual Purpose (Beef) S.R. = 2	140	5	80	1998	2002	40	10
(Milk)	2000						

*S.R. = Stocking rate expressed in AU/ha.

[1] Including forage tree species and additionally produce green manure and soil improvement.

Technical Parameters for Bean Project Outputs: Irrigated, Latin America

Current Mean Yield: 800-1300 kg/ha
Yield Potential: 2000-3000 kg/ha
Expected Total Yield Increase: 1000 kg/ha (Meso-America)
600 kg/ha (Andean)
Area: 500,000 ha

CONSTRAINT	YIELD INCREASE (KG/HA)	YEAR AVAIL. TO NARS	PROB. OF SUCCESS	YEAR AVAIL. FARMERS	TARGET AREA (x 1000 HA)	ADOPTION CEILING (% HA)
Disease resistance:						
Rust, BCMV, BGMV, ALS, root rots	300	1995	85	1998	400	80
Insect resistance:						
EMP	250	1995	85	1998	200	60
Bruchid (Zabr. + Acanth.)	100	1998	75 [1]	2000	200	80
Abiotic constraints:						
Nitrogen use efficiency[2]	250	2000	75	2004	350	50
Phosphorus def.	250	1998	85	2000	350	40
Water use efficiency	500	2000	85	2004	400	50
Heat tolerance[3]	1000	2000	75	2003	80	75
Yield potential:						
Meso	600	1998	75	2002	350	80
Andean	500	1998	75	2002	150	80

[1] Probability for Zabrotes alone is 100%
[2] Only considers *Rhizobium* inoculation technologies
[3] Permits production in hot "third season"

Technical Parameters for Bean Project Outputs: Semi-Arid N. Central Mexican Highlands

Current Mean Yield: 300 kg/ha
Yield Potential: 1300 kg/ha
Expected Total Yield Increase: 600 kg/ha
Area: 1,500,000 ha

CONSTRAINT	YIELD INCREASE (KG/HA)	YEAR AVAIL. TO NARS	PROB. OF SUCCESS	YEAR AVAIL. FARMERS	TARGET AREA (x 1000 HA)	ADOPTION CEILING (% HA)
Disease resistance:						
ANT., root rots (ALS, rust, CBB)	250	1998	80	2001	1500	50
Abiotic constraints:						
Nitrogen use efficiency[1]	200	2000	50	2003	1500	25
Phosphorus def.	300	1998	75	2001	1000	50
Water use efficiency	500	1998	75	2001	1500	70
Yield potential:						
Meso	400	1998	75	2000	1000	60

[1] Increased varietal BNF capacity

Technical Parameters for Bean Project Outputs: Semi Arid N.E. Brazil

Current Mean Yield: 300 kg/ha
Yield Potential: 1000-1500 kg/ha
Expected Total Yield Increase: 600 kg/ha
Area: 1,500,000 ha

CONSTRAINT	YIELD INCREASE (KG/HA)	YEAR AVAIL. TO NARS	PROB. OF SUCCESS	YEAR AVAIL. FARMERS	TARGET AREA (x 1000 HA)	ADOPTION CEILING (% HA)
Disease resistance:						
ALS, root rots, CBB, (ANT., rust, BGMV)	250	1995	95	1998	700	70
Insect resistance:						
EMP	250	1995	85	1995	500	70
Bruchids (Zabr.)	150	1995	100	1998	500	50
Abiotic constraints:						
Nitrogen use efficiency[1]	100	1998	70	2002	1000	50
Phosphorus def.	200	1998	85	2002	1000	70
Water use efficiency	400	1998	85	2002	1500	70
Temperature adaptation	250	2000	75	2005	500	70
Yield potential:						
Meso	300	1994	85	1996	1500	70

[1] Increased varietal BNF capacity

Technical Parameters for Bean Project Outputs: Subhumid Mesoamerican Highlands (Mexico and Guatemala)

Current Mean Yield:	500-800 kg/ha
Yield Potential:	2000-3000 kg/ha
Expected Total Yield Increase:	1200 kg/ha (Mesoamerica)
	600 kg/ha (Andes)
Area:	500,000 ha

