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2000 HIGHLIGHTS

OUTPUT I: EXPECTED IMPACT OF FUTURE RESEARCH ESTIMATED

Output 1.1. Trends affecting impacts of research analyzed.

- 1.1.2 Lower than average levels of poverty as measured in money income in Colombian frontier forest margins and savannas, but greater income inequality and in Amazonia, much higher frequency of unmet basic than average needs.
- 1.1.3 Countries, even with wealth of bean genetic resources, generally have far more to gain from improving productivity with genetic resources than they could potentially earn from royalties for ownership of genetic resources.
- 1.1.4 Growth in the production of cassava as an animal feed in Colombia reversed and fell sharply after trade liberalization, with cassava production of generally marginal profitability today. This emphasizes the need for improved technology to make cassava for competitive.
- 1.1.5 Even when small farmers have competitive advantage in production, high transaction costs can impede them from gaining from new market opportunities presented by growing demand for high value crops or added value processing. Strengthened social capital and community organization would be required to overcome this constraint.

Output 1.2. Impact and Future Research Outputs Estimated

- 1.2.1 Improving water resource management in Nicaragua is critically dependent on the capacity of local communities for collective action either by establishing buffer zones around water sources or by negotiating payments from off-site beneficiaries of reduced burning for land preparation.
- 1.2.2 Rice-pasture agropastoral systems for South American savannas confirmed as economically more attractive than improved pasture, native pasture, or a combination of the two.

OUTPUT 2: IMPACT OF PAST CIAT RESEARCH MONITORED

Output 2.1 Impact of past research synthesized benefits from CIAT.

- 2.1.1 Economic rice benefits from research have yielded the highest overall internal rate of return to CIAT investment in breeding, with a rate of 57% and a net present value of \$US5.5 billion.
- 2.1.1 Use of CIAT forage germplasm has produced benefits of nearly US\$1.4 billion, and a 36% rate of return to investment. Over 80% of the benefits from forages have occurred in Brazil.
- 2.1.1 Benefits from CIAT germplasm outside Latin America are particularly high, with a rate of return of 75% for cassava in Asia where total benefits are nearly \$400

million, and are almost four times as great as the benefits from cassava germplasm in Latin America.

- 2.1.1. Bean germplasm from CIAT has had an impact worth more than US\$1.2 billion with over US\$100 million coming in Africa where the internal rate of return to investment is a very high 59%.

OUTPUT 2.2 Empirical Case Studies Monitor Impact.

- 2.2.1 Improved rice varieties have led to a greater rate of increase in yields and production in Colombian frontier forest margin and savannas than in the rest of the country.
- 2.2.2 Adoption of improved forage germplasm may be reducing the conversion of natural ecosystems to agriculturally intervened systems in the Colombian savannas. While the area of pastures in improved grasses has nearly doubled, and the area in improved grass-legume association quadrupled, the area in native pastures has actually declined and the total pasture area has risen about 10%.

OUTPUT 3: DATABASES, AND METHODOLOGIES

- 3.1 Use of the impact assessment web page rose 50% in 2000.
- 3.2 New databases on agricultural competitiveness in Latin America and on poverty were added to the web site.

OUTPUT 4: INSTITUTIONAL CAPACITY ENHANCED

- 4.1 A methodological framework for assessing the impact of natural resource management research in reference sites was developed, and fieldwork initiated in Honduras, Nicaragua and Peru.

Several new studies were launched in 2000 that will report results next year:

- 1.2.3 The impact of rapid propagation systems for cassava is being studied.
- 1.2.4 The performance of rural information and communication technology centers is being assessed.
- 2.2.2 A major study on the impacts of participatory research is under way.
- 2.2.3 The use of marker assisted selection is being assessed.
- 2.2.4 The potential for adoption of arachis forages in Costa Rica is being appraised.

PROJECT DESCRIPTION

Objective: To generate and disseminate information and tools to improve the capacity of CIAT and partner organizations to allocate research resources efficiently.

Outputs:

Expected impact of future research estimated.

Impact of past CIAT research monitored.

Tools developed to assess the impact of research, *ex ante* and *ex post*.

Institutional capacity for estimating, monitoring, and evaluating research impacts improved.

Gains: Improved allocation of resources can increase the rate of return on investment in agricultural research. Project target is 2%.

Milestones:

- 2001 Two field studies on technology adoption and acceptability completed. Two new field studies on technology adoption and acceptability initiated. Impact monitoring system developed and implemented in one agroecological site. Aggregate productivity impact of CIAT germplasm estimated. Expected benefits of four potential CIAT research outputs appraised.
- 2002 Impact monitoring system developed and implemented for all agroecological sites and CIAT projects. Expected benefits of four CIAT research outputs appraised. Two new field studies on technology adoption and acceptability initiated. Two new field studies on technology adoption and acceptability completed.
- 2003 Two studies on technology adoption completed. Impact of investments in social capital on natural resource management estimated. Two new field studies on technology adoption initiated. Impact of CIAT research on poverty reduction estimated.

Users: Research planners in NARSs and the CGIAR who make decisions on resource allocation. Stakeholders who need to measure expected returns to investment in agricultural and resource management research.

Collaborators (2000): *Future Impact of Research:* CLAYUCA-Latin America Consortium for Cassava Development; Universidad del Valle, Colombia; Centro de Estudios Ganaderos y Agrícolas (CEGA), Colombia; Universidad Autonoma de Occidente, Colombia; University of Hohenheim, Germany. *CIAT Projects:* Genetic Resources, Biotechnology, Cassava, Agroenterprises, Hillside, Soils, Communication Unit. *Impact of past research:* Yale University, USA, CIP; ICRISAT; World Neighbors; CIAT Projects Beans, Beans in Africa, Cassava, Forages, Rice, Participatory Research, Biotechnology, Systems. *Institutional Capacity:* CIAT-Bolivia, CIAT Projects: Systems, NARS Strengthening, Hillside, Land Use, Agroenterprises, Participatory Research.

CGIAR system linkages: Improving Policies (100%).

LOG FRAME WORK PLAN, 2001-2003

Area: Strategic Planning

Manager: Douglas Pachico

Narrative Summary	Measurable Indicators	Means of Verification	Important Assumptions
Goal Knowledge and expertise for enhancing performance of decision making in the agricultural and development sectors is made accessible to appropriate users.	Performance of investment in tropical agricultural research improved.	Research project portfolios in tropical agricultural research.	
Purpose Generation and dissemination of information and tools to improve the capacity of CIAT and partner organizations to allocate research resources efficiently, and document the impact of research investments.	▪ Research resources allocated more efficiently (expected rate of return to CIAT research portfolios increased). ▪ Results of impact analysis used in decision making and priority setting. ▪ Economic and environmental impact of selected past research identified and quantified.	Scientific publications from BP-1 and other projects. Published planning documents of CIAT and partner organizations. Published minutes of planning meetings in CIAT (BoT, MT, Project Managers) and partner organizations. External reviews of CIAT. Data on use of CIAT-developed tools.	Adequate funding to agricultural research and extension. Decision makers willing to use economic analysis in research priority setting.
Output 1 Expected impact of future research estimated.	▪ Expected rate of return for potential research projects estimated. ▪ Expected economic, distributional, and environmental impact identified and quantified.	CIAT technical publications. CIAT published planning documents.	Willingness of decision makers to use the information. No external shocks that invalidate the results.
Output 2 Impact of selected past CIAT research documented.	Economic, social, and environmental impact of CIAT research outputs identified and quantified.	CIAT technical publications.	

Narrative Summary	Measurable Indicators	Means of Verification	Important Assumptions
Output 3 Tools developed to assess the impact of Research, <i>ex ante</i> and <i>ex post</i>.	• Methodologies generated. • Databases compiled and maintained.	Scientific publications and other technical publications such as manuals and guidelines. Databases available on BP-1 sites on Internet, on CIAT's internal network, and in BP-1's data library. Site flow data from web sites. Data on registered users of BP-1 software. Citations of project publications and tools in technical publications.	Analysts willing to use the tools in their impact analyses. Data available to use the tools.
Output 4 Institutional capacity for estimating, monitoring, and evaluating research impacts improved.	Appropriate and well-designed impact assessment components included in the work plans and budgets of CIAT projects and projects of partner organizations.	CIAT project log frames and budgets. Work plans of CIAT researchers. Research proposals submitted by projects. Similar documentation from partner organizations.	Institutional and financial support for impact assessment.

OUTPUT I: FUTURE IMPACT OF RESEARCH ESTIMATED

1.1 TRENDS AND POLICY ANALYSIS

1.1.1 Poverty in Latin America - by: *Libardo Rivas*

Meta para el 2000

Concluir el estudio iniciado el año pasado sobre las tendencias de la pobreza en América Latina.

- La mayor parte de las conclusiones e implicaciones de este estudio se presentó en el informe de 1999. En el presente año el trabajo se concentró en la revisión del documento preliminar, adicionándole al mismo toda la información estadística que soporta el análisis desarrollado.

Resumen

El estudio se basa en una amplia revisión bibliográfica de la literatura disponible en América Latina sobre la pobreza, sus causas y consecuencias.

En el trabajo se muestra como los niveles de pobreza y de indigencia se han incrementado con el transcurso del tiempo en América Latina y como la desigualdad es un elemento central al estudiar la pobreza regional. Dentro de las áreas en desarrollo América Latina presenta los mayores niveles de concentración del ingreso.

Adicional a las mediciones de pobreza basadas en los ingresos, el estudio muestra otros indicadores estrechamente relacionados con ella: Desempleo, acceso a servicios básicos (agua potable, energía eléctrica, servicios de salud y educación) y elabora un recuento crítico de las metodologías y enfoques empleados para abordar la temática de la pobreza.

Se concluye el tema de la pobreza en América Latina es amplio y complejo y que está fuertemente asociado con las tendencias globales del crecimiento, con las políticas económicas sobre educación, empleo, salud, recursos naturales, servicios básicos, con la dinámica demográfica y los flujos de población, con las formas de organización social y la participación de los distintos grupos sociales en la planificación de la sociedad y en la fijación de sus metas.

Toda esa complejidad debe ser abordada desde diferentes perspectivas: Económica, social, política, ambiental, tecnológica etc. En este punto radican muchas de las deficiencias de los estudios sobre la pobreza y de las políticas aplicadas para reducirla. Generalmente se aborda la pobreza con una visión muy parcial y limitada y esto puede ser una de las explicaciones para los magros resultados logrados en América Latina en la lucha contra este flagelo.

Dado que en el sector rural latinoamericano la proporción de pobres es mayor que en las ciudades, la modernización de la agricultura a través de nuevas tecnologías que incrementen la productividad, la producción y el empleo, puede representar una alternativa eficaz para mejorar la situación de los pobres no solo de aquellos que pueden salir de la pobreza empleando las nuevas tecnologías, sino de aquellos sin recursos económicos, que se beneficiarían con la generación de empleo en el sector rural.

1.1.2 Poverty in Frontier Forest Margins and Savannes of Colombia - by: Libardo Rivas

Meta para el 2000

Concluir el estudio tendencias socioeconómicas y de evaluación ex-ante de nuevas alternativas tecnológicas en la Amazonia y Orinoquia, cuyo primer borrador se elaboró en 1999.

- Se revisaron y actualizaron las tendencias económicas hasta 1998, utilizando la última información publicada por el Ministerio de Agricultura de Colombia en el presente año.
- Se revisó el documento elaborado en 1999, adicionándole información de tipo social tal como índices de pobreza, equidad y de satisfacción de necesidades básicas. Se efectuó una búsqueda bibliográfica para incorporar indicadores de tipo ambiental para A&O con resultados muy pobres, evidenciando la necesidad identificar y diseñar tales indicadores y de establecer sistemas de monitoreo de la situación ambiental en esta parte del país.
- En el análisis del impacto en A&O de los nuevos forrajes en ganadería, se adicionó un escenario que incluye diferentes períodos alternativos de duración de la adopción tecnológica, para mostrar la importancia y el impacto que tiene la velocidad de la adopción sobre los beneficios sociales y la alta rentabilidad de invertir en actividades que aceleren los procesos de utilización de las nuevas tecnologías.

Resumen

Tendencias Socioeconómicas

Al revisar y actualizar las tendencias económicas en A&O, se observa que algunas actividades de relevancia económica en la región como el arroz, que en el período 1995/1997 presentaron una acentuada tendencia declinante, en 1998 mostraron una importante recuperación tanto en hectareaje como en volumen de producción. No obstante, el área total en cultivos de la región aún no logra llegar a los niveles máximos que se observaron a comienzos de los 90.

Sintetizando la importancia de los cultivos de la región mediante tres indicadores: Área ocupada, volumen de producción y valor de la misma, se establece que los 5 cultivos

básicos son: Arroz, plátano, yuca, palma de aceite y maíz. En tres de esos cultivos (arroz, yuca y maíz) la investigación de los Centros Internacionales resulta pertinente y puede contribuir significativamente al desarrollo regional.

Pobreza y Equidad

No se encuentran indicadores de pobreza para todas las divisiones territoriales de A&O, pero existen algunos de ellos para las áreas más representativas como el Meta en los Llanos y Caquetá en la Amazonia. De la información analizada se desprende que los niveles de pobreza y de indigencia son menores en A&O que en Colombia como un todo.

La proporción de población bajo la línea de pobreza en A&O se estima en 48%, que en 1999 equivalía a aproximadamente 1.1 millones de personas.

La información disponible sugiere que la proporción de población pobre es significativamente superior en la Amazonia que en los Llanos (Cuadro 1).

Cuadro 1. Incidencia de la Pobreza y la Indigencia Colombia y en A&O. 1999

País/Región	Población bajo la línea de pobreza		Población bajo la línea de indigencia %	
	%	Población 1/	%	Población 1/
Colombia	53.8	22348	18.7	7768
Amazonia & Orinoquia 2/	47.9	1082	12.9	291
Caquetá	54.8	225	14.1	58
Meta	43.8	301	12.2	84

1/ Miles de personas

2/ Promedio ponderado por población

Fuente: DNP –UDS – DIOGS, con base a encuestas de hogares del DANE

El 13% de la población de A&O, casi 300 mil personas, sobrevive en condiciones de indigencia.

La situación de desigualdad en la distribución del ingreso, analizada mediante el índice de Gini, es menos acentuada en A&O que en el país en conjunto. (Cuadro 2)

Cuadro 2. Distribución del ingreso: Índice de Gini Colombia y A&O, 1997 - 1999

País/Región	Índice de Gini		
	1997	1998	1999
Colombia	0.56	0.56	0.56
Amazonia & Orinoquia 1/	0.44	0.44	0.49
Caquetá	0.47	0.45	0.45
Meta	0.43	0.44	0.49

1/ Promedio ponderado por población

Fuente: Cálculos de DNP-UDS-DIOGS, con base en cifras de DANE

Los índices de necesidades básicas insatisfechas (NBI) muestran que las condiciones de vida de la población en A&O son difíciles, debido a la falta de acceso de gran parte de su población a muchos servicios básicos como educación, salud, agua potable, alcantarillado, energía eléctrica, etc.

Mientras que el 37% de la población y el 31% de los hogares colombianos no pueden satisfacer la totalidad de sus necesidades básicas, en A&O los anteriores porcentajes son considerablemente mayores, 70 y 64% respectivamente. En la Amazonia, dado su menor grado de desarrollo relativo, las condiciones de vida son más difíciles que en la Orinoquia. (Cuadro 3)

En síntesis, se puede afirmar que en términos de desarrollo productivo, de dotación de recursos (cantidad y calidad) y de niveles de pobreza y de bienestar, A&O no constituye un bloque homogéneo. La Orinoquia presente un mayor grado de adelanto de la actividad productiva y menores niveles de pobreza y de necesidades básicas insatisfechas. En contraste, la Amazonia exhibe poco desarrollo productivo y mayores niveles de pobreza y de NBI.

Cuadro 3. Porcentajes de población y de hogares con Necesidades Básicas Insatisfechas (NBI) en Colombia y en A&O 1993

País/Región	Porcentaje de población y de hogares con NBI	
	Población	Hogares
Colombia	37.2	30.5
Amazonia 1/	69.9	64.3
Caquetá	58.2	51.6
Amazonas	69.5	61.6
Putumayo	78.8	74.5
Guaviare	79.8	73.8
Vaupés	100.0	100.0
Orinoquia 1/	40.9	34.2
Meta	41.3	34.8
Casanare	40.1	32.7
Amazonia & Orinoquia 1/	55.3	49.1

1/ Promedio ponderado por población

Fuente: Dane, Censo Nacional de Población 1993

Magnitud de los beneficios del cambio técnico y duración de la adopción

Dentro de la evaluación de los beneficios *ex-ante* de las tecnologías forrajeras, uno de los elementos más críticos es la duración del período de adopción de las mismas. Se reconoce ampliamente que ésta es mayor que la de los cultivos, pero no hay suficientes elementos de juicio que permitan determinar con un alto grado de confianza la duración de los procesos de adopción de forrajes en A&O.

Por lo anterior se efectuaron simulaciones con diferentes períodos de duración de la adopción de forrajes en A&O, para conocer su impacto sobre los beneficios tecnológicos. Los resultados logrados ponen en evidencia que si bien es crítico el desarrollo nuevo germoplasma adaptado, la velocidad de la adopción es clave para determinar la magnitud de los beneficios sociales recibidos por comunidad

Si el período de difusión de las tecnologías forrajeras sube de 15 a 25 años los beneficios tecnológicos se reducen en un 43% y si este se extiende hasta 35 años, bajarían un 72%.

La implicación directa es que para la sociedad una vez desarrollados los nuevos productos tecnológicos, es altamente rentable invertir en actividades que aceleren los procesos de adopción: Por ejemplo en labores de extensión, de generación de información para el empleo de las nuevas técnicas y para la toma de decisiones por parte de los productores.

Es crucial el fomento de las industrias que producen insumos críticos como las semillas, y el desarrollo y organización de los mercados de insumos y productos. La formación de capital social, humano y de infraestructura física pueden acelerar de manera importante los procesos de cambio técnico. La implementación de sistemas de monitoreo y evaluación de la adopción, que retroalimenten a los sistemas de investigación y de diseño de políticas, conducen a generar tecnologías mejor adaptadas y un clima económico favorable que facilite y permita la rápida adopción.

Si los procesos de adopción son muy lentos, la sociedad como un todo reduce significativamente los beneficios que podrían derivarse de la inversión en el desarrollo de las nuevas alternativas tecnológicas.

Cuadro 4. Valor de los beneficios tecnológicos en ganadería frente a variaciones del período de adopción. (\$col millones) 1/

Producto	Duración del período de adopción (años)								
	15			25			35		
	Cons. a/	Prod. b/	Total	Cons.	Prod.	Total	Cons.	Prod.	Total
Carne vacuna	236225	43140	279365	136203	25162	161365	67598	12755	80353
Leche	135489	20500	155989	76556	11740	88296	37145	5588	42733
Total									
\$ col. Millones	371714	63640	435354	212759	36902	249661	104743	18343	123086
us\$ millones 2/	232	40	272	133	23	156	65	11	76

a/ Beneficios recibidos por los consumidores. b/ Beneficios recibidos por los productores

1/ Valor presente de los beneficios en un período de 15 años, utilizando una tasa de descuento del 10%

1.1.3 The Distribution of Benefits from Ownership Rights in Genetic Resources: the Case of Beans - by: Douglas Pachico

Crop genetic resources are the foundation both of modern agriculture and the historic rise of civilization. The original farmers in Asia, Africa, Europe and Latin America first learned to cultivate wild plant food species. By domesticating these plants, they began a long process of plant improvement. Farmer selection increased the yield of crop species;

changed plant architecture; and adapted crops to new growing environments (Gepts). Millennia of farmer selection has endowed today's world with a wealth of crop genetic resources commonly called farmer land races. This legacy is the basis of modern agriculture.

In the last century, by building upon the inheritance of farmer land races, the science of genetics and plant breeding has vastly accelerated the process of plant improvement, leading to huge increases in crop productivity through breakthroughs like hybrid maize and semi-dwarf rice and wheat. While the human population has exploded, massive famine has been staved off due to these productivity advances that have been made possible only by the combination of improved scientific knowledge and the utilization of the genetic resources of farmer land races.

With the advent of the new genetic techniques of biotechnology, vistas have been opened of even greater future leaps in agricultural productivity. The potential gains of harnessing biotechnology to the improvement of genetic resources is so great, that significant controversy has begun to emerge over the distribution of the benefits deriving from this work. The private sector, particularly multi-national seed corporations based in the high income countries, has been eager to establish property rights in germplasm (Mooney). It is argued that without such property rights, there will be underinvestment of private resources in germplasm improvement, and society as a whole will thus lose due to a slower pace of innovation.

This innovation is also dependent upon the availability of genetic resources, which are the "raw materials" for biotechnology as well as conventional plant breeding. Historically, land races and related wild materials have been regarded as a common heritage or public good, open for use by all. However, as property rights in germplasm have been increasingly asserted by seed companies, the issue of ownership of farmer land races and native wild materials has been reassessed. In particular, it has been agreed in the Rio Convention on Biological Diversity, that such genetic resources are the property of the nations in which they originate. This result is very much the product of pressure from low income countries which are the source of most major agricultural crops as well as the major share of the world's biodiversity (Mooney; Brush).

Thus, there is an increasing recognition of legitimacy for compensation for use of land race germplasm - "farmers' rights" - as well as for compensation to the country of origin for the use of wild germplasm. It is generally accepted that low income countries would be net beneficiaries from a system of royalties paid by users of germplasm to the country of germplasm origin. Analysis at the level of regional groupings has confirmed this tendency (Kloppenburg and Kleinman).

This paper seeks to assess the international distribution of benefits from a system of ownership rights landrace and wild in germplasm. First, it attempts to quantitatively estimate the potential magnitude of royalty incomes that would accrue to countries of origin of germplasm. Second, it breaks down royalty flows by individual countries rather than regions, thereby revealing significant intra-regional variation. Third, a distinction is

made between payments for land races versus wild germplasm. Finally, an estimate of net benefits from germplasm is presented, that takes into account royalty receipts, payments, and the increase in productivity due to the use of the improved germplasm. Common beans (Phaseolus vulgaris L.) is used as a model crop for this analysis.

A Model System of Landrace and Wild Germplasm Royalties

To estimate the royalty flows associated with ownership rights in landrace and wild germplasm, this paper develops a conceptual model of how such a system would operate. This model assumes that payments for the use of germplasm are ultimately collected at the point of sale of seed. These payments are levied as a per cent of the value of the seed price. Thus, income generated by the use of germplasm is the product of the quantity of seed sold that is based on the germplasm; the price of the seed; and the proportion of the seed price that is paid as royalties.

Royalty payments made by countries for their use of germplasm, are calculated based on area planted to beans in the period 1990-92. To simulate the maximum possible total of royalty payments, these are estimated as if all area sown to beans had to pay royalties.

In actual practice, royalties could accrue both to both owners of the germplasm that is used to generate the genotypes sold as seed, and also to those who performed the research that produced the new genotypes. It is likely that the relative shares of these two classes of royalties would be the subject of negotiation among the involved parties. As such, final royalty share could to a significant degree reflect the relative bargaining power between, roughly speaking, the country that owns the germplasm and the seed company that develops the new variety.

If there were asymmetry in the bargaining strength of the negotiating parties, for example, due to cost of enforcement or the superior market access of the seed companies, royalty shares could be biased in favor of the stronger party which might well be the seed company. This paper abstracts from any such bargaining process, and assumes that the countries of origin of germplasm receive royalties equal to ten per cent of the value of seed sold. This may be an overestimate of what might actually be earned by the countries.

Royalty receipts garnered by the countries for their ownership rights in germplasm, would be proportional to the degree that their germplasm would be used in genotypes sown by farmers. Again in actual practice, negotiations on this point could be complicated because modern varieties have increasingly complex pedigrees, with ancestors typically coming from several countries. Although payments could be calculated relatively straightforward based on the per cent of ancestry coming from each country, this might not be fully acceptable. For example, germplasm from a given country might constitute only one of 16 ancestors, but contribute genes of particularly high value. In contrast, genes from another country might overcome only an occasional minor constraint, making it illogical that both countries receive the same royalty.

The procedure used here is to abstract from any negotiating problem and conduct a simulation as if countries received royalties proportional to the amount of genetic diversity they have. This in turn is based on the assumption that useful alleles are randomly distributed. In this conceptual model for common beans, then, a country's royalty receipts are equal to its share of useful diversity which is equal to its share in total diversity, both of land races and wild ancestors.

Historically, most gains in crop improvement have come from land races. However, there are recent examples of introgression of useful traits from wild ancestors into cultivated materials (Cardona et al). It is also known that genetic variability in wild materials is often greater than that present in domesticated germplasm (Gepts). Consequently over time, particularly with improved techniques for gene transfer, the contribution of currently undomesticated germplasm to agricultural productivity, could be as greater or greater in importance as further use of land races. Thus, in this paper these two sources of variability are treated as of equal importance.

It must also be noted, that while wild materials are only found in the centers of origin of crop species, land races have a much wider dispersion. In the case of common beans, it is known that it has two centers of origin, Mexico and the Andes (Singh). However, since the encounter of 1492, beans have spread throughout Africa, Asia and Europe, giving rise to the emergence there of unique diversity in the land races in the secondary centers of origin.

Thus, the approach of this paper is to include diversity from the land races of both the primary and secondary centers of diversity, as well as from the wild ancestors. The issue then becomes, how to measure the relative amounts of diversity by region. This is done by relying on prior work to select a core collection for common beans (Tohme et al). The core collection was devised to represent the distribution of diversity in common bean germplasm based on knowledge of variability in morphological, agronomic, and molecular characters as well as geographical data on the origin of accession. For this paper, then, the amount of variability in a country or region, is taken to be equal to its per cent participation in the common bean core collections, one for cultivated land races, the other for wild ancestors.

Projected Flow of Landrace and Wild Germplasm Royalties

Based on the proceeding model system for ownership rights, the estimated flow of annual royalties for common beans by major continental groupings was calculated. The situation modeled here is one in which all bean producing regions in the world would sow seeds using improved germplasm on which royalty payments were due. As such it is a model of the maximum possible royalty flows. Actual royalty flows would likely be considerably smaller, but this represents the ideal case in which all growers had access to the best germplasm.

This model does not obligate farmers to pay royalties on their own land race germplasm. It does assume, though, that their native germplasm is improved through the introduction

of new genes that are covered by ownership rights property protection. The model simulates a pattern of payments for these new genes that is proportional to the share of diversity in land races and wild ancestors by country or region of origin.

On this basis, Tropical America would owe the largest royalty payments since it has the largest area sown in beans, while sub-saharan Africa would owe the second largest amount (Table 1). However, as the major source of variability in land races and as the sole origin of wild ancestors, Tropical America would earn the vast bulk of royalties, so on balance would receive a positive net income of \$19.6 million from royalties on common bean seed.

In contrast, the high income countries of North America and Europe would have to make net payments under a royalty system for bean seed. Even taking into account receipts accruing from useful genes found in the diversity of their secondary center land race germplasm, the USA/Canada would pay \$2.6 million annually, and Europe \$1.3 million. This confirms the expected view that the wealthy industrialized countries would end up paying in a system of ownership rights for wild and landrace germplasm.

The biggest net payments under this system, through, would come from sub-saharan Africa. As the most important of the secondary centers of land race diversity, it would receive 7.2% of total royalties from land race genes, that being the region's estimated share of land race diversity. These royalty receipts of \$2.0 million are considerably overshadowed by projected payments \$14.1 million, leaving Africa with a net bill of \$12.1 million. The other two groupings of low income countries - East/South Asia and West Asia/North Africa, would also make net payments under a system of royalties for ownership rights in germplasm for common beans.

Thus, this analysis is consistent with the conventional view that in the aggregate, the high income countries would pay out, while low income countries would earn net positive receipts. However, not all developing regions would gain. Only in center of highest biodiversity will there be net gains. Further disaggregation by country illustrates that this pattern also repeats itself at the regional level. Table 2 shows estimated annual royalty flows for selected countries and sub-regions of Tropical America. These data portray remarkable disparities in net royalty income even within Tropical America.

At the positive extreme, is Mexico which is the world's greatest source of bean genetic diversity, both in land races and wild ancestors. Consequently, Mexico would earn a net of \$13.2 million annually, even though as the world's second greatest bean producer, it would be paying royalties of \$7 million for germplasm that is brought into Mexico. This is likely a real rather than an artificial result. Despite its wealth of bean genetic resources, self sufficiency would be unattractive. It has been found, for example, that the anthracnose pathogen (one of the most important bean pathogens in Mexico) has co-evolved separately with its host in the two major centers of primary diversity. Mexican strains of anthracnose can attack Mexican bean germplasm, but Andean germplasm is highly resistant to Mexican anthracnose. Hence, Mexico's best strategy for dealing with

several of its most important pathogens, is to import novel resistance alleles from the Andean center of diversity (Pastor-Corrales et al).

Peru, as the second most important home of common bean genetic diversity, reaps the second highest level of royalty earnings. Since it would make very minor royalty payments due to the relatively small area sown to beans in Peru today, it emerges as gaining overall from royalties even more than Mexico. Ecuador, Colombia, Central America, and Chile/Argentina would also be net winners from royalty payments.

Brazil, and to a lesser extent the Caribbean, represent the opposite extreme. Brazil is the world's largest producer of beans, but it has no known native wild ancestors and quite a narrow genetic base in its land races. As a major grower of beans, and thereby a major user of bean seed and bean genetic resources, projected royalty payments from Brazil reach \$18.3 million, with a net outflow of \$17.5 million.

At first glance, then, developing countries of Asia and Africa as well as Brazil and the Caribbean islands, would emerge as losers from a royalty payment system. Such a view overlooks the gains from increased productivity that would accrue to these countries due to improved germplasm. Several studies have shown that improved bean varieties can increase yields 30-40% (Janssen et al; Pachico and Borbon). Here, the conservative assumption is made that improved germplasm results in a 10% increase in production.

The benefits of increased productivity due to new germplasm are far greater than royalty payments. For example, although Brazil would pay \$17.5 million in royalties, improved germplasm would lead to production gains conservatively worth \$116.8 million, 6.7 times the amount of the royalty payments. Total net benefits to Brazil would be \$99.3 million. Similarly, Africa would gain ten times as much from improved productivity as it would have to pay in royalties.

For countries that are net recipients of royalties as well as bean growers, the two classes of benefits are additive (Table 3). Even for most of these countries, the benefits from improved productivity in beans considerably outweigh those from royalties. Only in Peru and Ecuador would royalty receipts exceed projected productivity gains. These countries have the unusual features of a wealth of bean genetic diversity combined with fairly small bean production. Since bean production is modest in these countries, productivity gains are slight. At the same time royalty revenues are high due to substantial genetic diversity.

Conclusions and Implications

A system of ownership rights in common bean land race and wild germplasm would generate income flows for those countries that are major sources of diversity in bean land races and wild relatives. The high income, gene-poor countries of the north, would indeed have to make payments to low income, gene-rich countries in the south. However, many countries in the south are poorly endowed in bean genetic diversity. In particular, Africa and Asia would be net payers for germplasm, as also would be Brazil and the Caribbean.

Notwithstanding the royalty payments, the north would very much emerge as gaining from access to germplasm. Even on conservative assumptions for productivity gains, and liberal assumptions for royalty payments, the projected gains in productivity in the north would far exceed royalty payments. This implies that economically it would be worthwhile for the north to pay for germplasm. If agreements about enforcement of ownership rights could be made workable, the system would be viable economically.

A system of ownership rights in bean landrace and wild germplasm would impose royalty costs on low income countries that are poor in bean diversity and are major bean growers. This might seem disadvantageous to Africa, Asia, Brazil and the Caribbean. Nonetheless these countries would gain substantially from improved productivity, and these gains would be 6 to 27 times greater than projected royalty payments. It would, in principle, be worthwhile for gene poor low income countries to pay for access to genes.

Alternatively, rather than a uniform system of ownership rights, the system could be discriminatory and offer preferential access to germplasm among low income countries while charging full prices for germplasm to those who can afford it. In practice, germplasm exchange may be negotiated bilaterally and such a system could evolve. It might, though, raise complicated issues of enforcement of rights with respect to subsequent transfer of germplasm to third countries.

Preferential germplasm access for low income countries, however, would do away with the bulk of the potential royalty flows in the case of beans. If bean germplasm were exchanged freely in the south without any royalty charges, total royalty payments from Europe and North America would amount to only \$4 million. This is such a small amount as to make the system hardly worthwhile.

In any case, most countries in the south have far more to gain from increasing the productivity of their bean crop than from a royalty system in bean germplasm. This suggests that they have most to gain from investing in agricultural research to develop improved germplasm. Not only is this generally true for almost all countries, but it is likely to be a good strategy even for the most gene rich countries. As noted above, royalties on property rights in improved germplasm include both compensation for genetic resources as raw materials, and compensation for the knowledge needed to identify and use these genetic resources. Typically raw material prices are a fraction of final product prices, with most income going to value added in processing. Therefore, it would be highly advantageous for countries which are origins of genes, to also develop them. This would not only contribute to their earning a larger share of royalties, but also could enable them to insure the development of their genes. Some valuable alleles may not be unique to a single country, and sometimes different alleles may produce a similar expression of a desired trait. Thus, it is in the interests of gene possessing countries to be able to expedite development of their genes. In addition, this would also contribute to their production agriculture, and in many if not most cases, this may yield benefits much larger than those from ownership rights in germplasm.

Since this paper deals specifically with the case of beans, it is useful to assess the degree to which this case is likely to be representative of other major crops. Royalty incomes from beans are modest in comparison to potential increases in productivity in low income countries due to improved bean germplasm. To a significant degree, this is due to the fact that 79.6% of beans are produced in low income countries. Obviously, the higher the share of production of a crop that occurs in low income countries the relatively less important royalty revenues become compared to productivity increases. Many other major crops, like beans, are grown principally in low income countries. Such crops include rice, sugar cane, cassava, banana sweet potatoes, yam, millet, coconut and sesame. Significant revenues from ownership rights to this germplasm could only come about through horizontal transfers among low income countries, but not to any important degree as revenues from the north to the south.

In contrast, some major crops are grown mainly in developed countries: wheat (64%), maize (64%), potato (78%), barley (86%) and soybean (66%). Revenues from germplasm rights to these commodities, would be relatively more important compared to productivity gains than in the case of beans. It is likely, though, that as in the case of beans, royalties would accrue principally to a few countries in the south that are particularly rich in genetic variability. Thus, ownership rights in germplasm may be a significant benefit to some selected countries, for example, Mexico and Peru in the Americas, and Ethiopia in Africa. The rest of Africa and Latin America could expect little income from ownership rights royalties in agricultural crops.

Nonetheless, a system of ownership rights in germplasm could be in the common interest if it serves to provide improved incentives for the conservation of genetic diversity. Moreover, ownership rights do reflect a concern for fairness in the distribution of benefits as property rights are increasingly asserted in germplasm. Such a system could produce important income flows for some poor countries. Finally, though, most low income countries, even the few with a wealth of genes, have far more to gain from a research capacity that enables them to more effectively utilize genetic diversity.

Table 1. Estimated Flows of Annual Royalties under a System of Ownership Rights in Landrace and Wild Common Beans (\$US million).

	Royalty Payments	Royalty Receipts from Land Races	Royalty Receipts from Wild Ancestors	Net Income from Royalties
Tropical America	30.6	22.7	27.5	19.6
Sub-Saharan Africa	14.1	2.0	0	- 12.1
USA/Canada	3.2	0.6	0	- 2.6
East and S. Asia	3.1	0.3	0	- 2.8
Europe	2.6	1.3	0	- 1.3
W. Asia/N. Africa	1.3	0.5	0	- 0.8

Table 2. Estimated Flows of Annual Royalties under a System of Ownership Rights in Landrace and Wild Common Beans in Selected Countries and Sub-regions of Tropical America (\$US million).

	Royalty Payments	Royalty Receipts from Land Races	Royalty Receipts from Wild Ancestors	Net Income from Royalties
Brazil	18.3	0.8	0	- 17.5
Mexico	7.0	8.0	12.2	13.2
Central America	2.0	1.9	3.3	3.1
Chile/Argentina	1.0	0.5	2.3	1.8
Caribbean	0.7	0.3	0	- 0.4
Colombia	0.6	1.5	1.3	2.2
Ecuador	0.2	1.2	1.3	2.3
Peru	0.2	7.9	5.7	13.4

Table 3. Comparison of Net Gains From Royalty Flows with Gains From Increased Productivity Due to Improved Germplasm.

	Net Payments or Income from Royalties (\$ US million)	Benefits from Improved Germplasm (US\$ million)	Total Benefits (US\$ million)	Ratio of Productivity Benefits to Royalties
Countries or Regions with Net Royalty Payments				
W. Asia/N. Africa	- 0.8	20.9	20.1	27.9
USA/Canada	- 2.6	71.8	69.2	27.6
Caribbean	- 0.4	9.4	9.0	22.9
Europe	- 1.3	28.6	27.3	21.7
Sub Saharan Africa	- 12.1	121.0	108.9	10.0
East S. Asia	- 2.8	27.2	24.4	9.7
Brazil	- 17.5	116.8	99.3	6.7
Countries or Regions with Net Royalty Income				
Southern Cone	1.8	13.6	15.4	7.4
Central America	3.1	17.4	20.5	5.6
Colombia	2.2	6.0	8.2	2.7
Ecuador	2.3	1.3	3.6	0.6
Peru	13.4	2.2	15.6	0.2

1.1.4 Cassava in Colombia - by: Veronica Gottret, Zully Escobar, and Salomón Pérez

2000 Milestones

- Two undergraduate thesis proposals were prepared with students of the Economics Department at the Universidad del Valle in Colombia. The objectives of the thesis are to analyze (1) the economic impact of technological changes in the production and processing of cassava in Colombia, and its principal production regions; (2) the competitiveness of fresh and dried cassava production in Colombia. These students are financed by CLAYUCA to work with BP-1.
- Production and market data was collected for the different cassava related productive chains (fresh cassava for human consumption, dried cassava for animal feed, and

cassava starch of industrial uses) to update and complement databases available in CIAT.

- A database structure was designed to organize all cassava-related data available, and to make it easily available. Data is being organized accordingly with this structure.
- A trend analysis of cassava production and prices in Colombia started and will continue with an analysis of input and labor cost trends as well as market trends.
- Baseline cassava production cost structures for the year 2000 without technology adoption for six regions of Colombia (North Coast, Santanderes, Quindio, Huila-Tolima, Llanos Orientales and the Cauca Department Valleys) were estimated. These cost structures will serve as the baseline to simulate four technological changes in cassava production: (1) mechanization of planting activities, (2) partial mechanization of harvesting activities, (3) introduction of improved cassava germplasm, and (4) introduction of a herbicide resistant gen in cassava varieties.
- A chapter is being written to contribute to the book on cassava production, processing and utilization that is being prepared by the cassava breeding project and CLAYUCA.

Progress Report

Background

In order to improve the competitiveness of the cassava-related production chains (fresh cassava for human consumption, dried cassava for animal feed and cassava starch of industrial uses) in Colombia, a sub-sectorial analysis has been conducted. One of the proposed options to improve its competitiveness was to reduce the production costs of cassava roots, increasing its productivity by the introduction of improved germplasm. Also, options to reduce production costs, where human labor occupies the highest proportion, such as the mechanization of planting and harvesting activities, and the introduction of a herbicide resistant gen in cassava varieties are being proposed. A third mechanism was proposed to improve the competitiveness of the dried-cassava agroindustrial chain by reducing dried cassava processing costs, increasing the cassava roots: dried cassava conversion factor, and securing year-round availability of dried-cassava by introducing new processing technology. One of the proposed technologies is a continuous artificial drying system of cassava chips, which permits a constant supply of cassava chips throughout the year as well as the per unit processing cost.

Although these options look promising to contribute to the improvement of the competitiveness of the cassava-related production chains, it is important to conduct a financial analysis to estimate economic net gains as the result of the introduction of new technologies in order to analyze their economic feasibility. Moreover, it is important to evaluate the consequences of these technologies on labor demand and employment generation. A priori we can say that most of the proposed technologies are labor-saving, and therefore, will have a significant impact in reducing labor demand for the poorer sector of the rural economy (the landless rural workers). However, as the cassava sector

develops and more area is brought into cassava production, the demand for labor will increase and more income will be generated. Therefore, it is important to analyze the net effect of the introduction of new technology, both in employment and income.

In order to conduct the above analyses, two undergraduate thesis research are being developed in CIAT under the supervision of the BP-1 project, in collaboration with CLAYUCA (The Latin America and Caribbean Consortia for the Support of Cassava Research and Development). This undergraduate research will permit to conduct a first ex-ante assessment on the impact of new cassava production and processing technology in Colombia as a case study that can be later conducted for other Latin American countries.

Objectives of the Research

1. Analyze cassava production, prices, demand and input cost trends in Colombia during the last 20 years.
2. Analyze the factors that determine the competitiveness of cassava-related production chains in Colombia including production, processing and transportation costs, factor and product prices, productivity, quality, and availability in terms of volume and constancy of supply throughout the year.
3. Conduct a financial analysis to estimate economic net gains as the result of the introduction of new technologies in order to analyze their economic feasibility.
4. Estimate the overall economic impact of the introduction of improved cassava production and processing technologies in terms of income surpluses, its distribution among the different interest groups and net gains in employment generation.
5. Analyze the impact of the development of the cassava sector on the feed, poultry, egg and pig markets in Colombia.

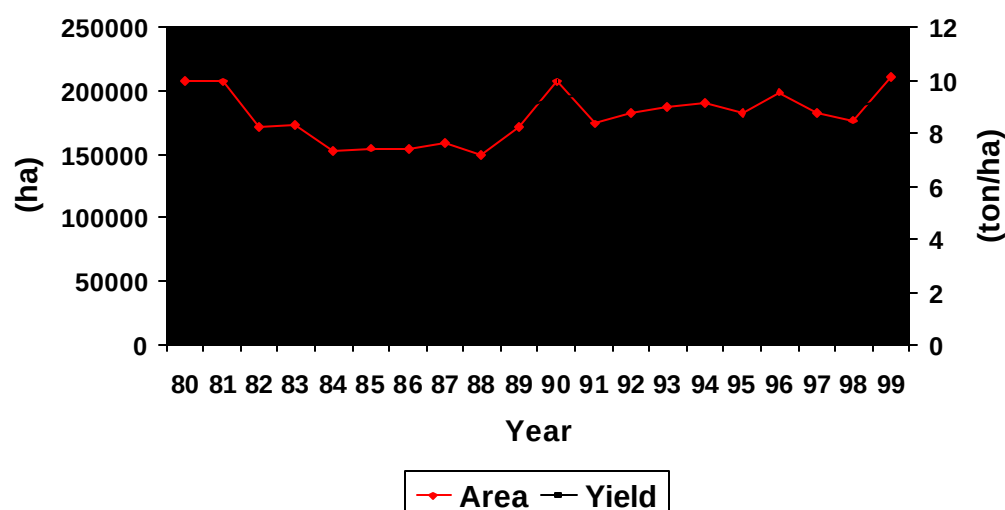
Trends in Cassava Production in Colombia

Colombia is the third cassava producer in Latin America after Brazil and Paraguay, with an average annual production in the last three years (1997-99) of 1.75 million-ton, an average area planted of 190,000 ha, and a mean yield of 9.2 ton/ha. Cassava markets in Colombia has been diversifying since the 1980s, rapidly changing from a subsistence crop to an industrial one which is being used as a raw material for expanding markets such as starches for industrial use, animal feed, and processed products for human consumption.

Figure 1 shows the trends in cassava production in the last 20 years (1980-1999). During the 1980s both cassava area and yields decreased at annual rates of 1.23 and 1.45, respectively, resulting in an annual fall in cassava production of 2.68% during this period. However, after the opening of the economy, in the early 1990s, cassava area started to growth in Colombia at an annual rate of 0.26% and yield continue to decrease but at a lower rate, resulting in a small net increase in cassava production of 0.08% per year. The

opening of the economy has affected the whole agricultural sector in Colombia because of its low level of competitiveness as the result of at least two factors. First, the overvaluation of the currency made Colombian products too expensive to compete in the world market, and secondly the low levels of technology used resulted in high production costs. Only after 1998 with the devaluation of the Colombian currency, products are becoming more competitive, but not as a result of a reduction in costs, but at the expense of the reduction in the acquisitive power of the population.

However, the opening of the economy has also open new markets and demands for cassava roots and cassava-based products. It is expected that these new opportunities, together with a structured support system for the cassava sector, through the CLAYUCA initiative, could improve the perspectives for this crop in Colombia by developing appropriate production and processing technology that increases its competitiveness.