CONSTRAINT	YIELD INCREASE (KG/HA)	YEAR AVAIL. TO NARS	PROB. OF SUCCESS	YEAR AVAIL. FARMERS	TARGET AREA (x 1000 HA)	ADOPTION CEILING (% HA)
Disease resistance:						
ANT., rust, BCMV (ASC., Halo blight)	300	1998	90	2003	400	60
Insect resistance:						
Apion	200	1998	85	2003	400	60
Bruchids (Acanth.)	150	2000	50	2003	400	30
Abiotic constraints:						
Nitrogen use efficiency[1]	200	1998	60	2003	350	30
Phosphorus def.	400	1998	85	2003	400	40
Yield potential:						
Meso	700	1995	85	1998	350	60
Andean (Canarios, Cacahuates)	500	1998	80	2001	150	60

[1] Increased varietal BNF capacity

Technical Parameters for Bean Project Outputs: Subhumid Andean Highlands - Bush Beans

Current Mean Yield: 700 kg/ha
Yield Potential: 1500-2000 kg/ha
Expected Total Yield Increase: 550 kg/ha (Mesoamerica)
Area: 150,000 ha

CONSTRAINT	YIELD INCREASE (KG/HA)	YEAR AVAIL. TO NARS	PROB. OF SUCCESS	YEAR AVAIL. FARMERS	TARGET AREA (x 1000 HA)	ADOPTION CEILING (% HA)
Disease resistance:						
ANT., Rust, CBB, (ASC., ALS)	300	1994	85	1994	150	80
Insect resistance:						
White fly, leaf miner	200	1996	90	1996	50	40
Abiotic constraints:						
Nitrogen use efficiency[1]	200	2000	60	2003	100	40
Phosphorus def.	300	1998	85	2002	150	50
Water use efficiency	300	1996	80	1999	100	60
Temperature adaptation	300	1998	80	2002	50	80
Yield potential:						
Andean	450	1997	80	2000	150	80

[1] Increased varietal BNF capacity

Technical Parameters for Bean Project Outputs: Subhumid Andean Highlands - Climbers in Association with Maize

Current Mean Yield: 400 kg/ha
Yield Potential: 1200 kg/ha
Expected Total Yield Increase: 650 kg/ha
Area: 150,000 ha

CONSTRAINT	YIELD INCREASE (KG/HA)	YEAR AVAIL. TO NARS	PROB. OF SUCCESS	YEAR AVAIL. FARMERS	TARGET AREA (x 1000 HA)	ADOPTION CEILING (% HA)
Disease resistance:						
ANT., ASC.	300	1995	85	1998	150	70
(BCMV, root rots)						
Abiotic constraints:						
Nitrogen use efficiency[1]	150	1994	80	1995	75	70
Phosphorus def.	250	1998	80	2000	100	60
Water use efficiency	300	2000	60	2003	100	50
Temperature adaptation	600	2000	70	2003	50	70

[1] *Rhizobium* inoculations

Technical Parameters for Bean Project Outputs: Low Fertility Hillsides of Central America (Guatemala, Honduras, El Salvador, Nicaragua, Costa Rica)

Current Mean Yield: 700 kg/ha
Yield Potential: 2500 kg/ha
Expected Total Yield Increase: 900 kg/ha
Area: 350,000 ha

CONSTRAINT	YIELD INCREASE (KG/HA)	YEAR AVAIL. TO NARS	PROB. OF SUCCESS	YEAR AVAIL. FARMERS	TARGET AREA (x 1000 HA)	ADOPTION CEILING (% HA)
Disease resistance:						
BGMV, CBB, ANT (WB)	500	1995	95	1998	350	85
Insect resistance:						
Apion (EMP, Zabr., Acanth.)	350	1995	95	1997	200	85
Abiotic constraints:						
Nitrogen use efficiency[1]	250	1998	60	2001	200	50
Phosphorus def.	500	1997	85	2000	250	70
Water use efficiency	400	1998	85	2001	300	70
Yield potential:						
Meso	600	1998	80	2000	300	80

[1] Increased varietal BNF capacity and *Rhizobium* inoculations

Technical Parameters for Bean Project Outputs: Moderately Acid Savannas of Brazil