Source: Estimated from Colombian Ministry of Agriculture Data

Figure 1. Cassava production trends in Colombia, 1980-1999

The distribution of cassava production among the different regions of the country is presented in Figure 2. The most important cassava-producing region of Colombia is the North Coast¹ where 45% of cassava roots are produced. Cassava production in this region is concentrated on small-scale farmers with production units between 0.5-2 ha, which represent 70% of producers. The rest of cassava producers (30%) are distributed among medium-scale farmers (2-5 ha) and larger-scale ones (> 5 ha).

The second most important cassava regions are the Llanos Orientales² (13.2%) and the Santander³ (13.0%). In the Llanos Orientales, cattle raising and rice production are the most important agricultural activities, however, cassava has been consolidating as another production option especially for industrial purposes and regional fresh cassava

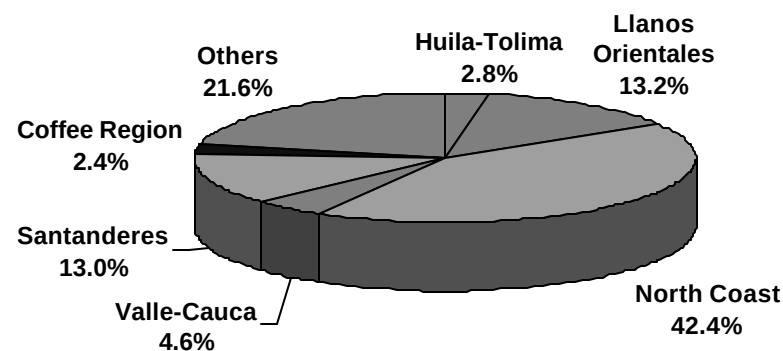
¹ Includes the Departments of Atlántico, Bolívar, Cesar, Córdoba, Magdalena y Sucre.

² Includes the Departments of Arauca, Caquetá, Casanare and Meta

³ Includes the Departments of Santander and Norte de Santander

consumption. Most cassava production in this region is concentrated in medium-scale farmers with farm size of 6-8 ha.

Cassava producers in the Santanderes are mainly small-scale with farm size between 0.5-2 ha and this has been by tradition an important cassava production and consumption region. However, cassava production practices have been traditional with low-input use and manual land preparation, and therefore, yields are in average low. Cassava is mainly produced for food security purposes and the small surpluses are sold mainly for the local fresh market.



Source: Estimated from Colombian Ministry of Agriculture Data

Figure 2. Distribution of cassava production in Colombia among different cassava production regions (average of the 1997-99 period)

The hillsides of the Cauca-Valle region have been traditionally an important cassava production area (4.6% of total cassava production), especially as a raw material for sour cassava starch production in small and medium-scale processing units. However, the fall of sugar prices in the world market have depressed the sugar cane agroindustry in the valley area. Therefore, dried cassava production for the animal feed market is being promoted in this region as an alternative for sugar cane production diversification. The same is happening with the Coffee Region⁴, where alternative to diversify coffee production are being evaluated and promoted. This region, especially the Quindio and Caldas Departments have an strategic location, which is equidistant from the three most important cities of Colombia: Santafé de Bogotá, Medellin and Cali, making this region an important source of cassava roots for fresh consumption.

Table 1 shows cassava production trends in the six cassava production regions of Colombia. These trends show in general that both cassava area and yields have been declining in the last 20 years. This decline in production has been more pronounced for the Huila-Tolima and the Valle-Cauca regions during the 1980s. The only region that

⁴ Includes the Departments of Caldas, Quindio and Risaralda.

shows an increase in production during the 1980s is the North Coast. In this region a significant effort had been made to develop the crop and its markets during this period, with the support of the Colombian government and international cooperation. During the 1990s, cassava production in most regions decreased but at a lower rate than during the 1980s. The exception was the Llanos Orientales and the Santanderes, where cassava production increased at annual rates of 0.55 and 0.89%. In the former region, cassava production increased as a result of area increases, while in the Santanderes cassava production increased as a result of yield increases.

Table 1. Cassava Production Trends in Different Cassava Production Regions of Colombia.

Region	Annual Rates of Change 1980-1990 (%)			Annual Rates of Change 1990-1999 (%)		
	Area	Yield	Production	Area	Yield	Production
North Coast	3.37	-2.55	0.83	0.50	-1.03	-1.53
Coffee Region	-0.16	-0.36	-0.52	-5.45	-0.80	-6.25
Llanos Orientales	-0.56	-2.28	-2.84	0.84	-0.29	0.55
Santanderes	-1.86	-1.51	-3.37	-1.19	2.09	0.89
Huila-Tolima	-11.3	-3.33	-14.68	-0.57	-2.57	-3.14
Valle-Cauca	-7.19	1.41	-5.78	-0.23	-1.78	-2.01

Source: Estimated from Colombian Ministry of Agriculture Data

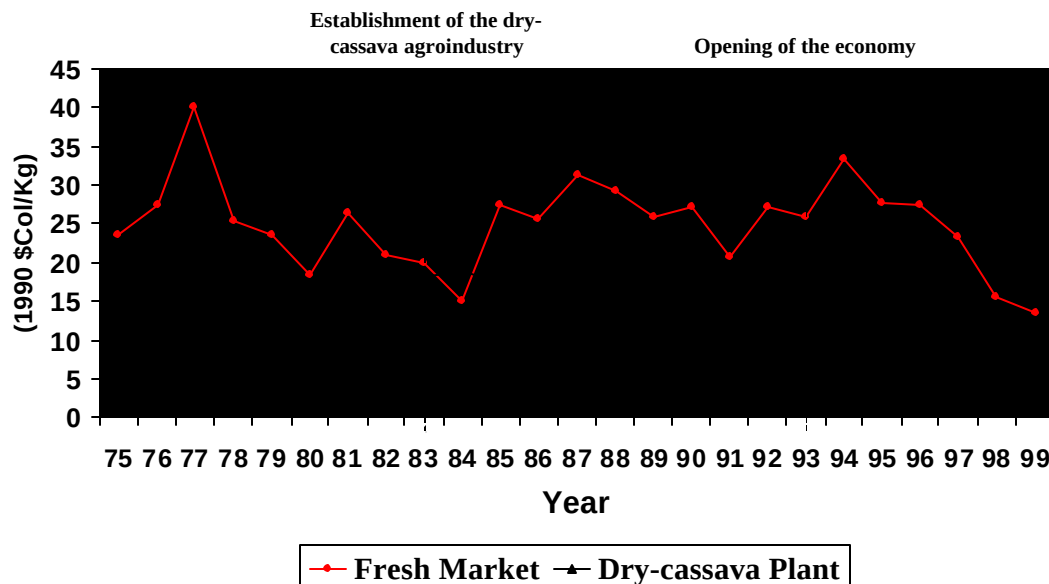
Trends in Cassava Prices

Figure 3 shows the trends in cassava prices paid to the producer in the North Coast. Time series for the other regions are not available and an effort is being made to reconstruct them from the Colombian Minister of Agriculture and its Departmental Agricultural office files. Constant 1990 cassava prices paid to the producer between 1975-83 decreased at an annual rate of 4.1 % as a consequence of credit program established in 1977 by the Colombian Government, that had the effect of encouraging farmers to intensify cassava production. By 1981, cassava production was extremely high an unable to find buyers, many farmers plowed their crops without harvesting.

The emergence of the dry-cassava agroindustry in the region after 1983 created an alternative market for cassava roots, and therefore, between 1983 and 1993 cassava root prices for the fresh market increased at an annual rate of 2.5%. At the same time, the price paid for cassava roots by the dry-cassava agroindustry started to provide a price floor, securing the market for cassava farmers.

In 1993, the Government moved toward a neoliberal system by opening up the economy to international competition (economic aperture) and decreased its presence, both in size and intervention. Hence, after 1993, prices of cassava roots paid by both the dried cassava agroindustry and the fresh market decreased at annual rates of 4.3 and 18.3%,

respectively. These steep decreases in prices were in part a result of Colombia importing grains for animal feed at lower prices, which were at that time particularly low, reducing to almost zero the profit margins received by the dry-cassava agroindustry.



Source: Data were obtained from the Integrated Cassava Research and Development Project monitoring and evaluation system.

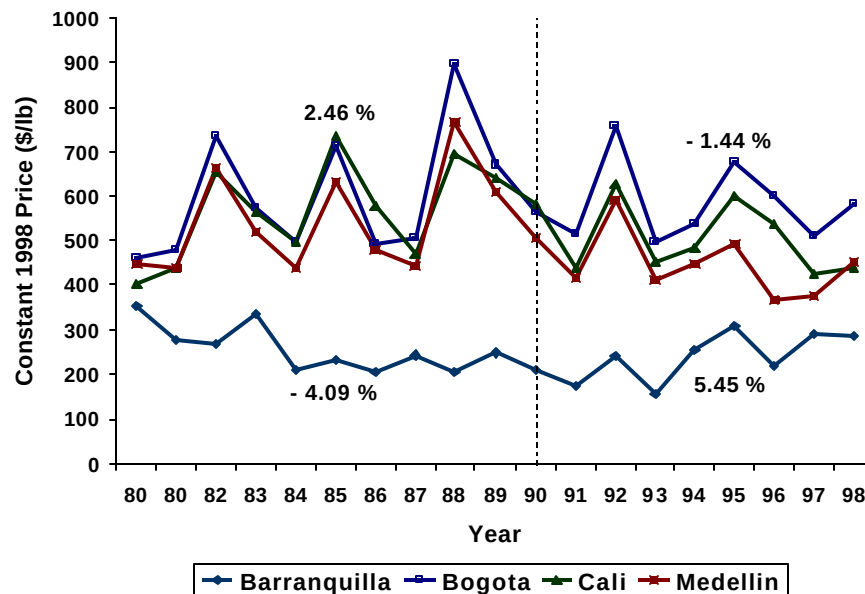
Figure 3. Trends in cassava prices in the North Coast, 1975-1999. Prices are based on the 1990 Colombian peso.

Consumer prices for cassava roots in the fresh market are reported in Figure 4. As can be seen in this Figure, cassava root prices in the fresh market increased during the 1980s in the three main cities of Colombia (Santafé de Bogotá, Medellín and Cali) at an annual rate of 2.46%. However, during the 1990s consumer prices started to decline at an average annual rate of 1.44%.

Consumer prices in Barranquilla show a different level and trend than prices in the other principal cities of the country. Firstly, prices are 54% lower than average prices in the other cities, mainly as a result of its closeness to the major cassava production region of Colombia (the North Coast), which reduces commercialization and transportation costs significantly. Secondly, consumer-price trends in Barranquilla behave the opposite than in the other cities. During the 1980s, cassava prices in Barranquilla decreased at an average annual rate of 4.09%. One of the reasons for this decline in price was the increase in production during this same period in the North Coast region, as a result of an increase in cassava production (Table 1). During the 1990s, consumer prices in Barranquilla started to rise at an annual rate of 5.45%, again responding to the decrease in cassava production during this period (Table 1).

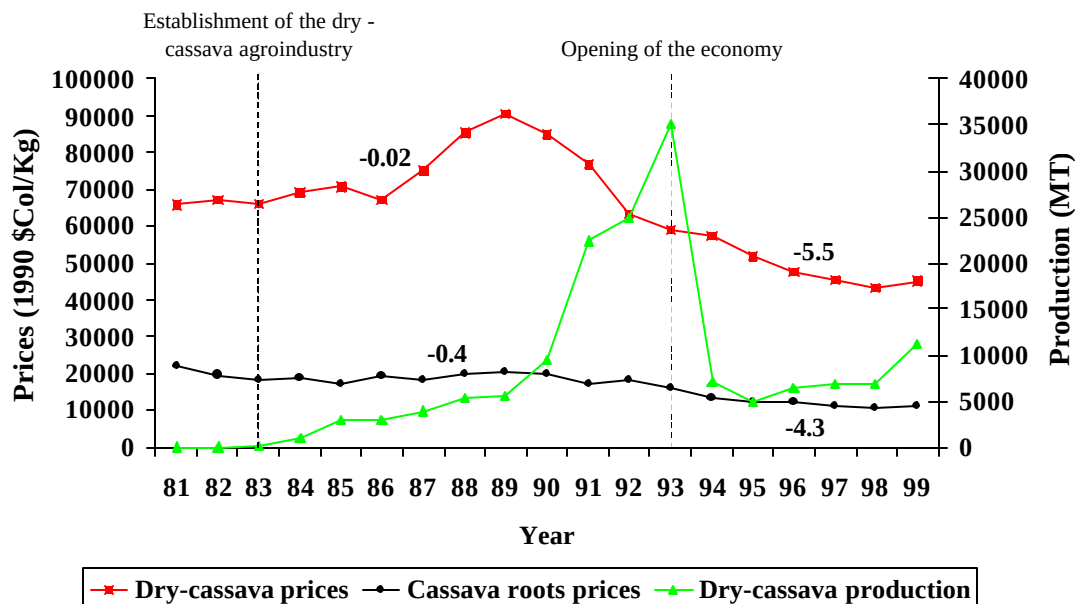
To continue with the analysis on cassava prices, Figure 5 shows the trends of the dry-cassava agroindustry prices and production in Colombia. As shown in this Figure, dry-cassava production increased sharply between 1983-93 as the result of the emergence of

the new agroindustry in the North Coast region. During this period, dry-cassava prices as well as the prices paid for cassava roots by the agroindustry, remain almost at the same level with a small tendency to decline at annual rates of 0.02 and 0.4%, respectively. However, with the opening of the economy that was operational since 1993, prices of both dried cassava and fresh roots paid by the agroindustry decreased at annual rates of 5.5 and 4.3%, respectively. Again, this is the result of the importation of maize at lower prices as discussed above. Dried cassava production is starting to increase again, as grain imports are becoming more expensive due to the recent devaluation of the Colombian peso.



Source: Estimated from DANE data

Figure 4. Cassava consumer prices in the fresh markets of the principal cities of Colombia, 1980-1998.



Source: Data were obtained from the Integrated Cassava Research and Development Project monitoring and evaluation system.

Figure 5. Trends in dried-cassava prices and production in the North Coast, 1981-1999.

Baseline Cassava Production Costs

Table 2 presents a comparison of estimated cassava production costs in six different regions of Colombia for the year 2000 with the existing technology. If we analyze these figures, a large share of direct costs are represented by labor, which range from 41% in the plain region of the Cauca Department to 74% in the Coffee region of the Quindio Department, and depend on the extent of inputs such as fertilizers and pesticides use.

These estimates show that the most competitive region is the North Coast, where the average direct cost is estimated at \$Col. 55,000/ton without fertilization using a yield of 12 ton/ha, and \$Col. 49,000/ton with fertilization using a yield of 17 ton/ha. The lower production costs in this region could be explained by three factors:

- (1) the planting material of traditional varieties is not sold but given for free from farmer-to-farmer,
- (2) labor costs are in average 33% lower than in the other regions of the country, and represent around 60% of direct production costs, and
- (3) the opportunity cost of the land is 60% lower than the average of the other cassava producing regions and only higher than the land cost in the Llanos Orientales and Santanderes regions.

However, producer prices are also lower in the North Coast (45% lower than the average of the other five regions) and producers only perceive a net benefit after direct costs of 25,000-30,000 \$Col./ton.

Another important characteristic of the North Coast is that because of its marginal production characteristics (semi-arid) cassava is one of the few alternatives of farmers as an essential source of food security and cash income because. In general, cassava, compared with other crops, has a high tolerance to seasonal low rainfall, high temperatures and intermediately fertile soils. Therefore, it is a major crop in this region that do not competes in production with other crop alternatives, making the supply of roots in this region more stable and secure.

The second most competitive region after the North Coast is the Cauca Department Valleys, where estimated direct production costs are \$Col. 59,000/ton. In this region, although labor costs are higher than in the North Coast, the quality of the land together with the use of fertilizer and soil improvement practices makes it possible to have higher yields than in the other cassava production regions of the country. Also, producer prices are more attractive than in the other regions with the exception of the coffee zone, resulting in a net benefit for producers after direct costs of \$Col. 42,000. However, cassava competes in production with other crops, and therefore, significant fluctuations in cassava root supplies could be expected as other competing crop prices fluctuate, such as the price of sugar.

The region with the highest net benefit for producers after direct costs is the Coffee region of Quindio. This region produces mostly for the fresh cassava market, and although labor costs are high and represent 74% of total costs, the quality of the land and fertilization practices results in a higher yield than the other cassava producing regions, with the exception of the Cauca Department Valleys. Moreover, the higher quality cassava roots of this region (var. Chiroso) have a high demand in the fresh cassava market that offers the highest price. Also, the strategic location of this cassava production region, near the three most important cities of the country (Bogotá, Medellin and Cali), is reflected in a much higher price paid to the producer than in the other cassava production regions of the country.

The other three cassava production regions of the country (Llanos Orientales, Tolima-Huila and Santanderes) seem to be less competitive and even a negative net benefit after paying for direct production costs was estimated for the Santanderes. However, the data obtained for these regions is less reliable and needs to be revised and validated further.

These estimates show that cassava production costs are still too high to make cassava production profitable, and cassava root prices competitive enough to develop further the potential industrial markets for the crop.

For example, with cassava root prices in the North Coast Region of \$Col. 80,000/ton, the direct costs of producing a ton of dried cassava sum up to \$Col. 224,000/ton. Adding fixed costs of \$Col. 10,500/ton and transportation costs of \$Col. 50,000/ton from Sincelejo to Medellin, the cost of placing one ton of dried cassava in an animal feed plant in Medellin is \$Col. 284,000. Given the actual import tariffs for maize of 46% that stand until January 2001, animal feed plants are willing to pay for dried cassava up to \$Col. 313,000. This represents a small margin of \$Col. 29,000, meaning a return to the

investment of 10%. Furthermore, in the next two years import tariffs for maize should decline gradually to reach a level of 15%, meaning that dried cassava prices will have to decline significantly by January 2003 to remain competitive as an animal feed source. Based on the above analysis, cassava root prices in other regions of the country, with the exception of the Santanderes, do not make the crop competitive for the animal feed market. However, given root prices in the Santanderes do not make the crop profitable, and therefore, farmers would have no incentives to increase their production.

Based on these cost structures, the impact of the proposed technological options will be evaluated on production costs, and their composition among mechanization, input and labor costs. These results will permit an assessment of the economic impact of the new production technologies that are being proposed to reduce production costs and improve the competitiveness of cassava in Colombia.

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Table 2. Comparison of Cassava Production Costs in Different Production Regions of Colombia, 2000

	Cassava Production Region of Colombia						
	North Coast (without fertilization)	North Coast (with fertilization)	Cauca Department Valleys	Llanos Orientales	Coffee Region of Quindio	Tolima-Huila	Santanderes
Average Yield (ton/ha)	12	17	23	15	20	12	12
Direct Costs / ton (\$ Col)	55.375	48.853	58.813	91.067	85.030	90.373	91.833
% Labor Costs	61.85	60.08	40.69	43.92	74.21	42.49	51.36
% Mechanization	21.07	16.86	10.21	7.94	0.00	5.90	18.15
% Inputs	17.08	23.06	49.11	48.14	25.79	51.61	30.49
Land opportunity costs (\$Col / ha)	110.000	110.000	300.000	80.000	614.250	300.000	80.000
Total Costs / ton⁵ (\$ Col)	84.477	72.911	93.029	129.184	156.478	142.908	131.560
Mean producer current price 2000 (\$Col / ton)	80.000	80.000	135.000	95.000	322.000	110.000	67.000
Net benefits after direct costs (\$Col / ton)	24.625	31.147	76.187	3.933	234.970	19.627	-24.833
Net benefits after total costs (\$Col / ton)	-4.447	7.089	41.971	-34.184	165.522	-32.908	-64.560

⁵ Includes land rent costs and financial costs

1.1.5 Social capital and Rural agro-enterprises in Colombia - by: Nancy Johnson

Progress Report

The project, “Social capital, collective action, and community agro-enterprise development: Understanding the linkages that contribute to poverty alleviation and sustainable natural resource management” was approved in July, 2000. The purpose of the project, which will be undertaken by BP-1, agroenterprises and several Colombian partners, is to better understand the role of social capital and collective action in community-based agro-enterprises. There are a growing number of studies that demonstrate positive relationships between aspects of social relations such as the number of organizations or group participation, and desirable development outcomes such as per capita income or household expenditure. None of these studies is able to identify specific mechanisms or pathways through which social relations become social capital. This study seeks to understand and document these processes in the context of community-based rural agro-enterprises. In addition to looking at how social capital affects agroenterprises, we will also look the social, economic, and environmental impacts of agroenterprises on communities, and attempt to related different types and distributions of impact to organizational structure of the agroenterprise.

To date, CIAT and partners have developed a draft methodology for collecting data on social capital and its role in agroenterprises, which consists of traditional surveys methods and participatory organizational mapping exercises which designed to identify and describe in detail the different types of relationships that the business has both within and outside the community, for example with providers of inputs such as product, credit, labor or information, or with buyers of output. By focusing on these relationships and their economic and non-economic characteristics, we expect to identify whether and how social capital affects the nature of the relationship. Social capital is hypothesized to play one of three roles: provide access to information, reduce transactions costs via trust, or support collective action. We have also selected 40 agroenterprises, ten in each of four communities. Each community has a distinct socio-cultural history which is hypothesized to influence the emergence and organization of the agro-enterprises.

Background and Context

Over the past several decades, the process of agro-industrialization⁶ has transformed agriculture and rural communities in many parts of Latin America, more so than in any other part of the world (FAO). As a result of demographic change, increasing regional and global income incomes, and structural adjustment and market liberalization programs undertaken in many LAC countries, agro-industrialization has expanded far beyond the traditional agro-export crops (Reardon et al). Today both traditional commodities and

⁶ Agro-industrialization has been defined as a process involving “ (1) growth of agro-processing, distribution, and farm-input activities off-farm; (2) institutional and organizational change in the relation between agri-food firms and farms, such as a marked increase in vertical coordination; (3) concomitant changes in the farm sector, such as changes in product composition, technology, and sectoral and market structures.” (Wilkinson, 1995).

new crops are being produced, processed, and marketed both domestically and internationally with the participation of national and multinational agribusiness companies. During the 1980s alone, non-traditional agro-exports rose by 348% in Costa Rica, 222% percent in Chile, and 78% in Guatemala (Carter et al).

In terms of regional and national agricultural competitiveness, these changes have often been beneficial. Many areas which formerly competed with industrialized countries in the production of basic grains have shifted into horticultural and other crops in which they have distinct advantages. In many cases, the total value of agricultural production has increased dramatically.

How agro-industrialization has affected poverty and the environment is less clear. There is no expected conceptual relationship, and the empirical evidence where available is decidedly mixed (Carter et al, Barham et al, Reardon et al). In many cases, poverty and rural unemployment not only persist but have even worsened (Reardon et al). Intensification of high value crop production may reduce pressure on marginal lands, but it also generally leads to higher input use (Pingali).

This presents a challenge for many governments that are interested in promoting both economic and social development via agro-industrialization. In an analysis of the evidence from three countries, Carter et al advocate an attitude of “informed pessimism,” regarding the distributional impacts of agro-industrialization, one that “offers more than a blind faith in market forces to deliver equity for the rural poor but does not necessarily reject agro-export promotion (p. 33). Policy, they argue, has a critical role to play if agro-industrialization is to contribute to inclusionary growth rather than exacerbate existing inequality in rural Latin America.

One reason for the failure of agro-industrial growth to stimulate sustainable development in rural areas is related to the vertical integration of large national or multinational corporations. If local participation in the process is limited, as it often is, to contract production and to low-wage labor in production and processing activities, there is little opportunity for local residents to influence production decisions or conditions, or to capture value-added along the product transformation chain.

Contract production occurs when agri-business companies make formal advance purchase agreements with producers. These contracts specify price, quantity, quality and date of delivery. They may also provide credit, technical assistance, and inputs to be used in production. Contract production appears to be a viable option for increasing producer incomes and providing access to technology, however it tends to favor better endowed producers, and may be more “wealth creating” than “wealth spreading” (CEPAL: Escobar et al). Over time these differential impacts can lead to increasing inequality.

There has been no systematic analysis of the indirect impacts of agro-industrialization, namely employment creation and expenditure linkages. Based on the available evidence, however, it appears that employment creation is not as great as expected and wages are low (Reardon et al; Escobar et al). While the employment in agro-processing activities

may be an important source of income in areas where there is no alternative, some evidence suggests that it is unlikely to lead to an increase in standard of living (Barrón and Rello). As for local multiplier effects, in many cases vertically-integrated companies also provide inputs and services, which they bring in from subsidiaries located outside the area, limiting the expenditure effects (Reardon et al, Escobal et al).

There is a vast conceptual and empirical literature on the determinants of industry organization in agribusiness, focusing primarily on the issues that determine contract choice in production (ie direct production vs. contracting vs. spot market purchases). The determinants of participation by small firms in service and input provision have been relatively neglected. In general, the conclusion is that the forces that drive vertical integration are not strictly the standard economic factors such as relative factor prices and productivity nor are they mainly related to the desire on the part of firms for monopoly power and profits (Antle).

Rather transactions costs resulting from market imperfections appear to be the forces behind the concentration that is characterizing agribusiness today (Runsten and Key). The need for companies to assure large volumes of high quality product delivered on time and to their exact specifications are major determinants of how processing and distribution companies organize themselves and their relations to their suppliers. Companies do not just look for low prices, they look for suppliers who are reliable, whom they can trust, and with whom the transactions costs of doing business are low. In a sense, the organization of relations along the product transformation chain is in part determined by the ability of different actors to engage in a type of collective action with the goal being maintenance of the integrated system for mutual benefit (Fukuyama).

The conceptual relationship between transactions costs and the participation of small farms and firms in the agro-industrialization process is not clear *a priori*. Some of the transactions costs, such as labor monitoring, favor small owner-operators, while others such as those associated with managing production contracts favor the large growers (Johnson and Ruttan).

In general, however, empirical evidence suggests that transactions costs appear to be negatively related to small farm and firm participation (Reardon et al). Small farmers and cottage industries may have productivity advantages in certain aspects of food production and processing, however the costs of integrating many small, decentralized farms and firms into a product transformation chain that is not only capital intensive but also technically-demanding (e.g. large volumes, high quality standards, and perishability) and informationally-intensive (e.g. safety and export regulations, changing market preferences) are often prohibitive (Binswanger and Rosensweig).

This suggests that in order to achieve the policy goal of making the process of agro-industrialization more consistent with the objectives of sustainable rural development, the transactions costs associated with integrating small farms and firms into the agro-industrial relations must be reduced. Policy interventions such as improvements in education, communications and transportation infrastructure, financial services such as

credit and insurance, technical assistance, and market information, have been suggested as ways to achieve this goal.

While these are all generally sound investments in rural development, there is evidence that they may not be sufficient to ensure the participation of small farms and firms in the agro-industrialization process. The reason is that these efforts to reduce transactions costs focus on technical and economic problems, while in many cases the main obstacles to small farm and firm participation in agro-industrial processes may be social.

How are social issues important? Several examples demonstrate the role that organization and cooperation play:

Producer associations. One of the ways that small farmers can overcome the high costs of contacting with processors is to organize themselves to produce, or more likely market, their production jointly. If the organization can represent the producers in contract negotiation and input purchase, and can take care of monitoring and enforcement issues, then an organization of small producers can compete with a large-scale grower in terms of both productivity and transactions costs.

Maintaining this collective action is not easy because members often face situations in which they are required to act against their own short-run best interests. For example, farmers would be better off selling outside the organization if market prices were high, or not adhering to quality standards if they were unlikely to be detected. In fact, many producers organizations fail for precisely these reasons. The ability of the producers associations to assure member compliance without excessive monitoring and enforcement costs—the ability to generate collective action—is critical to success.

Small-scale processing firms. As suggested earlier, if local communities could participate in processing activities as firm owners rather than employees they could capture some of the value added associated with agro-industrialization. There are examples of local firms engaging in preliminary, intermediate, or final processing activities, and then selling their output either as an input to a larger firm or as a final product to supermarkets or food wholesalers.

In these cases, local firms must manage their internal relationships as well as external relations with both upstream suppliers and downstream customers. Firms may face traditional collective action problems at the local level, especially if the organization is some type of cooperative. In addition, relationships with suppliers and customers are also often based on trust, reciprocity and mutual benefit. These relationships reduce the legal and administrative costs of doing business along the product transformation chain.

These are the most typical examples of collective action problems in agro-enterprise development; there are many others, ranging from managing the process of community-led research and product development, to the marketing of products harvested from a community or multiple use resource such as a forest. The ability to organize, work collectively, establish and maintain relationships based on trust and reciprocity, and

resolve conflicts are critical to agro-enterprise success. Fafchamps and Minten, in a study of agricultural traders, conclude that in the real world with transactions costs, the returns to social capital may be as high or higher than the returns to labor or to physical or human capital.

Fafchamps and Minten's definition of social capital is essentially social networks. Social networks are one of the main forms of social capital, along with norms and values and information channels, that Coleman identified in his groundbreaking work on social capital. Networks have not been the focus on a great deal of empirical work in the area of social capital, however. In general, the social capital literature has focused on aggregate level variables such as the number of organizations in a community, using them as proxies for cohesiveness and trust within a community. Analysis often focused on outcomes at the community level as well (Putnam; Helliwell and Putnam; Helliwell; Brown and Ashman; Krishna and Uphoff). While studies often found positive relationships between social capital and aggregate development outcomes, exactly how social capital actually affected individuals decisions and outcomes was often not addressed.

The original conception of social capital made it very clear that social capital may not be evenly distributed within the community, and that while it should generally have positive benefits for those who have access to and use it, the consequences maybe different for society as a whole (Coleman, Sandefur and Laumann, Edwards and Foley). Sandefur and Laumann argue that "a specific form of social capital may vary in the degree to which its benefits generalize to different kinds of goals, and how forms that are valuable for some purposes may be a liability for other purposes" (p. 1043). Further work in social capital needs to look more specifically at how different forms of social capital facilitate individual's economic activities. Until we have a better understanding of this, we will not be able to address the important policy question of "how social capital can be constructed so as to enhance the quality and sustainability of livelihoods" (Bebbington, p. 2039). The fact that many forms of social capital appear to be important in different aspects of agro-enterprises make agro-enterprises an appropriate context in which to look in more detail at the role and impact of different forms of social capital in facilitating different types of economic activity.

Partners:

- Rural Agroenterprise Project (SN1)
- Centro de Estudios Ganaderos y Agrícolas (CEGA)
- Corporación Colombiana Internacional (CCI)
- CENICAFE

Donor:

- Systemwide Program for Collective Action and Property Rights (CAPRI)

1.2 PROJECTED FUTURE IMPACT OF RESEARCH

1.2.1 Community Management of Resources in Nicaragua - by: Nancy Johnson

Outstanding results

- At just over US\$10,000 per year, the value of improving water quality in a rural watershed is roughly equivalent to a one percent increase in bean yields.
- Given this value, the most cost effective options for addressing highly site specific problems like water quality are likely to be based on methodologies for improving community organization for resource management rather than on purely technological solutions.

Community-based resource management has arisen as a solution to the problem of multiple stakeholders, resources uses, and scales that complicate the sustainable management of watersheds in many parts of the world (Rhoades). By incorporating diverse stakeholders into both the research and development processes, project managers hope to include the different perspectives, goals and time horizons that are often not considered in more-top down, disciplinary watershed management projects. One key element in this approach is often the creation or strengthening of user groups or other organizations in which different stakeholders in the watershed can come together to share information and negotiate mutually acceptable and beneficial solutions to resource use conflicts (Ravnborg and Ashby).

The goal of this paper is to assess the economic impact *ex ante* of strengthening local organizations and institutions for natural resource management.⁷ The argument behind the need for community management of NRM is that the externalities associated with natural resource use often mean that managing resources for individual benefit will not result in a resource allocation that is also socially optimal. If externalities are taken into account in resource use decisions, both individual and social welfare can be increased. This logic implies that the benefit of strengthening local organizational capacity can be measured as the increase in the value of environmental services that results from more cooperative management of resources.

This study estimates the value of improving environmental services via improving resource management capacity in the Río Calico micro-watershed in Nicaragua. Watershed degradation is contributing to diminishing water supplies throughout the hillsides of Central America, and deterioration of water supplies was identified by the study community as its greatest NRM challenge (Pender et al; PASOLAC, Vernooy et al.) Both residents and researchers believe that strengthening the ability of local organizations to manage their resources will play a critical role in resolving the water problems, mainly through negotiating and implementing more sustainable land use policies and practices. Technological innovations may also play a role, however, it is expected that institutional innovations will be the primary mechanisms through which

⁷ Organizations are defined here as formal or informal groups while local institutions include things like rules and norms that govern resource use and that are locally developed and socially enforced.

improvements in water availability will be obtained. In the paper, contingent valuation methods (CVM) are used to estimate the value of improving water supplies in the watershed.

Assessing the impact of an innovation also requires looking at the costs associated with its development and implementation. The CVM captures only the gross benefits that individuals perceive from restoring water quality and quantity. The costs associated with changing land use practices are not included. While it is argued that to precisely estimate these costs would not be cost effective, the paper does examine different institutional options for stimulating change in land use, and sketches out what they would imply for both research and implementation costs. Even at this crude level of analysis, some conclusions can be drawn about which approaches would be most cost-effective given the magnitudes of the potential benefits associated with improved water availability. The paper is organized as follows: Section 2 describes the community, with particular emphasis on its water use and management issues. Section 3 describes the contingent valuation study, and analyzes the results and their implications. Section 4 discusses potential costs associated with institutional options for resolving water problems. Section 5 summarizes and concludes with some general suggestions for the design and assessment of projects to improve resource management and social welfare via improving local NRM capacity.

Water services in a rural community in Nicaragua

Description of San Dionisio

The municipality of San Dionisio is located in the hillsides of Central America, about 165 kms north of Nicaragua's capital, Managua, and about an hour from the regional capital, Matagalpa. The municipality contains 144 kms², about 80 percent of the micro-watershed of the Río Calico. The Río Calico micro-watershed forms part of the Río Grande de Matagalpa watershed.

The total population of the municipality is about 24,000, of which 11,000 live in the urban area and the rest in 16 small communities in the surrounding hillsides. San Dionisio is among the poorest municipalities in Nicaragua (Arcia, et al). This region of Nicaragua is agricultural, with smallholders growing maize and beans for both home consumption and the market. Almost all production is rainfed since lack of water has led to a prohibition on irrigation in the zone. In the upper parts of the watershed, farmers grow coffee. The wealthier residents also have cattle.

San Dionisio has problems with both total water availability and water distribution. According to residents, both the quality and quantity of water are declining over time, a problem noted elsewhere in the region (Vernooy et al, Pender et al, PASOLAC). Degradation of watershed resources, principally deforestation and burning of fields, are blamed for perceived declines in the quantity of water available year round in many water sources. Water contamination associated with agro-chemicals and with agro-processing activities is also thought to be increasing (Vernooy and Espinoza).

There are a large number of natural water sources such as springs, wells, creeks and rivers in San Dionisio, and by law all are property of the community and accessible by all. Given that the land around the springs is private, access can be and often is denied in practice. Some households also have access to potable water. There are currently 11 potable water projects in San Dionisio which provide water either directly to households or, to a lesser extent, to public taps in communal areas such as school yards. The projects were built in cooperation with government organizations or NGOs, with households providing labor in exchange for a connection to the system. Coverage is uneven; some communities within the micro-watershed have almost total coverage while others have no projects at all. Many potable water projects also suffer rationing due to dry season water shortages.

Results of a survey of water use practices

In July, 1998, a survey was carried out to obtain basic data on water sources and water use, as well as opinions about water-related problems and solutions. A total of 153 households were chosen from a sub-sample of 5 communities—Susulí, El Jicaro, El Cóbano, Zapote and Wibuse-- within the watershed, representing approximately 15 percent of the population of the communities.⁸ These communities were chosen because they are representative of the watershed in terms of water resources, water access and water-related problems and conflicts (Vernooy et al; Vernooy and Espinoza). Table 1 summarizes some of the data collected.

Socio-economic data

A limited amount of socio-economic data were collected in the survey. Average household size was found to be 6.47, close to the watershed average of 6.37 (Barretto et al). In terms of education, we asked for the number of years of schooling for the most educated person in the family. The average was four, which is consistent with the low level of school attendance in San Dionisio. Households in which the school-age children were not attending school were not uncommon in the sample.

Since data on cash income is often difficult to obtain and not especially meaningful in a partially-monetized economy like San Dionisio, economic wellbeing was measured using an index based on household economic activities. Previous work on local measures of poverty in the zone identified a relationship between poverty and sources of income (Ravnborg and Baltedano).

According to those findings, households that earned money from livestock were generally the best off, followed by households that had basic grains and coffee. Households that only produced basic grains, were less well off than those that had coffee but better off than those that ran small businesses. Finally, day laboring was found to be the least lucrative economic activity. Because of the predominance of basic grains farmers, the

⁸ Given the lack of reliable census data in the rural areas, it was necessary to conduct a census using key informants. Because this census is not totally reliable, we can only approximate the percent of households sampled.

index was constructed using the top two sources of income in the households. The average value of the index corresponds to basic grains production.

Water sources and time spent collecting water

According to the survey, 76 percent of households had access to potable water projects, ranging from 98 percent in Susulí, a large community that is well supplied with water, to none in Wibuse. Having access to potable water did not guarantee that the household did not use other sources, however. Twenty-eight percent of households with potable water experienced rationing in the previous year, lasting on average 1.3 months. During this time, households either reduced water use or sought water from other sources.

Only in Susulí, where water is abundant, could households get by with just potable water systems. In other communities, the average household used at least one and up to 3 other sources of water during the year. Those who do not have access to potable water use alternative water sources year round.

Respondents reported using rivers, springs and wells as water sources. Households often use different water sources for different purposes, for example, for bathing, washing clothes, for drinking water, or for watering animals. Sources also varied by community, which would be expected given their different locations and ecological conditions.

Wells are the most frequently used water source. Wells are also the most popular source for drinking water; 45 percent of drinking water sources were wells. This suggests that they are the source of the best quality water, a fact born when respondents were asked to rate the quality of water from different sources.

On average, respondents felt that the quality and quantity from these water sources was currently acceptable, however they felt that over the past five years both quality and quantity had gone down. This confirms the participatory diagnoses in the areas that identify declining water supply as an important NRM problem.

One of the main benefits of having potable water is the reduction in time and effort associated with traveling to water sources. Of the 43 percent of families that reported carrying water from other sources, the average time spent carrying water each day was 37 minutes, ranging from 4 to 200 minutes per day. This average is equivalent to 225 hours a year, or 5 and a half weeks at 40 hours a week. It must be noted that this is an underestimate of the total amount of time spent going to water sources since in many cases family members go to the water source to bath, wash clothes, or water animals without actually bringing water back to the house.⁹

⁹ This time could be important because the fact that women so often multi-task in the household means that time spent away from the household could have a high opportunity cost. For example, a woman who is at the river washing clothes cannot be at home doing child care. Either children are neglected, or someone else must do the work.

Health

Questions about health were included in the survey because one of the main costs of contaminated water is illness. Doctors at the local health center say they have noted an increase in water-related health problems in recent years, and they formulated the health-related questions for the survey. Two types of health effects were considered, gastrointestinal problems and skin problems.

Thirty five percent of households reported having a member with gastro-intestinal problems in the past 6 months, ranging from 24 percent on Susulí to 81 percent in Wibuse. Households reported that an average of 4 days per year were lost due to illness, 3 of the sick days were for adults. When asked whether drinking water gave people a stomach ache, 8 percent of households responded yes. When asked whether drinking water made sick people better, worse, or had no effect, on average was between being better and having no effect. In two of the communities, El Cobano and Zapote, people felt that drinking water made sick people worse.

Factors affecting different measures of illness were statistically analyzed in order to establish a link between water and health. While no significant relationships were found between number of sick days and water¹⁰, there was a significant negative relationship between incidence of diarrhea and access to potable water. No relationship was found between different water sources and illness.

In terms of skin problems, 18 percent of households reported a stinging sensation while bathing, ranging from 12 percent in *Susulí* to 38 percent in Cobano, the only community that reported widespread use of water from the Calico river. Eight percent reported skin rashes from bathing, ranging from 25 percent in Wibuse to 4 percent in *Susulí*. Eighty nine percent of the stinging and 65 percent of the rashes were reported to occur during the months of May through August. This is the rainy season, and also the start of the agricultural season when fertilizers and other agro-chemicals are used.

Valuing the benefits of improving water services using the contingent valuation methodology (CVM)

CVM and valuation of water services

Since the principal use of ground and surface water in San Dionisio is for domestic consumption, it must be valued directly as a consumption good, rather than indirectly as an input into a production process such as agriculture, agro-processing or energy production. In some ways, this complicates its valuation since empirical methods are often more reliable for inferring water's value than for measuring it directly. Where water markets exists, the value of changes in water supply can be estimated using data on prices and quantities from water transactions. When such data are not available—which

¹⁰ When the dependent variable was sick days and the dependent variables included household and water source characteristics, the only variable that was significant was mother education. This variable, as expected had a negative effect, but it was not robust to different specifications.

would be in the vast majority of the cases in developing countries—contingent valuation appears to be the best method for valuing water as a private consumption good (Young, 1996)

The contingent valuation method, in which people are asked hypothetical questions about how much something is worth to them, is not without controversy (see, for example, Cummings et al, 1986, and Mitchell and Carson, 1989; Randall et al, 1983). There are many conceptual and empirical shortcomings, however in general it is accepted as a reliable alternative to market-based valuation of goods and services. It is particularly useful in environmental analysis, and while it has been widely used in developed countries, its use in developing countries is also growing (Shultz).

Potable water projects have not traditionally been the focus of economic analysis, instead justifying themselves on the basis of people's right to have access to potable water (Whittington and Swarna). The experience of such projects, however, has not been entirely positive. Many potable water projects are not well-maintained by users and in some cases not even used (Whittington et al, 1990; Drangert). In the past the rule of thumb was that as long as the costs associated with using a water project did not exceed 5 percent of household income, households would have a positive demand for the project (Whittington and Swarna). Experience suggests that this may not be the case, and that a better understanding of household demand for water supply projects is needed.

A series of case studies of potable water projects was recently carried out in Asia, Africa and Latin America by the different development agencies that support projects to improve local water supply systems (see various studies by Whittington and collaborators; World Bank Water Research Team). In several of the studies contingent valuation methods were used to estimate the value of new water supply systems. In addition to doing statistical tests for reliability, the study authors also incorporated specific tests of the biases often suspected to invalidate the use of CVM data. Whittington et al (1990), in a study in Haiti, designed and implemented their survey instruments in order to be able to test for several important biases associated with CVM: strategic bias, starting point bias, and hypothetical bias.

Strategic bias occurs when a respondent feels that his or her response could actually influence a policy decision and therefore has an incentive to not answer truthfully. For example, if an individual feels that the results of the survey will be used to set actual service fees or tax levels, he or she is likely to underestimate willingness to pay (WTP). To test for this bias, Whittington et al used two form of their questionnaire, one which stressed the fact that people would not be charged for the new water system, and another which said nothing about whether or not people would have to pay. If strategic bias existed, people who responded to the first question should have higher WTP than those who responded to the second question. In fact, the mean WTPs of the two groups were not significantly different, which does not support the hypothesis of strategic bias.

Starting point bias could occur as a result of the fact that in a bidding-game format—where respondents are offered different prices and asked if they would be willing to pay

them—the initial price offered may affect the final WTP. The bidding game format is preferred over open ended question since it approximates a real economic decision in which a consumer sees the price of a good or service and makes a yes or no purchase decision (Shultz). However there is always the danger that by initiating the question with a certain price, the interviewer is giving the respondent clues about what the “appropriate” range of WTP should be. To test for the presence of starting-point bias in the survey, the authors used three different surveys, each of which started with a different value. Again, the mean WTPs from the three groups were not significantly different, which does not support the existence of starting-point bias.

Finally, the authors test for hypothetical bias, which would occur if respondents were unable to conceptualize the situation they are being asked to value in a realistic fashion. If people are not used to valuing the environment it may not be feasible for them to say what they would be willing to pay to improve environmental services. This may be especially true if the survey is being carried out in a rural area of a developing country where the economy is not fully monetized. If hypothetical bias is a problem, the results of the survey will likely be random numbers invented by the respondents to satisfy the questioner but bearing no relationship to the actual value that the respondents place on the good or service in question.

Testing for hypothetical bias in the context of WTP for improved water services can be done using consumer demand theory. Economic theory suggests certain relationships between WTP and personal characteristics such as income or education, and characteristics of the water source, such as costs of using existing services. Whittington et al model WTP and confirm the expected relationships in the data. This results suggest that respondents were able to understand and evaluate the question and give responses that accurately reflected their WTP.

Willingness to pay for improved water supplies

As part of the San Dionisio survey, respondents were asked about their willingness to pay for improved water services, using the following question, *“Imagine that it were possible to improve your most frequently used water source, be it potable water, well, spring, stream or river. Improve the source means that there would be more water of better quality from the same source. Think about how much it would be worth to you to have water from this source.”* Respondents were then asked if they would be willing to pay a declining series of values per month, beginning with 15 córdobas (US\$1.43 at the current exchange rate) and ending with 3 córdobas, in increments of 3 córdobas.