Current Mean Yield: 700 kg/ha
Yield Potential: 1700-3000 kg/ha
Expected Total Yield Increase: 800 kg/ha (Mesoamerica)
Area: 1,300,000 ha

CONSTRAINT	YIELD INCREASE (KG/HA)	YEAR AVAIL. TO NARS	PROB. OF SUCCESS	YEAR AVAIL. FARMERS	TARGET AREA (x 1000 HA)	ADOPTION CEILING (% HA)
Disease resistance:						
BGMV, CBB, ALS (Rust, ANT)	450	1995	85	1998	1300	85
Insect resistance:						
EMP (Tropical mites)[2]	200	1995	85	1998	300	60
Abiotic constraints:						
Phosphorus def.	250	1998	85	2002	800	85
Al/Ca stress	200	2000	50	2004	800	40
Nitrogen use efficiency[1]	150	2000	75	2004	800	50
Water use efficiency	250	1996	85	2000	500	70
Yield potential:						
Meso	600	1996	80	1998	800	80
Andean	300	1998	80	2004	75	80

[1] Increased varietal BNF capacity and *Rhizobium* inoculations
[2] Induced secondary pest problem

Technical Parameters for Bean Project Outputs: Subhumid Lowlands of Southern Brazil and N.W. Argentina

Current Mean Yield:	500-800 kg/ha
Yield Potential:	1700-3000 kg/ha
Expected Total Yield Increase:	800 kg/ha (Mesoamerica)
	500 kg/ha (Andes)
Area:	2,200,000 ha

CONSTRAINT	YIELD INCREASE (KG/HA)	YEAR AVAIL. TO NARS	PROB. OF SUCCESS	YEAR AVAIL. FARMERS	TARGET AREA (x 1000 HA)	ADOPTION CEILING (% HA)
Disease resistance:						
BGMV, ANT, CBB, (ALS)	300	1996	85	1999	2000	80
Insect resistance:						
EMP, (Zabr.)	250	1995	85	1998	400	75
Abiotic constraints:						
Phosphorus def.	300	1996	80	2000	2000	70
Al/Ca stress	250	2000	50	2004	1000	50
Nitrogen use efficiency[1]	200	1998	70	2002	1000	60
Water use efficiency	300	1998	80	2002	1000	70
Yield potential:						
Meso	500	1997	85	2001	2000	80
Andean	300	2000	85	2004	200	80

[1] Increased varietal BNF capacity and *Rhizobium* inoculations

Technical Parameters for Bean Project Outputs: Humid Tropical Lowlands and Forest Margins (Caribbean, Lowland Mexico and Central America, Brazil, Bolivia, Peru)

Current Mean Yield: 300-500 kg/ha
Yield Potential: 800-1500 kg/ha (Meso)
Expected Total Yield Increase: 500 kg/ha
Area: 350,000 ha

CONSTRAINT	YIELD INCREASE (KG/HA)	YEAR AVAIL. TO NARS	PROB. OF SUCCESS	YEAR AVAIL. FARMERS	TARGET AREA (x 1000 HA)	ADOPTION CEILING (% HA)
Disease resistance:						
WB, CBB, BGMV	400	2000	65	2005	350	60
Insect resistance:						
EMP	100	1995	85	1999	50	50
Abiotic constraints:						
Phosphorus def.	250	1998	85	2002	200	50
Nitrogen use efficiency[1]	250	2000	75	2002	150	40
Al/Ca stress	150	2000	50	2003	100	40
Temperature adaptation	300	2000	75	2003	200	60
Yield potential:						
Meso	300	1998	75	2001	200	60
Andean	200	1998	85	2001	150	70

[1] Increased varietal BNF capacity

Technical Parameters for Savanna Project Outputs

Project Output		Annual Production Increase Over Cycle (kg/ha)	Target Area (million ha)	Adoption Ceiling (%)	Probability of Success	Year Available to NARS	Year Available to Farmer	Year Adoption Ceiling Reached
Minimum Input Crop Pasture Systems	Rice Meat	630 96	6	30	90	1998	2001	2013
Low Input Crop Pasture System	Rice Meat	750 43	3	30	80	1998	2001	2013
Intensive Crop Pasture System	Rice Meat Maize Soybeans	1,100 30 900 950	3.6	30	70	1998	2001	2013