Enumerators, local residents who received training in how to implement the survey, were told to explain to respondents that the goal of the survey was to see how important the problem was to people, not to determine water charges. Much time during the training session was devoted to convincing the enumerators that this was true. The reputation of CIAT in the community and the fact that surveyors were local people working in their own communities were expected to help reduce strategic bias.

Which values to use in the questions were chosen during the process of pre-testing the survey. During the pre-tests, some respondents were asked the question in an open-ended fashion while others were given ranges of possible values based on the opinion of key informants within the community. The vast majority of responses fell into the range 15 to 0 córdobas.

The question was phrased in a very general way, and no attempt was made to quantify how or how much water supplies would improve. This is clearly a shortcoming in terms of being able to value specific levels of change, however it was felt that asking people to value specific quantity or quality changes would be very difficult. Rather the question was left open so that people would respond based on their own definitions of what improvements would occur. Given that water problems in San Dionisio are defined in relation to historical levels which are observed to be declining, it was felt that people would use those historical levels as benchmarks in their responses to the question. Allowing people to use their own judgement and experience regarding what levels of improvement they could reasonably expect would be the best way to obtain feasible and realistic estimations of what improvement would mean to them.

On average households were willing to pay 3.95 córdobas (US\$0.38) a month for improved water. Among the communities, the average willingness to pay (WTP) ranged from 11 córdobas in Cobano to .21 in Zapote (Table 1). The Zapote average is significantly lower than in other communities, even Susulí where water problems appear to be minimal. Zapote does have significant problems with water availability; potable water projects in the community suffer rationing for an average of over 6 months a year. Zapote is known as a well-organized community, and is in the process of trying to deal with its water problems. The WTP result may reflect the fact that there is opposition in the community to raising water charges or implementing other similar measures such as water-use meters. People want to solve the problem in other ways. The enumerator in Zapote is involved in water management, and therefore the survey may have been linked to efforts to increase water charges, in spite of efforts to convince people otherwise. This appears to be a clear case of strategic bias. Therefore, it would be more appropriate to use the average values from the other community as an estimate of the average WTP among the study communities.

Excluding the 17 observations from Zapote, the average WTP in the community is 4.40 córdobas, or US\$0.42 per month. On the level of the micro-watershed, the value of improving water quality on an annualized basis for the micro-watershed would be US\$10,362.¹¹ Estimating income at the daily wage of C\$30, this would be .61 percent of an annual income of US\$823.¹² While no other studies of improving natural water sources could not be found, the literature on potable water systems reports willingness to pay values from less than .5 percent of income to 10 percent, or even higher during times of drought (Whitting and Swarna). In cases where reliable alternative sources in the form of traditional wells or village pumps were available, households were willing to pay

¹¹ Based on an estimate of 2056 rural households

¹² Assuming that a person was able to find work 24 days a month, the monthly income would be C\$720.

1 percent or less of their income to move up one level of service, for example from traditional sources to village pumps or from village pumps to private taps.

A test of the reliability of the CVM results

To test the reliability of the results, statistical analysis was conducted of the determinants of WTP. The statistical model for examining the determinants of WTP is ordered probit, which takes into account the fact that the dependent variable (WTP) was constrained to take one of the five values offered in the survey question (Whittington et al; Greene, p. 672-676; Limdep manual;).

Consumer demand theory suggests demand for a good is based on its price, the price of related goods (substitutes and complements), and individual/household characteristics such as income or education. This is analogous to WTP for a good, and the same theoretical relationships would be expected to apply, with the exception of own price which is not included (Whittington et al).

Theory suggests that WTP would be positively related to income and to the costs associated with using existing water services. In this case, the main cost of existing service would be time spent collecting water. While improving a water source will not make it any closer to the house, one of the main reasons that people go to distant water sources is that the nearby ones are either dry or dirty. Therefore improving the quality of these water sources would reduce time associated with carrying water. By this same logic, women could also be expected to be willing to pay more for water improvement than men since they are the ones who do most of the water carrying work (World Bank Water Research Team).

The results of the analysis of using these and other variables hypothesized to affect willingness to pay are presented in Table 2. The two main hypothesized relationships are confirmed by the data, namely income and the cost of existing sources. Income is positively related to willingness to pay, however this relationship is only significant at the 15 percent level. Given the imprecision of the income index, this result could be considered satisfactory. The amount of time a household currently spends carrying water is also positively and highly significantly related to WTP.

The dummy variable for sex was not significant, suggesting that women are not willing to pay more than men for improving their existing water sources. In a related study based on the same fieldwork which looked at WTP for potable water projects, women were willing to pay significantly more than men (Johnson and Baltadono). One explanation is that in the case of potable water projects, payment was in terms of work days over a six month period rather than money. Some studies have found that women are more likely to commit household labor resources than cash (World Bank Water Research Team).

A dummy variable for potable water was also included to control for the fact that people may feel differently about paying for the improvement of natural sources than for potable water projects. Which sign this variable should take is unclear. On one hand, people are

accustomed to paying for potable water and therefore may find it easier to imagine paying more for improved service. On the other hand, people who are already paying for a service that is often not adequately provided may be disinclined to even pay more so that it can be improved. The idea of paying more to improve the potable water projects has been raised in several communities, and many people are strongly against it. This ambiguity is reflected in the results of the analysis. The variable, equal to 1 if the household had potable water, is not significant. A dummy variable was also included to control for the apparent strategic bias in WTP in the community of Zapote. This variable, equal to one for households in Zapote, was highly negatively related to WTP, as expected.

In general, the results of the analysis support the use of the WTP data as an estimate of the value of improving water supplies in rural San Dionisio. The WTP estimates do not appear to be random numbers, but rather are consistent with what economic theory would predict about the major factors that influence WTP. These results support the previously cited work about the usefulness of CVM for valuing changes in water services in developing countries. They also extend those results beyond the case of potable water projects to include improvements in natural water sources.

Interpretation of the results of the CVM analysis

The value US\$10,362 can be interpreted as the value of providing everyone in the watershed with improved water supplies in their principal water sources. As such, it is the maximum benefit possible; institutional or technological changes that improve water supplies for only some would have a lower value. On the other hand, the WTP measure only includes the benefits that people perceive. If people are unaware of benefits—as may be the case with health benefits (Whittington and Swarna)—or if there are externalities associated with water source improvement, then this estimate would underestimate the true value of the social benefits.

Another shortcoming associated with WTP is that it is related to income, meaning that poorer people will always be willing to pay less than richer people, other things equal. Five percent of an average income of US\$800 is 5 dollars, while 5 percent of an average income of 30,000 would be \$1500. If this value were used in the calculation of watershed value, improving water supplies would be worth about 3 million dollars a year. This inherent bias in favor of high incomes would appear to argue for the use of additional criteria—for example, poverty alleviation or social justice—in addition to economic efficiency in making decisions about which types research and development project to fund. Whittington and Swarna argue against overemphasizing the income bias, however. The wide ranges of WTP that have been found in empirical studies suggest that there are other important factors besides income that affect WTP and that economic analysis is capable of capturing the value of these other factors.

As mentioned earlier, the costs associated with alternative water sources are also a significant determinant associated with WTP. In the case of San Dionisio, households report that current levels of quantity and quality are acceptable, however they are

concerned that quality and quantity are declining over time. In five years, if nothing is done about water situation and the deterioration continues, WTP may be significantly higher than what was observed in 1998. This would imply that waiting until a problem gets worse will increase the return associated with solving it.¹³

There are reasons to believe that the value of US\$10,326 could over or underestimate the true benefits that would be realized by improving water supplied in San Dionisio. As such, the estimate should be considered preliminary, and more empirical research should be done on estimating the magnitude of the benefits associated with improving water and other environmental services in rural watersheds. The results of this analysis suggest that such benefits may be relatively modest—in this case roughly equal to a 1 percent increase in bean yields in the micro-watershed (Beltran). This implies that if economic efficiency is an important criterion for research or project evaluation, then the types of solutions that should be considered for solving these problems must either be low cost or very widely applicable.

Some Institutional Solutions and their Costs

Relating costs and benefits

Looking at benefits alone tells us little about the possible returns associated with solving a problem. We need also to consider the costs associated with developing and implementing a solution. As mentioned earlier, previous work in the area identified institutional solutions as possibility for addressing the water problems. This was confirmed in the survey results. Only 20 percent of survey respondents thought that the solution to water problems in San Dionisio was to build more water projects. The remaining 80 percent believed that other solutions involving changes in land use practices would be more appropriate.

Therefore, the ideal next step in this study would be to construct a bio-economic model that would permit examination of the relationship between land use and water availability in the micro-watershed. Different land use practices could be simulated, and the distribution of the associated costs and benefits calculated. With this information, it would be straightforward to see whether and how welfare-enhancing land use changes could be implemented, and to identify relevant stakeholders.

Unfortunately, such models are rarely available even in developed countries (Mostaghimi et al). The data requirements are enormous and the results very site specific, which means that the effort would likely not be cost effective. Nonetheless, it is possible and useful to identify some possible solutions and sketch out their implications for costs. This section evaluates two possible “institutional” solutions for improving

¹³ One way to see whether the gravity of the problem changes WTP would be to repeat the survey done here during the peak of the dry season. The data reported here were collected in July, shortly after the rainy season began. Memories of the dry season were not far in the past, however it might make a difference has the survey been done in March or April. Re-visiting the same households for a follow up study would not be possible in this case since the first survey was done pre-Hurricane Mitch. The hurricane had a significant effect on the landscape, including water sources. Thus, the two surveys would not be comparable.

water supplies in the zone: protecting water sources and reducing burning of fields as a form of land preparation.

Protecting the water source

One way of maintaining or improving the quantity and quality of water is to protect the water source. Local organizations are expected to play an important role in promoting and maintaining the establishment of buffer zones around water sources. The logic behind this is that there are significant externalities and free rider problems associated with these conservation measures, and collective action will be necessary to negotiate acceptable standards for buffer zone creation, and to ensure compliance (Ravnborg and Ashby).

Information on water source conservation activities was collected in the survey, and the analysis reveals a slightly different story. According to the survey, households reported protecting 44 percent of water sources. Protection measures include cleaning, planting trees, and building or maintaining walls or other structures. The most significant determinant of whether or not a household engaged in conservation activities appears to be whether or not the households owned the water source (Johnson).¹⁴ Sixty two percent of water sources were reported to belong to someone else, and households are significantly less likely to engage in conservation measures on these water sources than they are on water source located on their own land. (Table 3).

A factor that was not correlated with engaging in conservation activities is the number of other families using the water source. Households reported sharing their water sources with between 0 and 20 other households, yet this was not appear to affect their decisions to engage in conservation activities. If shortages existed and if externalities and free riding were discouraging conservation, a negative relationship would be expected between willingness to engage in conservation and the number of other families using the water source, controlling for other factors. This relationship was not found in the data.

Given that specific water sources were not identified in the survey, it is not possible to say what percent of total water sources in the survey communities are currently being protected. Depending on how the location and use of water sources are distributed, it could be the case that every spring in need of protection is being protected by its owner, and that other users, who are not doing anything to protect the spring, are free-riding on the conservation activities of owners. The skewed distribution of land ownership in the municipality and the reported problems with access to water sources would argue against the hypothesis that current situation is resulting in an optimal level of conservation, however.

If lack of secure access to water sources is discouraging conservation, there is a clear role of local institutions in the resolution of the problem, namely in negotiating access and use rights. Conservation appears to be profitable on one's own land since people are already doing it. If tenure is the main barrier to undertaking conservation measures, then

¹⁴ As mentioned earlier, water sources are technically public property. However ownership of the land around the water sources appears to confer a de facto title to the water source as well.

resolution of tenure problems could be expected to lead to increased conservation of sources that are used by non-owners.

What would it cost to increase the ability of a local organization to facilitate this negotiation of property rights? If no local organization exists, then an appropriate one would need to be established. This will certainly involve some training and capacity building activities. If this were done by an NGO using existing techniques, the costs should be relatively modest. If it were done by a research institute as part of an social science action research program, the costs will likely be higher. In the case of the action research programs, however, all the costs would not need to be justified by the local benefits since presumably the research results will be applicable to many communities and many resource management situations. In the case of both NGOs or research institutes, it is likely that the local benefits will spillover beyond just the case of potable water. Local organizations and institutions are, at least in theory, multi-purpose.

The total cost of strengthening organizational capacity, as well as the probability of success associated with a capacity-building intervention, may depend on how well organized the community currently is. In the case of San Dionisio, the community is not known for its ability to cooperate, however there are some community-level groups that have shown some capacity to deal with water related issues. Every community that has a potable water project has a potable water committee or CAP, from the Spanish acronym. Initially, the CAPs focused on system maintenance, however they have recently become involved in broader water management issues such as conservation of water sources and negotiation of water access rights with other CAPs. A process is underway to create a second-order organization of CAPs to manage water at the supra-community level.

The CAPs clearly offer an opportunity for building on existing capacity in local resource management. Strengthening these groups—in particular with regard to dealing with to property rights issues—would very likely be much more cost effective than establishing a new organization. In the survey, 67 percent of the households that were familiar with the operation of CAPs supported their branching out into broader NRM activities. San Dionisio is also not unique in that it has local water organizations. Pender et al found that in a large scale study of rural communities in Honduras, potable water was the main resource around which communities could generate collective action. Building on the communities' ability to address a critical and relatively straightforward issue such as potable may be a useful way to begin to address other more complex NRM issues.

The previous discussion focused only on whether households do or do not engage in conservation activities at the water sources they use. It did not address issues of productivity of conservation practices, nor externalities associated with water source conservation. Increasing the productivity of conservation activities should induce more people to engage in conservation activities, as well as increase the level of conservation among those who are already doing it. Quantifying any off site benefits of conservation could also increase conservation activities if the externalities could be internalized via coordinated resource management.

Both of these situations suggest a need for further research on water conservation technologies, their productivity, and their impacts. A detailed analysis of the cost-effectiveness of the research activities or on the optimal levels of conservation is beyond the scope of this paper, however a general observation can be made. Unless it can be shown that this type of research is very inexpensive, would be widely applicable beyond the research site or beyond just water conservation, or would lead to such significant increases in water availability that it would lead to non-marginal changes in current water use patterns—eg irrigated agriculture would become possible—the size of the benefits associated with any potential new conservation technology do not appear large enough to justify the research costs. It bears repeating that any widespread effort to enhance productivity would still have to address the land tenure issues as a barrier to adoption.

There is an effort underway in San Dionisio to test the productivity of different trees species for water source protection. CIAT and other research partners operate an innovative system of community-managed experimental plots in the micro-watershed, and trees species were identified by residents as an area of interest.¹⁵ The experiment currently being carried out is very small scale, involving a few water sources and about a dozen trees species. Tree species are available for interested residents to take home and try for themselves based on the results that they observe the experimental plot. This type of small scale, participatory approach to testing technologies appears appropriate given the magnitude of the problem it is designed to address.

Reduce the use of burning as a method of land preparation

Another option for improving water availability would involve implementing broader changes in land use practices within the micro-watershed. Many people in the survey mentioned that burning fields as part of land preparation contributed to reduced water availability, an observation that has been noted elsewhere (Pasolac; Ravnborg and Ashby).

Little scientific information is available about the effects of burning on water availability, especially on the off-site effects. There are few rigorous empirical studies associated with the costs and benefits associated with burning in the context of crop production. Nonetheless, a number of anti-burning campaigns have been carried out over the past few years, and the documentation associated with these efforts provides some insights into why producers choose to burn.

Anti-burning campaigns carried out in San Dionisio and other parts of the Central America have had a moderate degree of success in reducing burning (Castro; Reyes; anon). It appears that with regard to burning there are essentially two types of farmers. The first are those for whom burning is a habit that can easily be dropped when its disadvantages are pointed out. Since many if not most of the disadvantages of burning are plot-level and do not involve externalities, the way to reduce burning is to convince farmers of the connection between burning and loss of soil, soil fertility, and water penetration and retention capacity (Castro).

¹⁵ Add more detail on SOLs here.

The other group of farmers are those for whom burning is an critical part of the production process and cannot be profitably abandoned. Burning requires much less labor than other forms of land preparation and it reduces pest and weed infestations (Castro Blandón). In some areas, especially the hillsides, crop production would be nearly impossible without burning due to weed and pest problems (Estrada). Campaigns carried out by governments and NGOs are successful with the first group of farmers, but are unlikely to have an impact on the second. These producers need either technological alternatives that are superior to their current practices, or compensation for the losses they would suffer.

In the context of the Río Calico water supply problem, one potential role of local organizations would be to formulate land use agreements that take into consideration the potentially conflicting objectives of burners and of water users. Through a combination of education, negotiation, social pressure and sanctions, a strong local organization could reduce or eliminate destructive practices such as burning. Critical to this process would be the identification and quantification of the benefits and costs associated with burning. As mentioned earlier these relationships are not currently well understood, and would require a significant long-term research effort to understand them sufficiently to be able to be of use in developing technologies and policies.

Given the magnitude of the benefits associated with improving water supplies in the micro-watershed, it does not appear that this type of research could be justified solely on the basis of off-site water benefits. It would have to be demonstrated that the research would be widely applicable beyond the specific watershed, and that it would be useful for solving many other problems besides that of declining water supplies.

There is evidence that burning is causing off-site problems not related to water. Burning is usually carried out in late spring, and during this time much of Central America, including major cities, is under a cloud of smoke. This has been known to cause airport shut downs and other problems in the region, and to contribute to air quality problems as far away as Florida, USA. The State of Florida is willing to invest in research and development initiatives designed to reduce burning (Sanz), something that has been suggested in other parts of the world where burning of fields and forests is widespread (Tomich)

Morally unappealing as it may be, it is very likely that the economic benefits associated with reducing air pollution in Florida are significantly higher than the benefits of improving water supplies in rural Central America. If offsite benefits such as those realized in Florida are included among the benefits associated with a reduction in burning, this would likely change the economics of the research investment quite significantly. Research activities focused on developing alternative technologies to burning in the production system, or on designing policies to reduce burning and compensate individuals for the costs incurred would likely be economically justifiable. In the former, local organizations may not have a major role to play, however in the latter they would likely be very significant.

The role of local organizations in negotiating with external agents is important in the watershed context, and may be the major way in which significant investments in research and development can be justified, not just in the case of smoke but also in rural-urban water conflicts (see for example, Estrada and Rivera). The value of solving site specific local problems may not be large enough to justify investment on economic grounds, though it may be appealing on other grounds. If this off-site approach is going to be successful, however, more research needs to be done on the characteristics of local organizations that can manage external versus internal problems. Preliminary evidence suggests that the same organization may not be able to do both, which would suggest the need for articulation of different types organizations within the watershed (Ravnborg and Ashby, Westermann).

Summary and Conclusions

This paper estimated the value of improving water quality and quantity in the Río Calico watershed to be US\$10,362 dollars per year. The estimation was done using contingent valuation methodology, and the reliability of the results in statistical analysis suggest that this method can be used to value changes in environmental services in rural areas of developing countries.

While significant in the context of the poor communities in the study, US\$10,362 is not an enormous sum of money, roughly equivalent to a one percent increase in bean yields in the micro-watershed (Beltrán). While these results are preliminary and more evidence would be necessary before drawing any definitive conclusions about the magnitude of the value of benefits to rural communities of improving local NRM, these results suggests that they may not be very high compared to other development-oriented investments.

This does not mean that the benefits are not important, nor unworthy of research and development investment. As mentioned earlier, economic valuation techniques such as CVM may be inherently biased against both the poor and against preventative rather than restorative NRM interventions. In addition, an investment is not judged on the basis of the benefits alone; the costs must also be considered. If cost are low enough, the return on investment can still be attractive.

Two potential solutions to the water problems which are based on institutional innovation were considered: protecting water sources and reducing burning as a method of land preparation. In the case of protecting the water source, technologies such as tree planting can reduce degradation of water sources, however there is evidence that institutional problems—namely land tenure—may be discouraging the adoption of conservation measures. This suggests an opportunity for re-negotiation of tenure rules for the mutual benefit of land owners and water users. Since a local organization already exists and has some capacity to deal with these problems, it appears that this would be a cost-effective way to approach the problem. Since improved organizational capacity is very likely to be useful in other areas, unexpected benefits may also be generated.

The other option for improving water availability is to reduce burning of fields as a form of land preparation. Burning is thought to have negative effects on water availability. In this case, little is known about the precise relationships between local ecology, land use practices and water availability, and the magnitude of the estimated benefits associated with improving water supplies alone would not appear to justify a significant increase in knowledge in this area.

Off site benefits of reducing burning could be larger than the benefits inside the micro-watershed, however. Casting the problem in this framework may warrant a significantly larger research investment than when the aim was to solve a local problem with a local solution. Local organization may still have a major role to play in negotiating with external actors. The question is whether the same types of organizations and organizational capacity can facilitate both local solutions to local problems and local solutions to regional, national and international problems. This is an important question for further research.

In general, it appears that given the modest size of the benefits that might be generated by resolving any particular resource conflict or management problem in a micro-watershed, and given the diversity of watersheds and communities in developing countries, an intensive, high-cost research approach will not be justifiable. Rather, research must focus on upstream strategic issues of broad applicability, while adaptive research would focus on methodologies for finding solutions rather than solutions themselves. These methodologies, if applied by NGOs, local government agencies, or communities themselves, could prove to be cost effective ways to find local solutions to local problems such as the one analyzed here. Multipurpose intervention such as strengthening organizational capacity may have particularly high payoffs.

Table 1. Average values of selected variables

Variable	Total	Cobano	Zapote	Susulí	Jicaro	Wibuse
Sample size	153	9	17	85	26	16
Average household size	6.47 (2.91) ⁺	8.56 (4.10)	6.88 (2.39)	6.01 (2.81)	6.23 (2.3)	7.69 (3.44)
Years of education of the most educated person in the household	4.18 (2.84)	4.67 (2.78)	4.18 (2.43)	3.82 (2.45)	5.85 (3.92)	3.06 (2.24)
Percent of households who own land	80 (40)	67 (50)	76 (44)	79 (41)	85 (37)	87 (34)
Index of sources of income*	13.59 (2.58)	14.44 (1.67)	15.41 (2.58)	13.04 (2.31)	15.12 (2.52)	11.56 (1.97)
Percent with access to a potable water project	76 (.43)	44 (53)	82 (39)	98 (15)	62 (50)	0
Number of months per year during which potable water is rationed	1.3 (2.54)	3.75 (2.5)	6.14 (3.51)	.17 (.7)	2.31 (1.96)	na
Number of alternative water sources used	.79 (1.0)	1.11 (.60)	1.53 (.62)	.09 (.29)	1.54 (.95)	2.31 (.87)
Number of alternative potable water sources used	.56 (.77)	.89 (.78)	1.06 (.43)	.07 (.26)	1.12 (.86)	1.56 (.73)
Index of water quality in alternative sources**	1.32 (.51)	1.25 (.420)	1.29 (.47)	2.17 (.41)	1.14 (.33)	1.27 (.49)
Index of potable water quality in alternative sources **	1.48 (.54)	1.21 (.39)	1.37 (.48)	1.88 (.64)	1.36 (.48)	1.65 (.57)
Index of change in water quality***	2.09 (.43)	1.94 (.42)	2.11 (.33)	2.33 (.52)	2.03 (.41)	2.14 (.49)
Index of change in water quality***	2.16 (.48)	1.94 (.68)	2.08 (.28)	2.38 (.52)	2.12 (.38)	2.30 (.56)
Willingness to pay for improved water supplies	3.95 (3.84)	11 (3.1)	.21 (.8)	3.14 (2.6)	7.04 (4.56)	3 (0)++

+ Standard deviations are in parentheses

* index goes between 1 and 20, with 20 representing highest income.

** The index goes between 1 and 3, with one being the best. Note: this index refers to water sources other than potable water projects.

++ In Wibuse, only a few people (get number) answered the survey due to a misunderstanding about implementation procedure

Table 2 Determinants of Willingness to Pay for Improved Water Supplies

Dependent Variable	Sign on coefficient	P-value
Income index	Positive	.1447
Time spent carrying water (Minutes/day)	Positive	.0015
Dummy for potable water (0=no access)	Negative	.3370
Dummy for sex of informant (0=woman)	Negative	.3844
Dummy for Zapote (1=Zapote)	Negative	.0000
Number of observations	128	
Chi square (degrees of freedom)	60.76	
Significance of model	.00000	

Table 3. Percent of water source with conservation measures, by tenure of land on which spring is located (n=115)

	On own land	On Public land	On someone else's land
No conservation	30	44	81
Conservation	70	56	19

Persons and Institutions Involved:

- Maria Eugenia Baltodano, CIAT-Ladereas, Nicaragua (PE3)

Donors:

- Rockefeller Foundation
- SDC

1.2.2 Agropastoral Systems for the Savannas in Latin America: A Cost-benefit Analysis - by: Albert Gierend

Introduction

The Savannas in Latin America cover around 243 million ha and are one of the major under-utilised production frontier on the continent. 180 million ha are located in Brazil (Cerrados), 17 million in Colombia (Llanos), 28 million ha in Venezuela, and 4 million ha in Bolivia (COLE, 1986). Only in Brazil and Venezuela the Savannas are rapidly exploited. Traditionally the Savannas has been used for extensive grazing and ranching

on unimproved native grasses. The introduction in the late 60s of improved pasture grass (e.g. *Brachiaria decumbens*) and other species tolerant to low soil fertility and acidity led to rapid expansion of the area of improved grazing land and increased beef production. For example in Brazil, the number cattle in the Cerrados grew by 3.5 in the 1970s and by 4.2 percent in the 80s while the area under improved pasture expanded in the 1970 to 15 % and in the 1980 reached more that 40% (WALLIS, J. A. N. 1997, p. 95).

Technical advances in annual crops (acid tolerant varieties, improved soil and fertility management, large-scale mechanisation, and the rise of soybean as animal feed) has triggered rapid expansion of intensive and mechanised crop production. The greatest dynamics in commercial agricultural exploitation of the Savannas took place in the Brazilian Cerrados which extend to just over 2.0 million square km (204 million ha). Much of the land is still not used intensively but the potential that as much as 137 million ha (67 %) could be brought into arable farming. Of this potential cropland only about 4.6. million ha (3 %) were under cultivation in the 1970s, but that area has more than doubled to 10.2 million ha by 1990. Still 92 % to what agricultural believe is the potential total crop area is not utilised. Due to this dynamic expansion of cropland, the Cerrados now produce a large proportion of the national production for major crops such as soybean (34.2 %), maize (21.1), rice (20.9 %), beans (19.4 %), and coffee (19.5 %)(WALLIS, J. A. N. 1997, p. 88).

The clearing of the Cerrados, principally for soybeans, that took place in the 80s and excessive use of discs for land preparation resulted in severe water and wind erosion on cropland. Pasture as well is said to face large degradation with more than 15 million hectares of improved pasture (*Brachiaria*) are highly degraded (SANZ et al, 1999, p. 233).

The necessity to revert the degradation process of native and improved pasture and as well as to slow yield decline in heavily monocropped and mechanised areas has triggered the integration of livestock and crop production through agropastoral systems. The advantages of agropastoral mainly steam from synergistic effects between its livestock and crop components. According to LOPES et al. (1999, p. 24) these advantages can be summarised as follows: increase in soil fertility and soil biological activities, improved nutrient cycling and better timing of nutrient availability according to plant requirements, additional nutrient supply for pasture establishment, improvement of the physical and chemical soil conditions, reduction of pest and weed incidence. All these factors have contributed to the economic attractiveness of agropastoral systems compared to the productions systems currently in use which has been supported by various economic analyses (e.g. RIVAS, et al. 1991, BOTERO, R.B. et al. 1991, and ACEVEDO, L.V. 1990, and others).

The purpose of this study is to evaluate the impact, simulate the process of future adoption, and generate a detailed spatial distribution of the potential benefits across the 4 Savanna countries. Some refinements are added compared to older studies, such as a more differentiated assessment of the adoption process by country and even departments, the inclusion of the effect of degradation on yield dynamics, and the introduction of

agropastoral systems not only as an alternative to pure pasture but also to crops planted in monoculture.

Adoption of Agropastoral Systems

In the Llanos of Colombia where rice/pasture systems are said to be especially successful 5000-6000 ha were sown either to rice or rice/pasture in former extensive grazing areas and in Brazil about 50,000 ha of degraded pasture have been renovated by sowing rice/pastures using the "sistema Barreirão" (THOMAS et al. 1995, p.76). Another study reports from a sample of 73 farms in the Colombian Llanos being surveyed in 1989 and 1992 that only 1.5. % of the area was planted with crop/pasture rotation from which 82% consisted of pure grass pasture without legumes (CADAVID, J.V., and SMITH, J. 1994, p. 68). However these recent adoption figures should be looked at with caution and are not well suited for representing the Savannas on a global scale since they have been taken from small samples, and only cover limited area (eventually biased towards areas with heavy research and extension activities). Moreover, it has been observed that where integration of crop and pasture were undertaken both activities were maintained on separate areas of their farms, thus overestimating the existence of real crop/pasture rotations on the same plot.

Major obstacle to adoption are seen in the need for more infrastructure, and higher capital requirement, for e.g. land preparation, fencing, or grass seeds. Additional animal too may be requires to increase the stocking rate in line with higher feed availability per ha. Additionally, more complex farm administration for controlled grazing, rotation of animals, and establishment of the rice crop imply greater management efforts that land owners often absentee landlords cannot fulfil without hiring a resident trained administrator. Another obstacle for widespread adoption is their tradition as either ranchers or farmers in which livestock activities and crop production are mixed or even integrated in a crop/pasture rotation. Among farmers who integrate perceive livestock rather complementary to grain production rather than substitutes to their principle grain production. Pasture and livestock is rather held on land unsuitable for crops and mechanisation (AYARZA, M.A. et al. 1999, p. 22).

Because of the paucity of empirical adoption estimates and studies to identify the thriving forces behind adoption the extend and speed at which adoption takes place must be looked at by recognizing particular situations in each country and region. Key determinants such as infrastructure, market access, level of commercialisation, priority in national development, research and extension, were used to develop a consistent and logic pattern of adoption estimates by country and departments. It was assumed that all 4 countries differ considerably with highest adoption (between 10 and 40 %, see Table 1) occur to Brazil due to favourable circumstances such as good infrastructure, high priority in research and extension, predominance of large holdings with sufficient investment capital, and innovative behaviour of farmers and ranchers. Next follows Venezuela with good infrastructure and market access but a somehow low priority given to agricultural research (the focus is more on industrial development). The the lowest adoption rates are assumed for Bolivia and Colombia attributing to major shortcomings such as a lack of investment capacity of the Bolivian Farmers and the persistent insecurity in the Colombian Llanos caused by the Guerrilla. At the next lower level, departments in the

countries were subdivided into 3 major groups (low, medium and high adoption potential) according to the adoption determinants outlined above.

Table 1. Estimated future adoption rates (in %) of agropastoral systems (rice/pasture rotation) in pasture and annual crops (monocropped rice).

	Conversion of pasture			Conversion of monocropped rice		
Adoption rate by departmental group	Initial adoption rate	Adoption after 10 years	Maximum after 15 years	Initial adoption rate	Adoption after 10 years	Maximum after 15 years
Colombia						
Group 1: high	0.5	15	20	0.5	5	8
Group 2: medium	0.5	10	15	0.5	3	5
Group 3: low	0.5	7	10	0.5	2	4
Brazil						
Group 1a: high	0.5	25	40	0.5	13	20
Group 1 b: high	0.5	15	30	0.5	13	20
Group 2: medium	0.5	13	20	0.5	6	10
Group 3: low	0.5	6	10	0.5	3	5
Bolivia						
Group 1: high	0.5	10	15	0.5	/	/
Group 2: medium	0.5	9	12	0.5	/	/
Group 3: low	0.5	6	8	0.5	/	/
Venezuela						
Group 1: high	0.5	25	40	0.5	13	20
Group 2: medium	0.5	20	30	0.5	7	10
Group 3: low	0.5	10	15	0.5	5	8

Colombia

Group 1: Caqueta, Meta; Group 2: Arauca, Casanare; Group 3: Guainia, Guaviare, Vaupes, Vichada

Brazil

Group 1a: Goias, Minas Gerais; Group 1 b: Mato Grosso, Mato Grosso do Sul; Group 2: Bahia, Brazil, Ceara, Para, Piaui; Group 3: Amapa, Amazonas, Maranhao, Rondonia, Roraima, Sao Paulo, Tocantins

Bolivia

Group1: Beni, Santa Cruz; Group 2: Cochabamba, La Paz; Group 3: Pando

Venezuela

Group 1: Barinas, Guarico, Portuguesa, Anzoategui; Group 2: Apure, Bolivar, Monagas, Cojedes, Group 3: Amazonas, Aragua, Carabobo, Delta Amacuro, Distrito Federal, Miranda, Yaracuy, Sucre

Further distinction is made whether agropastoral system is introduced on former pasture as a means for recuperation and renovation of degraded pasture, or introduced on crop land aimed at increasing soil fertility and reverting the process of long-term yield decline in annual crops planted in monoculture. It is hypothesised that crop/pasture rotation introduced in pasture is more likely to occur because it provides an additional high value crop and revenues rather than introduced in annual crops where farmers may be reluctant to accept lower cash crop earnings during the time land is held under pasture. The path of future adoption is approximated by a logistic function that takes the form:

$$Y_t = \frac{a}{1 + be^{-ct}}$$

with Y_t = adoption rate at year t

a = maximum adoption rate (ceiling level)

b, c = constants

t = time

Experts were asked to provide 3 points, namely the adoption at the begin of the process (which was assumed to be 0.5 %), adoption after 10 and after 15 years representing the time where adoption almost reaches its highest level. Based on these 3 points the coefficients a , b , and c of the logistic function were then approximated by the MS Windows curve fit program “*Curve Expert 1.3*”.

Pasture Productivity of Agropastoral systems

Several positive effects contribute to higher productivity of improved pasture with legumes compared to extensive grazing on native grass, such as higher dry matter production per ha, higher carrying capacity per ha and also positive reproductive performance of animals by shorter calving intervals and age at first calving.

Various studies show the huge potential for higher pasture productivity and thus animal production per area. Experiments in the Colombians Llanos with grass/legumes pastures show a 2 times higher per animal production and an up to 10 time higher animal production on a area basis compared with a managed native Savanna grassland. Compared with pure grass pasture the introduction of legumes increased liveweight gains per head by 50 % and per ha by 20-30 %, e.g. *Arachis pinto*i associated with *Brachiaria* spp indicate that animal liveweight gains can be as high as 500 kg/ha/ year. (THOMAS, R. J., and LASCANO, C. E. 1995, p. 281 ff.).

Pasture performance in crop/pasture rotation have shown high productivity in Brazil. Annual animal production can be as high as 230 kg/ha (crop +grass) and 350 kg/ha (crop+grass/legumes) with low inputs and up to 500kg/ha on high inputs. (AYARZA, M. A. et al, p. 29). At the same pots carrying capacity has between increased from 1.85 ha/cow in traditional, to 1.3 ha/cow in improved, and 0.96 ha/cow under crop/pasture

(AYARZA, M. A. et al. 1999, p. 31) resulting in an increase in revenue in calf production from 43 to 95 and 110 US\$ per ha pasture. One of the highest pasture productivity were reported from VALENCIA, R. A. and LEAL, D. (1999, p. 125 ff.). In rice/pasture rotation in the Colombian Llanos carrying capacity varied between 2.04 under *Andropogon gayanus* grass and 1.93 under *Brachiaria dictyoneura* grass with and liveweight gains varied between 835 and 692 g/animal/day resulting in highest annual gains of around 549 kg/ha.

Table 2. Productivity Indicators of Different Pasture Systems.

Pasture system		Coefficient (animal/ha)	Production ¹⁾ kg/year/ha
Carrying capacity (animals/ha)	Extensive pasture	0.5	
	Improved pasture (only grass)	1.1	
	Improved pasture (grass/legume)	1.5	
	Agropastoral system with grass/legume pasture	1.5	
Liveweight gains g/day	Extensive pasture	100	18.25
	Improved pasture (only grass)	250	100.38

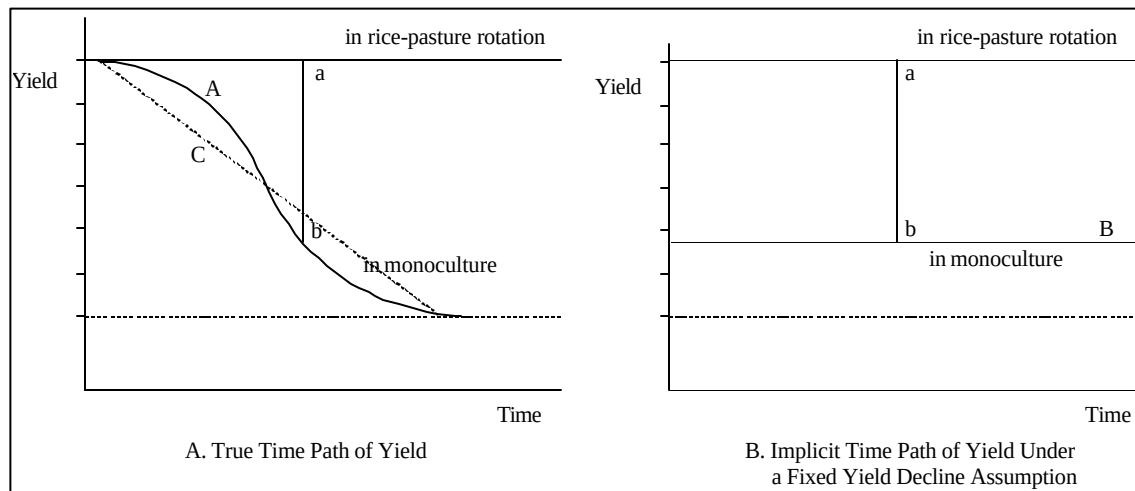
Rather “conservative” estimates on pasture productivity were taken as representative figure for all Savanna countries in order to account for the upward bias of yields in closely supervised field trials compared to what livestock keepers achieve on average (see Table 2). Carrying capacity on extensive (native) pasture were assumed to average around 0.5 animals/ha although there are cases that report much lower capacity of around 0.1 animals/ha. Improved grass/legume pasture were assumed to produce around 220 kg/ha/yr. with a carrying capacity of 1.5 animals per ha and 400 g/day leading to a 10 fold high per animal production than under extensive pasture (around 18 kg/ha).

Yield Dynamics

Due to paucity of comparative long-term yield studies under different land management options (conservation, erosion protections, or monoculture) most economic analysis studies resort to a fixed yield difference between the technology under consideration and the reference situation (see Figure 1, left part). A fixed yield difference model is appealing because data requirement is modest, and perhaps can be filled in quickly by the observed yield on samples from field trials at a given time. However, apart from the fact that fixed yield assumption is a very poor representation of the real degradation or yield decline process and it may severely distort the results form cost- benefit analysis. This distortion will not only affect the numerical results but also the qualitative behaviour of the system. A fixed yield decline model leads to an apparent front-loading of the losses

related to yield decline causing them to be weighted more heavily in the analysis (PAGIOLA, S. 1992, p. 487). The likely returns to rice/pasture rotations would thus be overestimated.

Figure 1. Comparison of a gradual and fixed yield decline model



Probably the best representation of the yield decline process is a logistic function as shown in Figure 1, curve A, where yields are relatively stable at the beginning, then drop dramatically and finally converge to a certain minimum yield threshold.

This analysis applies a gradual yield decline model but simplified in a way that yield in rice monoculture decrease linearly instead of a logistic function as (line C in Figure 1).

Yield decline in continuous rice can be substantial. It is assumed in which yields of is assumed, reports from a continuous rice monocrop experiment a linear decline for a acid tolerant rice variety (*Oryzica Sabana 6*) at a rate 400 kg/ha/yr from 3.8 to 2.6 tn/ha over a period of 4 years despite adjusted fertiliser inputs to maintain sufficient nutrient level (AMESQUITA, E. et al. 1995, p. 53). Similar results could be observed with maize monocropping. Among the usual causes for yield decline (weeds, pests and diseases) both experiments show a strongly negative N balance as a major contributing factor (CIAT 1997, p. 54). In accordance with these field results the following assumptions regarding incremental yield difference between rice in monoculture and rice/pasture were made: a linear constant yield decline starting at year 2 from the actual yield and reaching a minimum yield level at 1 tn/ha after 10 years. In contrast rice yields in rice/pasture were held constant over time.

For profitability calculations one must recognise that yield decline may pass through the break-even point below which profitability turns negative, that is around 1 to 2 tn/ha for rice. However, farmers do not produce with negative returns in the long-run but rather adjust their input intensity to operate at a positive profitability level. Therefore, a tiny but

positive gross margin at 20 US\$ was assumed as soon as yield falls below the break-even yield point.

Research Costs

A rough guess about the research investments accounts for the research activities of the most prominent institutions EMBRAPA, Colombian research institutions and CIAT that all devote significant resources into research of agropastoral systems. Research costs were estimated for a 10 yrs time ahead sufficiently to develop, improve, test and promote viable agropastoral systems that are applicable across all Savannas countries. Bolivia and Venezuela, that do not conduct major research on agropastoral systems, are assumed to benefit from research spillover by those research institutions and have free access to all research results. As outlined in Table 3 CIAT's annual research budget for agropastoral systems accounts approximately 600,000 US\$. The same amount is spent by Colombian research institutions. EMBRAPA with its numerous regional research offices and staff contributes the largest share of around 1.5 million US\$ annual. On aggregate this amounts to around 170 million US \$ over 10 years.

Economic Impact Analysis

Farm-Level Analysis

The first step in the economic analysis starts with an comparative investment analysis on farm-level for rice/pasture systems and its reference systems, namely extensive pasture and rice monocropping. Annual costs for investments and variable items and revenues are summed up in a cash flow analysis and the net present worth of the stream during the whole investment period is calculated. The different economic properties (constant annual gross margin and cash flow in rice, and irregular cash flow in pasture systems with fixed investments) requires the calculation of the annuity from the net present worth as the common yardstick for the annual profitability differences on a per area basis, and later on, for extrapolating the per ha gains on a global scale by incorporating total area under production and adoption potential.

The investment period comprises 8 years as the time interval extensive pasture is renovated. For improved pasture renovation takes place every 4 years and in rice/pasture rotation the pasture is re-established after the rice crop is planted every 4 years and harvested after 3 months. Due to lack of data on production costs the study takes results from past detailed cost analysis (e.g. RIVAS, et al. 1991, BOTERO, R.B. et al. 1991) as reference but price levels were adjusted for inflation while preserving the proportion of the cost patterns for the different investment items and variable inputs.

Table 3. Research Investments in Agropastoral Systems.

CIAT	Begin 1989	year 1	year 2	year 3	.....	year 10	Total
Principal scientists	Number	10	10	10	.....	10	
Work share		0.50	0.50	0.50	.....	0.50	
Costs per year	US\$	120,000	120,000	120,000	.....	120,000	
	Sub total		600,000	600,000	600,000	.....	600,000
Associated researchers	Number	10	10	10	.....	10	
Work share		0.60	0.60	0.60	.....	0.60	
Costs per year	US\$	40,000	40,000	40,000	.....	40,000	
	Sub total		240,000	240,000	240,000	.....	240,000
Support staff	Number	30	30	30	.....	30	
Work share		1.00	1.00	1.00	.....	1.00	
Costs per year	US\$	20,000	20,000	20,000	.....	20,000	
	Sub total		600,000	600,000	600,000	.....	600,000
	Total		1,440,000	1,440,000	1,440,000	.....	1,440,000
Brazil							
10 times CIAT's contribution		14,400,000	14,400,000	14,400,000	.....	14,400,000	144,000,000
Colombia							
Equals CIAT's contribution		1,440,000	1,440,000	1,440,000	.....	1,440,000	14,400,000
Total (million US\$)			17.28	17.28	17.28	.....	17.28
							172.80

Table 4 outlines the results from the cash flow analysis for each country showing that the per ha profitability of extensive pasture is very low in all countries compared to improved pasture and rice/pasture rotations (although the returns to per unit labour may much more favourable as extensive pasture is aimed at). By comparing improved pasture with the rice/ pasture systems it becomes obvious that adding a rice crop every 4 years significantly improves the returns per ha. This increase is more pronounced in Bolivia (returns more than double from 77.07 to 163.22 US\$) and is considerably lower for Brazil and Venezuela.

Looking at the relative profitability between rice production versus animal production Bolivia and Colombia are the countries where rice production performs best and yields higher per ha return than improved pasture and rice/pasture rotations. Difference in yields and input intensity (e.g. yield in Colombia compared to very low yields in Brazil) may be important to explain this but most likely the key factors are national differences in the prices for rice and beef. In Bolivia rice is relatively much higher priced than beef while the opposite is true for Brazil and Venezuela).