Technical Parameters for Hillside Project Outputs

Project Output	Technical Change	Target Area (millions ha)	Adoption Ceiling (%)	Probability of Success (%)	Year Available to NARS	Year Available to Farmer	Year Adoption Ceiling Reached
Erosion Control	Reduce erosion by 65 tons soil/ha of cropped area Avoid 0.4%/yr loss in crop productivity	4.5	33	67	1996	1998	2008
Improved Fallow	Reduction of average fallow period from 2.5 to 1.5 years Increase of milk production of 300 lt/ha/yr in fallow lands	12.5	16	75	1999	2002	2012

APPENDIX II:

Sustainability Appraisals of Project Outputs

Rice Projects Self-Evaluation for Effect on Natural Resource Base of Successful Production of Project Output. (3 = very great positive contribution; 2 = significant positive contribution; 1 = minor positive contribution; 0 = no effect; -1 minor negative effect; -2 = significant negative effect; -3 = very great negative effect).

Project Output	Biodiversity	Soil Quality	Water Resources	Pollution	Pest Ecology
Lowland Yield	+1	0	-1	-1	+1
Upland Yield	+1	+2	+1	-1	+1
Blast	+1	0	0	+2	+1
Weeds	0	0	+1	+2	0
HBV	+1	0	0	+1	+2
IPM	+2	0	+1	+2	+2

Cassava Projects Self-Evaluation for Effect on Natural Resource Base of Successful Production of Project Output.

(LHT = lowland humid tropics; SHT = subhumid tropics, SAT = semi arid tropics; HT = highland tropics; ST = sub-tropics).

		Latin America					Asia				Africa				
		LHT	SHT	SAT	HT	ST	LHT	SHT	SAT	ST	LHT	SHT	SAT	HT	ST
Gene Pool[1] Development	Biodiversity	1	1	2	2	2	2	2	3	3	2	2	3	3	3
	Soil quality	0	0	0	1	0	0	0	0	0	0	0	0	1	0
	Water resources	0	0	1	0	0	0	0	1	0	0	0	1	0	0
	Pollution	0	1	0	1	2	1	2	0	1	0	0	0	0	0
	Pest ecology	2	2	2	2	2	2	1	1	2	2	3	3	2	2
Pest and Disease Management	Biodiversity	1	2	2	1	1	1	2	2	1	1	2	2	1	1
	Soil quality	1	2	1	2	1	1	2	1	1	1	2	1	2	1
	Water resources	1	1	2	1	1	1	1	2	1	1	1	2	2	2
	Pollution	3	3	2	2	2	1	2	1	1	3	3	2	2	1
	Pest ecology	3	3	2	2	2	1	2	1	1	3	3	2	2	1
Soil Conservation and Fertility Maintenance	Biodiversity	3	2	1	2	1	3	2	1	1	3	2	1	2	1
	Soil quality	3	2	2	3	2	3	3	3	2	2	1	1	3	1
	Water resources	2	2	3	2	2	2	1	2	2	2	2	3	3	3
	Pollution	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Pest ecology	3	3	2	2	2	1	2	1	1	3	3	2	2	1
Propagation Methods	Biodiversity	1	2	3	1	2	1	2	3	2	1	2	3	2	3
	Soil quality	1	1	2	2	1	1	2	3	1	1	1	2	2	2
	Water resources	0	1	2	0	0	0	1	2	0	0	1	2	2	2
	Pollution	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Pest ecology	2	2	2	1	1	1	1	1	1	2	2	2	1	1
Root Quality[2] Improvement	Biodiversity	1	1	2	2	2	2	2	3	3	2	2	3	3	3
	Soil quality	2	2	0	2	1	1	1	0	1	2	2	0	2	1
	Water resources	2	2	1	2	1	1	1	1	1	2	2	1	2	1
	Pollution	2	2	2	2	2	2	2	2	3	3	3	3	3	3
	Pest ecology	0	1	1	1	1	0	0	0	0	0	1	1	1	1