The introduction of rice/pasture into former pasture is associated with high returns. However, these gains vary according to whether the rice/pasture is introduced on extensive or improved pasture. Only little is known about the spatial distribution of extensive and improved pasture in the Latin American Savannas. It is assumed that for the whole Savanna around 40 % of pasture is improved with better high yielding and acid tolerant grass varieties and renovated on a regular basis, while the remaining 60% is still native. This proportion is taken to build a "hypothetical" pasture system (activity 4 in Table 4) which consists of 60% of native and 40 % of improved pasture on which the economic gains from rice/pasture are assessed. This directly simplifies the analysis by assuming that the proportion is equal across all part of the Savannas.

The economic gains expressed in term of increase in annuity between rice/pasture (activity 5, Table 4) and activity 4 are considerable. The economic return per ha can be increased by 6 to 8 times compared to pasture showing that increased pasture productivity, much higher liveweight gains per ha, and additional revenues from rice offset the relatively high investment costs for pasture renovations and other input costs.

The picture looks different when rice/pasture is introduced in rice monocropping. It is certainly profitable in Brazil and Venezuela where rice production is less economical than animal production on improved pasture. In contrast, rice/pasture rotations are not competitive to rice as monocrop in Bolivia and are almost equal in Colombia. All this only holds true as long as rice yields are not affected by depressing yields over time. By including continuous yield decline in rice monoculture the competitiveness of rice becomes less striking for Bolivia and may even turn in favour of rice/pasture system as it will be shown from the forthcoming results in the next chapter.

Table 4: Economic Profitability of Different Pasture Systems (in US \$)

		Pasture systems					
	1	2	3	4	5		
	Rice	Extensive pasture	Improved pasture (grass/legume)	60 % extensive and 40% improved pasture	Rice-pasture rotation	Difference between 5 and 4	Difference between 5 and 1
Colombia							
NPV (9 %)		1.631	95.623	39.228	193.743	154.515	
IRR (%)		9.7	23.1	18.9	53.4		
Annuity (9%)	60.381	0.295	29.516	7.088	59.802	27.917	-0.579
Brazil							
NPV (9%)		23.228	278.539	125.353	356.361	231.008	
IRR (%)		17.0	44.5	37.3	71.3		
Annuity (9%)	38.26	4.197	85.976	22.648	109.997	41.737	71.737
Bolivia							
IRR (%)		19.82	249.68	111.77	528.79	417.02	
Annuity (9%)	257.66	3.58	77.07	20.19	163.22	75.35	-94.44
Venezuela							
NPV (9%)		21.57	217.26	99.84	315.33	215.49	
IRR (%)		15.97	32.48	28.08	55.47		
Annuity (9%)	47.22	3.90	67.06	18.04	97.33	38.93	50.11

NPV = Net Present Value; IRR = Internal Rate of Return

Economic Results by Country

Accounting the annual benefits and costs over the investment period for the establishment of agropastoral systems in all 4 countries results in an overall Internal Rate of Return (IRR) of around 30% (Table 5) which shows that this technology proves very competitive with other sustainable management systems. The IRR does not change much when benefits are accounted over a different periods of 25, 30, and 35 years. Due to its immense size and amount of land under pasture the Net Present Value (NPV) would

account for more than 2 billion US\$. It is interesting to note that when the replacement of rice monocrop though agropastoral systems is included the IRR and NPV even increase.

This can be explained by the fact that gradual yield declines assumed for rice in monoculture offset much of the losses in revenues from replacing rice with a 4 year sequence of pasture under rice/pasture rotation.

The distributions of the benefits are unevenly spread among the 4 countries. Due to its size and high adoption potential around 95% of the benefits (37.4 billion US \$, undiscounted) are captured by Brazil. On departmental level, benefits are unevenly spread between large and small departments. What matter is the size of the department, its area under pasture and rice, and the potential adoption rate. For example, in Brazil the highest benefits occur in the Departments of Goias, Mato Grosso do Sul, and Minas Gerais (Figure 4). In Colombia the biggest impact would be located in the Meta, Casanare, and Vichada departments (Figure 4).

Agropastoral systems induce significant additional production as well. Table 6 summarises the additional productions gains for rice and beef. The investment period of 30 years is subdivided into 3 classes since it is expected that production effects follow the logistic form for adoption with the most dramatic changes occur late in time. In Table 6 annual additional production is aggregated of the 3 time classes. In total, adoption rice production over 30 years would account for more that 420 million tons with a market value of 61 billion US\$. At similar range lie the market gains of 59 billion US\$ from the additional beef production of 50 million tons.

Table 5: Internal Rate of Return IRR, Net Present Value NPV (10%), and Benefit-Cost Ratio (BCR)

	Introduced in pasture		
	Benefits accumulated over 35 years	Benefits accumulated over 30 years	Benefits accumulated over 25 years
IRR (%)	29.05	29.03	28.96
NPV (million US \$)	2,280.25	2,152.67	1,947.21
BCR	22.48	21.27	19.34
	Introduced in pasture and rice		
IRR (%)	29.15	29.13	29.06
NPV (million US \$)	2,314.24	2,184.83	1,976.41
BCR	24.32	23.02	20.90

Part of the changes in beef production is related to adjustments of the herd size. According to model assumption the average carrying capacity of 60% extensiv/40 % improved pasture is 0.74 animals per ha, in agropastoral systems it is 1.5 heads per ha. Any conversion of pasture and rice in monoculture into agropastoral system necessarily

increases the number of cattle. Table 7 outlines the magnitude of changes in the number of cattle compared to a constant herd size that would prevail without agropastoral systems. For the first 10 years the herd size increase by 6 %, but in the following decades would peak to 32 and 35 % . In absolute terms herd size would increase on average by 4.7, 25.7 and 27 million animals per year for the different time spans. In terms of percentage the largest increase would occur in Brazil with more that 38 % in the final years, while the lowest rate occurs in Colombia.

Table 6. Additional Production of Rice and Beef

	Brazil	Colombia	Bolivia	Venezuela	Total
	Rice (additional production in million metric tons)				
1 st 10 yrs	36.46	0.49	0.38	1.70	39.04
2 nd 10 yrs	200.48	2.21	1.86	8.43	212.99
3 rd 10 yrs	215.25	2.31	1.96	8.88	228.39
Total	452.20	5.01	4.20	19.02	480.42
	Rice (market value in million US\$, in prices of 1995)				
1 st 10 yrs	4,558.05	65.10	81.36	271.88	4,976.38
2 nd 10 yrs	25,059.87	296.39	396.14	1,344.96	27,097.37
3 rd 10 yrs	26,906.57	308.70	416.02	1,416.11	29,047.40
Total	56,524.49	670.18	893.52	3,032.95	61,121.14
	Beef (additional production in million metric tons)				
1 st 10 yrs	3.83	0.03	0.04	0.18	4.08
2 nd 10 yrs	21.07	0.12	0.20	0.89	22.27
3 rd 10 yrs	22.63	0.12	0.21	0.93	23.89
Total	47.53	0.26	0.44	2.00	50.24
	Beef (market value in million US\$, in prices of 1995)				
1 st 10 yrs	4,523.10	19.94	44.62	200.71	4,788.36
2 nd 10 yrs	24,867.73	90.77	217.25	992.89	26,168.64
3 rd 10 yrs	26,700.28	94.54	228.15	1,045.41	28,068.37
Total	56,091.11	205.25	490.02	2,239.00	59,025.37

Table 7. Increase of the Cattle Herd

	Brazil	Colombia	Bolivia	Venezuela	Total
Number of cattle 1995 (in million heads)	67.51	1.42	1.68	4.89	75.50
Addition cattle (annual average, in million heads)					
1 st 10 yrs	4.43	0.03	0.05	0.22	4.73
2 nd 10 yrs	24.38	0.13	0.23	1.012	25.752
3 rd 10 yrs	26.17	0.14	0.24	1.056	27.606
Increase in %					
1 st 10 yrs	6.57	2.08	2.77	4.50	5.97
2 nd 10 yrs	36.11	9.47	13.49	20.70	32.77
3 rd 10 yrs	38.77	9.86	14.17	21.60	35.17

Figure 2. Distribution of the Economic Gains by Country

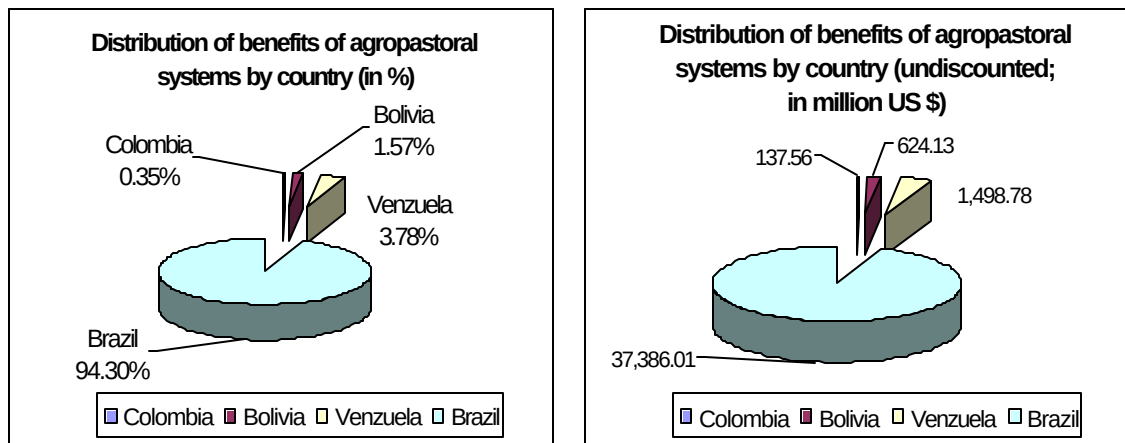


Figure 3. Benefits Distribution for Brazil

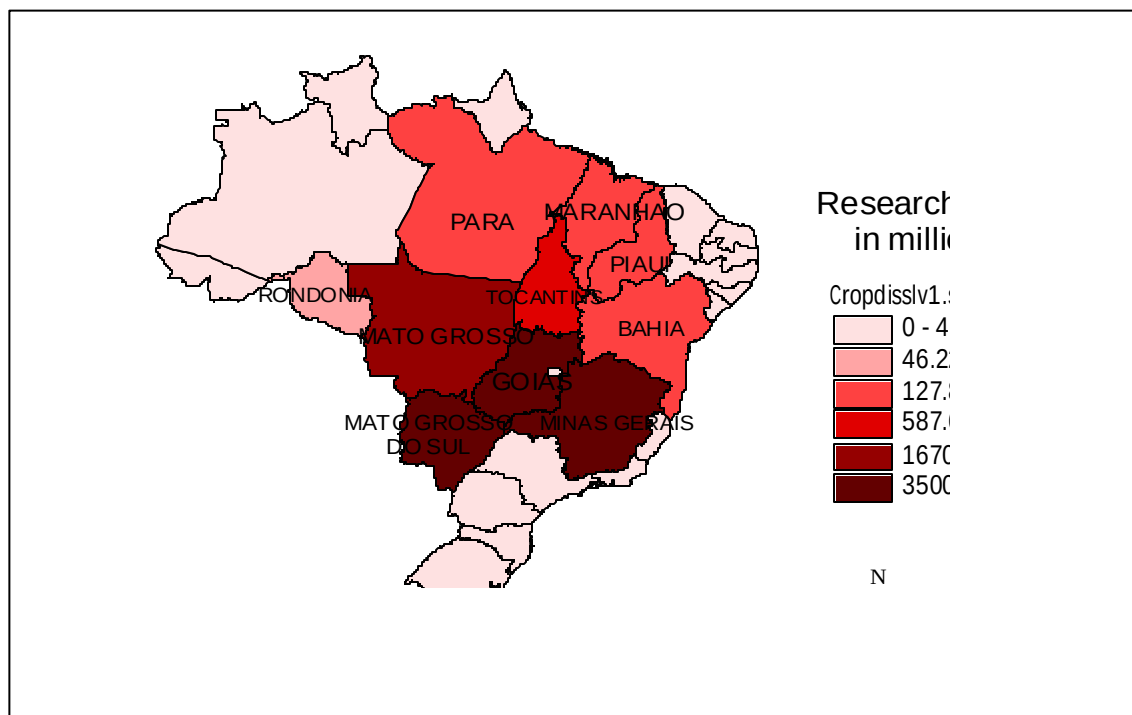
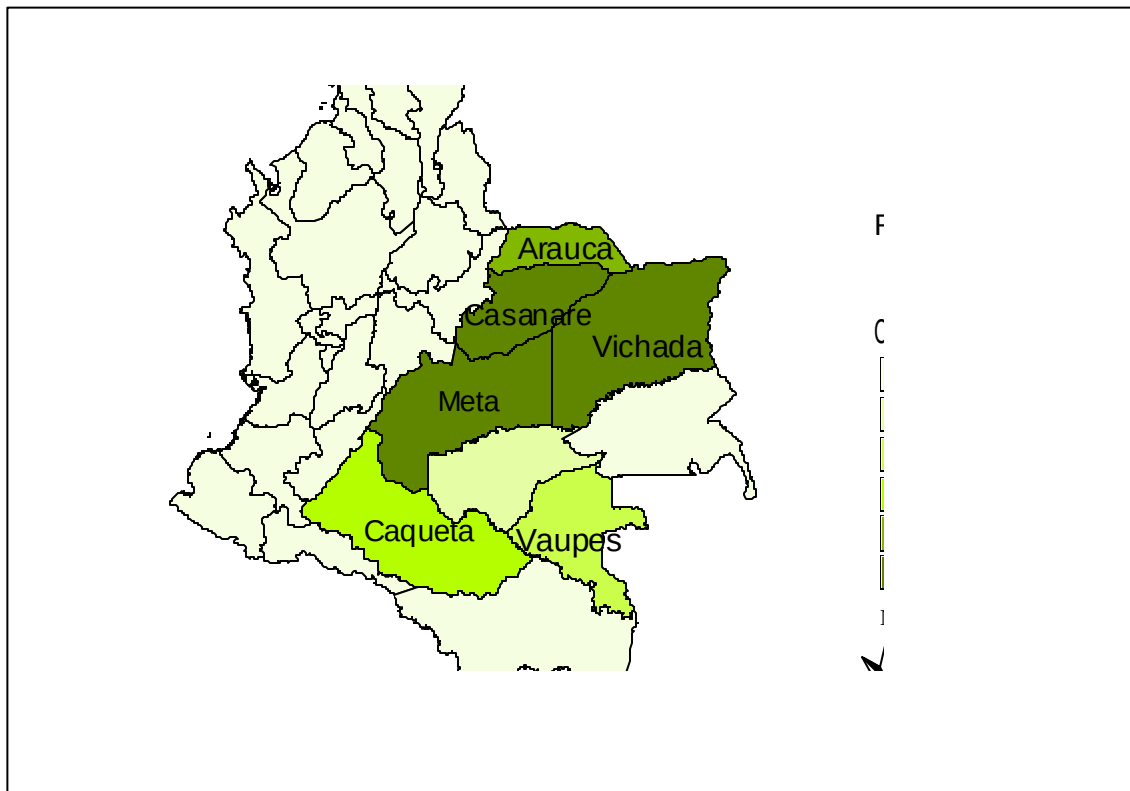


Figure 4. Benefit Distribution for Colombia



1.2.3 Rapid Propagation for cassava - by: *Juan.David Quiñones*

Antecedentes

El cultivo de yuca es una de las pocas alternativas de producción que ofrece rentabilidad a los pequeños productores de las zonas planas y de ladera del departamento del Cauca; sin embargo, en los últimos años los rendimientos del cultivo vienen disminuyendo por diferentes causas, tales como prácticas agronómicas inadecuadas y el deterioro del material de siembra (semilla) por enfermedades y plagas entre otros.

Objetivo

El objetivo de este proyecto, es la elaboración de un análisis comparativo de los costos de producción de semilla de yuca mediante cultivo de tejidos en técnicas in vitro, de bajo costo, y de propagación masiva, sistemas desarrollados por la unidad de Biotecnología del CIAT.

Colaboradores:

- J.D. Quiñones, R.H. Escobar, J. Tohme y D. Pachico.

1.2.4 Impact of community tele-centers - by: N. Johnson

Progress Report

In 2000, the projects “Evaluating and Enhancing the Impact of Community Telecenters: Initiative to Foster Sustainable Development in Marginalized Regions,” The purpose of this project is to strengthen the ability of community telecenters to offer information and communications services that contribute to food security, social and economic development, and improved natural resource management in marginalized regions.

This project would be the companion of an effort already under way to develop community telecenter models for fomenting sustainable development in marginalized communities. Telecenters are public facilities that provide access to information and communication technologies (ICTs). The project would complement InforCauca by strengthening its ability to evaluate the performance and impact of telecenters and to enhance their benefits through the development of new telematic applications (Web-based information tools) that are relevant to the needs of poor rural and urban communities. This work would focus on a network of three community telecenters being established in one urban and two rural communities of southwestern Colombia.

Research on impact will explore the links between telecenter services and the development of human and social capital, leading ultimately to stronger food security, economic and social development, and improved natural resource management. For this purpose the project will employ a case study format to conduct systematic, comparative analysis of telecenter experiences. The approach will include household surveys and participatory methods to obtain quantitative and qualitative information, providing the basis for a series of "mapping" exercises aimed at understanding how the telecenters interact with local organizations, how the telecenters can be made economically sustainable, and how their services can have impact in local communities. The theoretical framework for this research will be based on an economics of information approach.

Telecenter managers and other representatives from local organizations will be closely involved in the impact study and will receive training in research methods. This should enable them to continue the evaluation as a mechanism for generating information that helps improve telecenter performance.

With a view to enhancing telecenter impacts, the project will build a local capacity to develop new telematic applications, dealing with information on markets, production and processing technologies as well as other topics in which local communities express strong interest.

Key outputs of the project--i.e., the results of the impact study and the telematic applications--will be made widely available by various means, including an InforCauca Web site, a Latin American regional network of telecenters, and a workshop held at the close of the InforCauca initiative.

Donor:

- Rockefeller Foundation

Partners:

- Communications Unit
- IPRA (SN3)
- Agro-enterprise project (SN1)
- Corporación Universitaria Autónoma de Occidente

OUTPUT II: IMPACT OF PAST RESEARCH MONITORED

2.1 REVIEWS OF PAST RESEARCH IMPACT

2.1.1 Impact of past research on crop genetic improvement - *by: Nancy Johnson and Douglas Pachico*

Outstanding results

- Over the past 3 decades, CIAT has contributed to the development and release of over 700 improved varieties of rice, beans, cassava and tropical forages in 50 countries.
- Cumulative global impact of CIAT's genetic improvement work is estimated to be over 6.8 billion dollars.
- The top three beneficiaries of these impacts—Brazil, Colombia and Ecuador—are in the LAC region, however two of the top ten beneficiaries, Thailand (#5) and Rwanda (#10) are in the mandate regions of CIAT's regional cassava and bean programs
- All of CIAT's research programs show acceptable rates of return, ranging from 57 percent for rice to 24 percent for cassava.

Progress report

Over the past 3 decades, CIAT has contributed to the development and release of over 700 improved varieties of rice, beans, cassava and tropical forages in 50 countries. The goal of this study is to estimate the impact that these improved cultivars have had on global agricultural production. The analysis is part of a CGIAR system-wide study on the impact of international agricultural research centers (IARCs) on agricultural production and income. Companion studies also sponsored by the Impact Assessment and Evaluation Group (IAEG) will look at the impact of IARC research on poverty and on the environment. Together, the three studies will permit the evaluation of the progress of the CGIAR system towards achieving its mandate of increasing agricultural production and reducing poverty while protecting the environment.

This report is organized as follows. Section 1 presents the objectives of the IAEG study and of CIAT's contribution. Section 2 describes the data sources that were used in the analysis. In Section 3, some preliminary results are presented on the release, adoption, and impact of CIAT-related varieties. Internal rates of the return to the research programs are also presented. Finally, Section 4 summarizes.

The IAEG Study and CIAT's Contribution

The IAEG study consists of three parts, center studies, country studies, and a global analysis. The center studies are conducted by individual CG centers on the impact of their mandate crops. Seven centers are participating¹, and 10 crops² are being analyzed. The goal of the studies is to document the production, release, adoption and impact of IARC-related varieties. Center studies will also look at investment in varietal production by both IARCs and national agricultural research systems (NARS).

The country studies focus on measuring the impact of IARC investment in varietal production on productivity in agriculture in three important agricultural countries in the developing world, Brazil, India and China. These studies are carried out by consultants, and are based on extensive time series data sets on agricultural production and its determinants. Preliminary results are available in Evenson (1999).

The global impact study will use a computable general equilibrium (CGE) model to look at the effect of IARC varieties of production, prices, and welfare as measured by reduction in malnourished children. Preliminary results for the case of rice in Asia are also available in Evenson (1999).

The Impact of CIAT-related Varieties: Some Preliminary Findings

Varietal production

Varietal releases

Since CIAT does not release varieties directly, there is no such thing as a CIAT variety. Rather, there are varieties which have been released by national programs or other authorized entities, to which CIAT has made a significant contribution. For a variety to be considered as CIAT-related, it must be a genetic resource unit (GRU) from a CIAT germplasm bank; a cross-made in CIAT³; a cross made in a national program using CIAT parents or grandparents, or a variety that arrived in a country via a CIAT-supported network.

¹ CIAT, CIP, CIMMYT, ICARDA, ICRISAT, IRRI and WARDA

² Rice, wheat, maize, sorghum, pearl millet, beans, barley, lentils, potatoes and cassava

³ This category includes crosses made and selected at CIAT as well as crosses made at CIAT but selected locally.

Since 1970, over 700 CIAT-related improved cultivars have been released in 50 countries (Table 1).⁴ Approximately half of these varieties were bean varieties (362) followed by rice (243), cassava (62) and tropical forages (45).⁵ As Table 1 shows, Brazil has released the largest number of CIAT-related varieties (131) followed by Colombia (45), Mexico (37) and Cuba (35).

Use of varietal release data to evaluate IARC and NARS breeding programs

Before presenting further analysis of the release data it is important to acknowledge several shortcomings of using these data to draw conclusions about the productivity of IARC or NARS breeding programs. First, varieties may be released in different countries with different names, which makes it difficult to equate number of varieties released with number of varieties produced. Second, the norms and regulations governing varietal releases differ by country and even by breeder. Some countries may release many varieties—or even different selections of the same variety—while others will release only the one or two best-rated varieties.