Cassava Projects Self-Evaluation for Effect on Natural Resource Base of Successful Production of Project Output

		Latin America					Asia				Africa				
		LHT	SHT	SAT	HT	ST	LHT	SHT	SAT	ST	LHT	SHT	SAT	HT	ST
Product, Process[3] and Market Development	Biodiversity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Soil quality	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Water resources	1	1	1	2	3	3	3	2	3	1	1	1	1	1
	Pollution	1	1	1	2	3	3	3	3	3	1	1	1	1	1
	Pest ecology	0	0	0	0	0	0	0	0	0	0	0	0	0	0

[1] Gene pool development requires the ex-situ conservation and characterization of Manihot. This indirect contribution to BIODIVERSITY has not been included.

[2] Root quality improvement will increase farmer income and reduce processor costs which could indirectly contribute to the adoption of resource conservation practices. This contribution has not been quantified.

[3] Process improvement and new product/market development generates value added in the rural sector which could also indirectly contribute to the adoption of resource conservation practices. This contribution has not been quantified.

Forages Projects Self-Evaluation for Effect on Natural Resource Base of Successful Production of Project Output. (3 = very great positive contribution; 2 = significant positive contribution; 1 = minor positive contribution; 0 = no effect; -1 minor negative effect; -2 = significant negative effect; -3 = very great negative effect).

	Biodiversity	Soil Quality	Water Resources	Pollution	Pest Ecology
Savanna					
Grass Only Pastures	1*	-1	-1	0	1
Legume/Grass Pastures	2**	3	1	0	0
Forest Margins					
Grass Only Pastures	1	-1	0***	-1	1
Legume/Grass Pastures	2**	3	0	1	0
Hillsides					
Grass Only Pastures	1	2	2	-1	1
Legume/Grass Pastures	2**	3	2	1	0

* Germplasm collection

** Germplasm collection + soil macro and micro fauna

*** Pastures in the context of already deforested areas

Bean Projects in Latin America Self-Evaluation for Effect on Natural Resource Base of Successful Production of Project Output. (3 = very great positive contribution; 2 = significant positive contribution; 1 = minor positive contribution; 0 = no effect; -1 minor negative effect; -2 = significant negative effect; -3 = very great negative effect).

Project Output	Biodiversity	Soil Quality	Water Resources	Pollution	Pest Ecology
Disease (LAM)	2	0	0	3	2
Meso Yield (LAM)	2	0	0	0	2
Drought (LAM)	1	1	3	1	0
Phosphorus (LAM)	1	2	0	0	0
Insect (LAM)	2	0	0	3	2
Nitrogen (LAM)	1	2	1	1	0
Andean Yield (LAM)	2	0	0	0	2
Al/Ca Stress (LAM)	1	1	1	0	0
Temperature (LAM)	1	0	0	0	0

Savanna Projects Self-Evaluation for Effect on Natural Resource Base of Successful Production of Project Output. (3 = very great positive contribution; 2 = significant positive contribution; 1 = minor positive contribution; 0 = no effect; -1 minor negative effect; -2 = significant negative effect; -3 = very great negative effect).

	Biodiversity*	Soil Quality	Water Resources	Pollution	Pest Ecology
Minimum Input System	-1	2	1	0	-1
Low Input System	0	2	2	0	-1
Intensive Systems	-2	3	1	-1	-2

* Heavily weighted towards plant biodiversity.
If soil biodiversity is the issue, then the ratings would be 0, 0, -1 or even +1, +1, -1.
If farming systems diversity is considered, then the ratings would be 0, 1, 2.

Hillsides Projects Self-Evaluation for Effect on Natural Resource Base of Successful Production of Project Output. (3 = very great positive contribution; 2 = significant positive contribution; 1 = minor positive contribution; 0 = no effect; -1 minor negative effect; -2 = significant negative effect; -3 = very great negative effect).

	Biodiversity	Soil Quality	Water Resources	Pollution	Pest Ecology
HS Erosion + Fertility Mgt.	1	3	3	3	1
HS Fallow	3	2	3	3	2
HS Land Policy	3	2	3	3	2

APPENDIX III:

Definitions of Project Outputs

Very brief descriptions of research project outputs are listed below by research area.

Bean Diseases: Development of improved bean germplasm with improved resistance or tolerance to principle disease complexes in Latin America (LAM) and Africa, as well as some work on integrated management of diseases.

Bean Insects: Development of improved bean germplasm with improved resistance or tolerance to principle insect pests as well as development of integrated pest management systems.

Bean Drought: Development of improved bean germplasm with better water use efficiency.

Bean Phosphorus: Development of improved germplasm adapted to soils of moderately low phosphorus availability.

Bean Meso-American Gene Pool: Development of improved material with better yield potential or adaptation from the Meso-American gene pool.

Bean Andean Gene Pool: Development of improved material with better yield potential or adaptation from the Andean gene pool.

Beans Nitrogen: Development of improved bean germplasm or selection of rhizobia to improve biological nitrogen fixation.

Beans Temperature: Development of improved germplasm with greater tolerance either of high or low temperatures.

Bean Al-Ca: Development of improved bean germplasm with better tolerance to Al-Ca toxicities in acid soils.

Forages *Arachis*: Selection and enhancement of *Arachis* forage legume germplasm.

Forages Shrub Legumes: Selection of species and accessions with superior potential as forages shrubs and erosion barriers.

Forages *Brachiaria*: Improvement of *Brachiaria* as a pasture grass, including breeding for resistance to spittlebugs.

Forages *Centrosema/Desmodium*: Selection and enhancement of *Centrosema* and *Desmodium* forage legume germplasm.

Forages *Stylosanthes*: Selection and enhancement of *Stylosanthes* forage legume germplasm.

Forage Mixtures: Development of forage systems based on utilization of mixtures of legume species.

Hillsides Erosion: Improved practices and systems to reduce soil degradation and sustain production in the well watered hillside agroecosystem.

Hillsides Fallow: Improved management systems incorporating multi-purpose forages into intensified fallow rotations.

Hillsides Land Policy: Decision making tools for land use planning at community and watershed.

Rice Lowland Yield: Improved rice germplasm with increased yield potential for lowland production systems.

Rice Upland Yield: Improved rice germplasm with increased yield potential for upland production systems.

Rice Weeds: Rice germplasm with improved ability to compete with weeds.

Rice Blast: Rice germplasm with more durable resistance to rice blast.

Rice Hoja Blanca Virus: Rice germplasm with improved and more durable resistance to the hoja blanca virus and its insect vector.

Rice IPM: Improved integrated pest management systems for selected regions of lowland rice production.

Savanna Intensive System: Development of crop/pasture management systems for intensive land use in the savanna agroecosystem. Prototype systems will include rice, maize, soybeans, and high productivity pastures. Crops occupy land about 70% of time.

Savanna Low Input System: Development of low external input renovations of grass pastures with rice.

Savanna Minimum Input System: Development of crop-pasture rotations making minimum use of critical external inputs. Land use 80% pastures in rotation

Yuca Gene Pool Humid: Improved cassava germplasm adapted to the humid lowland agroecosystem.

Yuca Gene Pool Sub-Tropical: Improved cassava germplasm adapted to the sub-tropical agroecosystem.

Yuca Gene Pool Sub-Humid: Improved cassava germplasm adapted to the sub-humid agroecosystem.

Yuca Gene Pool Highlands: Improved cassava germplasm adapted to the tropical highland agroecosystem.

Yuca Gene Pool Semi-Arid: Improved cassava germplasm adapted to the semi-arid agroecosystem.

Yuca Products and Processes: New processing methods to convert yuca into useful products, and the development of new uses for cassava.

Yuca Quality: Development of cassava germplasm with more desirable quality characteristics for specific uses.

Yuca Soils Management: Development of improved management systems for cassava cropping systems that reduce soil erosion or improve soil fertility.

Yuca Pest/Disease Management: Development of improved management systems, including biocontrol, to overcome priority cassava disease and pest constraints.

Yuca Planting Materials: Development of improved management systems for improving the propagation of cassava.