Third, just as many released varieties may never be adopted, many adopted varieties may never have been officially released. There are many cases of “escapes”—varieties which get into the hands of farmers while they are still officially in development—or of varieties that are released in one country and become widely available in neighboring countries. In the release analysis, generally only officially released varieties are considered.⁶

Because of these shortcomings, making specific comparisons between crops and countries may not be appropriate. However, the goal of this analysis is to look at general trends of commodities at the global and regional levels. In this case, the number and composition of varietal releases can serve as a rough indicator of the productivity of breeding programs over time and space.

Trends in number of varieties released

Two observations can be made from a review of release data over time (Chart 1). In terms of the average number of releases per year, the commodities appear to fall into two groups. One group, which includes rice and beans, has had a relatively higher number of yearly releases, averaging between 10-15 varieties a year. The other group, which consists of cassava and forages, has had fewer releases, averaging between 0 and 5 varieties per year.

Another striking observation is that in general the number of varieties released increased until the late 1980s or early 1990s and then declined, in some cases dramatically. The exceptions to this pattern are beans in Africa and cassava in Latin America. To get a better idea about the productivity of varietal improvement programs, Chart 2 shows trends in varietal releases per year

⁴ Data on varietal releases come from the cassava, rice, beans and tropical forages projects.

⁵ Tropical forages are not included in the IAEG study but are being included in this analysis since they are part of CIAT's commodity mandate.

⁶ One exception is the case of forages in SE Asia. Map 5 shows varietal releases however these cultivars have not been officially released since there is no official release system for forages.

per breeder.⁷ Fewer data points are available in this analysis since unlike release data which is annual, breeder data was generally available only for two or three different points in time. Nonetheless, the same pattern appears with regard to a decline in varietal releases after about 1995. This suggests that the decline is not entirely attributable to a decline in investment in breeding. Each breeder is also producing fewer varieties.

How to interpret this finding is not clear. One explanation is that the data are not complete for recent years, and in fact varietal production has not slowed down. This is likely the case in rice, however the argument is less convincing in other commodities whose data bases include releases up to 1999. It may also be the case that using number of breeders as a proxy for investment fails to capture the effects of funding cuts that leave people with fewer resources with which to do research.

Assuming that the data do reveal a real decline in varietal production per scientist, it is still not clear how to interpret it. One explanation is that the decline in varieties per scientist could reflect diminishing returns to breeding research. There are already many good varieties out there, and it is increasingly difficult to find new varieties that are superior to existing varieties. A decreasing number of varieties could also reflect a change in strategy towards producing fewer better varieties. It could also be a consequence of a research strategy focused more on upstream-strategic research such as biotechnology that has not yet resulted in varietal releases. These last two cases would not necessarily imply negative impacts on production or productivity.

Finally, the decline could be the result of funding cuts. It could simply be that the loss of resources and the general instability in NARS in Latin America during the 1990s has resulted in a loss of critical mass in breeding research.

At this point it is not possible to draw any conclusions about the causes or consequences of the observed phenomenon. The trends in varietal releases and their impacts of productivity would be an appropriate subject for further analysis.

CIAT Contribution to varietal improvement

Charts 3-8 show the trends in total average annual varietal production as well as CIAT-related annual varietal production. The difference between the two lines are the varieties that were released by national programs without any input from CIAT.

Again the data suggest two observations. The first is that the total number of varieties and number of CIAT-related varieties tend to move together. The fact that the data are in terms of average annualized releases over five-year periods may mask inter-year variation, but it in no case do we see the trend lines crossing. This does not support the theory that the IARCs have crowded-out the NARS in terms of varietal production.

⁷ Breeders are defined as scientists with a BS degree or higher who work on varietal improvement. Data on number of breeders in CIAT came from annual reports. Data on the number of breeders in national programs came from a variety of published and unpublished sources, including expert opinion (see Johnson, 1999).

The second observation is that CIAT-related varieties are a high proportion of total varieties, generally well above fifty percent. According to the data on number of breeders, CIAT breeders are a small percentage of total breeders, usually less than 10 percent (Table 2). The fact that the proportion of CIAT varieties is well above the proportion of CIAT scientists would appear to reflect a higher productivity of scientists and quality of varieties in IARCs compared with NARS.

Composition of CIAT-related improved varieties

As mentioned earlier, CIAT-related varieties are of four basic types: 1) genetic resource units (GRUs) from CIAT germplasm banks; 2) crosses made in CIAT and selected either at CIAT or locally by NARS; 3) NARS varieties with CIAT parents and varieties that were transferred via CIAT-supported networks. Charts 9-13 show how the composition of CIAT-related varieties has changed over time.

The changes in composition of releases reflects the general evolution of breeding programs. Initially, production gains are realized by selecting and disseminating promising landraces. These are represented in the data by the GRUs, which were a significant portion of CIAT-related bean and cassava varieties in the 1970s and 1980s. All CIAT-related tropical forage releases to date have been germplasm accessions, which is why there is no chart for forages.

Further production gains are achieved by replacing selected landraces with crosses, and this process is clearly visible in the data. This is most notable in the case of cassava, whose proportion of GRU releases dropped significantly between the 1980s and the 1990s. It is less dramatic in the case of beans. In the case of rice, no GRUs were ever released as CIAT-related varieties. Even by the late 1960s, rice breeding had moved beyond the stage of releasing germplasm accessions.

Among the crosses, another trend is also visible. Between the 1980s and the 1990s, the proportion of crosses made in CIAT declined and the proportion of crosses made in NARS using CIAT ancestors increased. This is the case in cassava in Asia and for all crops in Latin America. The same trend has been observed for rice in Asia, and has been interpreted as a sign of a healthy relationship between IARCs and NARS (Evenson, 1999).

One final comment should be made on the network varieties, which are important in both beans and rice.⁸ The importance of networks in beans and rice appear to be declining over time, however this is due to the way the data are categorized rather than to a reduction in the importance of networks. In order for a variety to be classified as having been transferred through a CIAT network, it must be the case that the variety has no other CIAT contribution aside from the network. If a CIAT cross travels through a network, it is classified as a CIAT cross.

⁸ The main networks are PROFRIJOL in Central America, PROFRIZA in the Andean region and INGER, the global system of rice nurseries.

In the 1970s, the networks transferred IRRI crosses to Latin America or circulated non-CIAT bean germplasm within the region. As CIAT germplasm became increasingly important, the varieties that flowed through those networks increasingly had other connections to CIAT. Rice and bean networks are still very active in Latin America and now Africa, and an important piece of further research would be to look at the role of the networks in the production of varieties.

Adoption and Impact of CIAT-related varieties

While varietal releases may be a good measure of the productivity of a breeding programs, the varieties must be adopted by farmers in order to have impact. This section of the paper reviews the evidence on the adoption and impact of CIAT-related varieties over time. The following sections describe in detail how the data and estimates were obtained for each crop, and report results on the area planted to CIAT-related varieties, and on the economic value of production increases associated with the varieties.

Before presenting the results, several general clarifying points should be made. First, in order to be consistent with the other Center analyses in the IAEG study, CIAT network varieties were not included in the adoption and impact analysis. Second, estimates are only presented for countries where data were available. If an estimate is not made for a country in which varieties were released, it does not mean that no adoption took place, only that we were unable to get a reliable estimate of adoption. Finally, no attempt is made in the impact estimates to apportion credit for a variety between CIAT and the NARS.

Rice

CIAT and the Fund for Irrigated Rice in Latin America (FLAR)⁹ maintain a data base on area planted and total production from improved and traditional varieties for important rice-producing countries in LAC. Varieties are separated by ecosystem: irrigated, favored upland (counted as irrigated in the analysis) and upland. In this analysis, irrigated and favored upland varieties have been grouped together, and the results presented below are for this category. The adoption and impact analysis of upland varieties has not yet been completed.

Since the CIAT/FLAR adoption data are not broken down by variety, in order to get the area planted over time to varieties with CIAT content, it is assumed that the area planted to improved varieties was proportional to the CIAT-content of the available pool of improved varieties, i.e., if 50 percent of available improved varieties in a given year were from CIAT, then 50 percent of the area planted in that year was planted to CIAT varieties. To allow for the lag between release and adoption, varieties were not considered as part of the varietal pool until two years after their release date.

⁹ FLAR, founded in 1995, is an association supported by rice producing countries in Latin America. It serves as a forum for identifying needs and opportunities of member countries, as well as conducts research and training activities on rice priorities for Latin America

The results of the proportional method of estimation were reviewed by the director of FLAR. In every case they were below the “variety x area” estimates that he had for 1997, however in most cases the differences weren’t very significant so we decided to go with the proportional estimates. In the cases where there were significant differences, adjustments were made to the estimates to reflect the greater role for CIAT materials in planted varieties.¹⁰ As a result of this analysis we know that the CIAT content of planted varieties is greater than or equal to the CIAT content of released varieties.

Estimates of yield gains were based on the observed differences in yields between traditional and modern varieties under irrigated conditions. In cases where 100 percent of area was planted to improved varieties, the average difference over the last 5 years when the difference could be observed was used. Others studies have calculated the yield gain attributable to the improved varieties by taking a fixed percentage (25-30) of the difference between modern and traditional yield gains. The results seem to be about the same on average.

To calculate the economic value of production increases, international rice prices (FOB Bangkok are used). Prices were converted to US dollars and deflated to 1990 dollars using the US PPI.

Table 3 shows the area planted to improved rice varieties in the major rice producing countries in Latin America. The data are presented in two ways, the percent of total irrigated rice area planted to CIAT-related varieties and the total number of hectares planted to CIAT-related varieties. Brazil is the largest adopter of CIAT-related rice varieties, both in terms of percent of area (94) and area planted (almost 1.5 million hectares). Colombia, Ecuador and Peru are the next largest, in percent and total area terms. These are also the top four countries in terms of the total value of production increases associated with CIAT-related varieties (Table 4). The cumulative benefits to irrigated rice research are the highest of any CIAT commodity research program, totaling US\$5.5 billion dollars worldwide.¹¹

Beans

Adoption data for impact analysis for LAC were drawn from existing empirical impact studies.¹² These studies were revised and synthesized, and based on specific observations and general patterns, diffusion curves were estimated and area planted calculated. The total area planted in each country comes from FAO data.

To calculate economic impact, generally national prices from FAO are used where available. Use of national prices was appropriate since for much of the period of study, there was not significant

¹⁰ In the case of Brazil, data on sale of certified seed was also available however it was decided not to use these estimates since they may overestimate the importance of recently released varieties. Many farmers get their seed from other sources such as neighbors, millers, and these sales are not accounted for in the certified seed data.

¹¹ 1990 dollars

¹² See the CIAT impact assessment webpage for abstracts of many of the studies (www.CIAT.CGAIR.ORG under impact)

international trade in beans among the study countries. Where national price data were not available, I used prices from Hertford and Garcia or from neighboring countries. Prices in local currency were converted to dollars and deflated to 1990 dollars using the US PPI.

Adoption and impact data for Africa come from PABRA impact studies. The studies are based on case studies and on expert opinion. The specific methods and assumptions are detailed in PABRA (1999).

Tables 3 and 4 report the area planted to CIAT-related bean varieties and the total cumulative value of that impact in terms of the value of increased bean production. In economic terms, Brazil was by far the largest beneficiary of production increases from CIAT-related varieties, followed by Argentina, Rwanda and Guatemala. The reason for the high value relative to area planted in the case of Rwanda is that the shift was from bush beans to climbing, which are much higher yielding.¹³ The total benefits of CIAT-related varieties is estimated to be almost US\$1.3 billion.¹⁴

Cassava

Adoption and yield gain information come primarily from internal estimates from the cassava scientists in Colombia and in Asia. Adoption estimates were made by country for 1998, along with diffusion curves by region. To get time series adoption information by country, I assume that the diffusion curve is the same for all countries in the region and calculate previous years based on the 1998 estimates. Data on total area planted comes from the FAO database.

In terms of the economic value of production increases, the economic value of cassava in Asia is based on two things, the total root yield and the starch content of the roots. Since most cassava in Asia is processed for its starch, buyers reward producers for higher starch content with higher prices. In order to capture these two effects, we calculate the value of increases in root and starch production separately. In order not to double count, the standard root price (not including the starch premium) is used to value the increase in root production and the starch price is used to value the increase in starch production. In Latin America, starch content is not generally rewarded so economic impact is calculated for increased root yield only.

National level root prices were used for Asia (FAO) however the world starch price was used since national level starch prices were unavailable. For Latin America, an estimated world root price is used since national level data is not available. All prices are converted to US dollars and deflated to 1990 dollars.

Tables 3 and 4 show the adoption and cumulative economic impact of CIAT-related cassava varieties in Latin America and Asia. The largest impact has been in Thailand, which has 52 percent of area planted to CIAT-related varieties, and a cumulative value of increased production

¹³ The higher input costs were taken into consideration in this analysis (See Sperling et al). The reported production gains are net gains associated with varietal improvement only.

¹⁴ 1990 US dollars

of US\$391 million (1990 dollars). The biggest beneficiaries in Latin America have been Haiti (US\$33 million), Brazil (US\$17 million) and Cuba (US\$411 million).

The difference in adoption and impact between Asia and Latin America is in large part due to the structural differences in their cassava markets. As mentioned earlier, cassava is an industrial crop which is processed into animal feed, largely for export. This has led to a strong demand for production by processors, which is reflected in a strong demand for new varieties by producers. Until recently was not the case in Latin America, where cassava is generally marketed fresh. Recently, however there has been growing interest in cassava as an industrial crop in Latin America, as reflected by the formation of a public-private research consortium CLAYUCA.¹⁵

Tropical Forages

Data on tropical forage adoption rates comes from both empirical impact studies and from expert opinion of local sources (Table 3). What is striking about the adoption data for pastures is that in terms of percent of area, the adoption rates seem very low. The highest is Costa Rica, with 10 percent of permanent pasture area planted to CIAT-related germplasm. In terms of area, however, the figures are impressive. In Brazil, over 5 million hectares are estimated to be planted to CIAT-related cultivars.

Very little empirical evidence is available on the costs and benefits associated with improved pasture. In this analysis, we used sets of estimates, one for the beef operations *llanos* and *cerrados* and one for the multipurpose (beef and dairy) operations of Central and South America. In the case of beef production, pasture establishment costs were estimated to be US\$150 per hectare. The benefits were assumed to be 100 kilos/hectare/year of beef, of which 67 percent can be attributed to improved pasture.

In the case of multi-purpose operations, empirical evidence suggests that the pasture establishment costs are higher, about US\$250 per year. The benefits of improved pasture are estimated to be 380 liters of milk/hectare/year and 40 kilos of beef per hectare per year. Again, two-thirds of the benefits are assumed to be due to improved pasture.

Table 4 reports the estimated impact of CIAT-related improved forages. Again, the magnitude of the areas planted to pastures and to improved forages are reflected in the magnitude of the cumulative value of increased beef and milk production. In spite of the fact that CIAT-related improved forages have been released and adopted relatively recently when compared with rice or beans, the total value of production (US\$1.4 billion) is second only to rice. This growth is consistent with a projection of the 1990 CIAT Strategic Plan that the benefits of research in the beef and milk sectors would some day be the highest of the four mandate crops sectors.

¹⁵ Consorsio Latinamericano para la Yuca

Internal rate of return to CIAT research

In order to evaluate the effectiveness of CIAT's research programs in germplasm improvement, we must consider not only what was produced by the varietal improvement programs but also what went into them. The standard way to measure both input and output is to look at the internal rate of return, which is equal to interest rate that would have to have been received on the amount of money invested in a project in order to obtain the observed benefits.¹⁶

Information on the costs of CIAT research by program were obtained from Annual Reports. The proportion of program spending dedicated to germplasm improvement was estimated using the ratio of breeders to all scientists in the program.¹⁷ In terms of benefits, it was assumed that fifty percent of total value of benefits from improved germplasm were due to CIAT's research, and that the remaining fifty percent was due to NARS contribution.

Table 5 shows the results of the analysis. As expected, rice had the highest rate of return, 57 percent. This is actually somewhat lower than other estimates of rice research, with much of the difference due to how CIAT-related varieties were defined. In this study, the early IRRI varieties which passed through CIAT are not included as CIAT-related.

It is also interesting to note the difference between the rates of return for cassava and beans in Latin America and in the regional programs. In the case of beans, research in Latin America had a rate of return of 26 percent while research in Africa had a rate of return of 59 percent. In the case of cassava, the figures were 12 and 75 percent, respectively. The reason for the difference is that in the calculation of the rates of return for research in Africa and Asia, only costs beginning at the time of the establishment of the regional programs are included.

This way of calculating the rates of return to the regional programs makes then marginal rather than total rates of return. They are higher because they include spillover benefits from research done at headquarters without having to pay the costs of that research. Therefore, the two rates of return are not directly comparable. The value of reporting the global and regional rates of return is that it demonstrates the large benefits which can be realized by extending CIAT's Latin American research to other countries.

Summary and Conclusions

This report analyzed the production and impact of CIAT-related improved varieties of rice, beans, cassava and tropical forages. Over 700 CIAT-related varieties have been released in 50 countries. The cumulative economic impact of these varieties was estimated to be US\$6.8 billion. The main beneficiaries of these impacts are in the LAC region (Brazil (#1), Colombia (#2) and Ecuador (#3)), however two of the top ten beneficiaries (Thailand #5 and Rwanda #10) are in the mandate regions of CIAT's regional cassava and bean programs.

¹⁶ See Alston et al for an extensive review of rate of return studies in agriculture.

¹⁷ The exception is forages, where expert opinion was used to allocate budget to germplasm improvement.

In terms of trends in variety production and release, positive evidence was found of a healthy and complementary relationship between CIAT and the NARS. No evidence of crowding-out was found. CIAT-related varieties continue to be the majority of all varieties released in most countries, however it appears that the NARS are increasingly using CIAT materials as parents in their own breeding activities.

One potentially worrying trend is that the number of varieties released per scientist per year may be declining. While it is too early to know whether this trend is robust or whether it will have significant economic implications, it is something that should be monitored over the coming years.

All of CIAT's research programs show acceptable rates of return, ranging from 57 percent for rice to 24 percent for cassava. Relatively higher rates of return for regional programs suggests that significant benefits can be reaped from extending CIAT research to new areas.

Table 1 Varietal releases

COUNTRY	RICE	BEANS	CASSAVA	FORAGES	TOTAL
ARGENTINA	1	30			31
AUSTRALIA		2		1	3
BELIZE	1				1
BOLIVIA	7	19			26
BRAZIL	74	44	11	7	136
BURUNDI		12			11
CANADA		1			1
CHILE	2	6			8
CHINA			6	1	7
COLOMBIA	21	11	7	7	46
DR CONGO		12			12
COSTA RICA	9	18		5	32
CUBA	7	23	2	3	35
CYPRUS		1			1
DOMINICAN REP.	8	3	2		13
ECUADOR	7	9	2	1	19
EL SALVADOR	5	5			10
ETHIOPIA		13			13
FRANCE	1				1
FRENCH GUIANA	1				1
GUATEMALA	10	11		1	22
GUYANA	3				3
HAITI		1	2		3
HONDURAS	5	12		4	21
INDONESIA			3		3
KENYA		11			3
MADAGASCAR		1			1
MALAWI		7			7
MALAYSIA			2		2
MEXICO	27	4	2	4	37

COUNTRY	RICE	BEANS	CASSAVA	FORAGES	TOTAL
MOZAMBIQUE		4			4
NICARAGUA	7	14		1	22
PANAMA	9	8	1	3	21
PARAGUAY	5				5
PERU	19	12		2	33
PHILIPPINES		1	8		9
RWANDA		19			11
SOUTH AFRICA		5			5
SPAIN		3			3
SURINAME	7				7
SWAZILAND		3			3
TANZANIA		7			7
THAILAND			7		7
TURKEY		3			3
UGANDA		11			10
URUGUAY	1				1
USA		2			2
VENEZUELA	7	8		5	20
VIET NAM			7		7
ZAMBIA		3			3
ZIMBABWE		3			3

Table 2 CIAT Breeders as Percent of All Breeders (1970-1998).

Region	CIAT Breeders/All Breeders
Rice	.05-.06
Beans-LAC	.03-.06
Beans-Africa	.05-.08
Cassava-LAC	.04-.16
Cassava-Asia	.04

Table 3. Percent of total crop area planted to varieties with CIAT content for selected countries, 1997.

Country	Rice		Beans		Cassava		Forages	
LAC	(Pct)	(000 Has)	(Pct)	(000 Has)	(Pct)	(000 Has)	(Pct)	(000 Has)
Argentina	72	225	77	220				
Bolivia	50	80	95	10				
Brazil	94	1425	50	1681	2	32	.3	5,000
Colombia	82	284	9	14	9	19	2	650
Costa Rica	89	52	85	33			10	243
Cuba	33	110			26	20		
Dominican Republic	22	113			52	10		
Guatemala			38	49			1	28
Haiti					59	50		
Honduras			43	37			3	48
Ecuador	86	282	19	13	8	2	9	468
El Salvador			25	21			.4	3
Mexico	9	36			88	.1	.2	175
Nicaragua			30	46				
Panama	63	25	40	4	2	.1		
Peru	84	240	16	12			.6	162
Uruguay	6	186						
Venezuela	71	175						
Asia								
China					1	2		
Indonesia					.5	6		
Philippines					3	7		
Thailand					52	622		
Vietnam					9	22		
Laos								
Malaysia								
Africa								
DR Congo			18	120				
Ethiopia			5	32				
Kenya				.3				
Malawi			.2	2				
Rwanda			16	31				
Tanzania			2	15				
Uganda			10	54				

Table 4 Value of total production increases associated with CIAT-related varieties (millions of US\$1990).

	BEANS	RICE	YUCA	FORAGES	TOTAL
AGRENTINA	134.59	259.07			379.79
BOLIVIA	2.87	26.40			29.27
BRAZIL	766.72	2,409.30	16.93	984.66	4,177.61
CHINA			2.05		2.05
COLOMBIA	12.93	963.83	10.67	209.20	1,196.63
COSTA RICA	35.63	268.18		47.28	351.10
CUBA		8.82	11.48		20.30
DOM REP			5.69		5.69
DR CONGO	14.22				14.22
ECUADOR	8.31	805.98	0.41	70.58	885.28
EL SALVADOR	19.41			0.57	19.98
ETHIOPIA	2.31				2.31
GUATEMALA	79.12			5.70	84.82
HAITI			33.78		33.78
HONDURAS	21.44			9.32	30.76
INDONESIA			12.34		12.34
KENYA	0.06				0.06
LAOS					
MALAWI	0.11				0.11
MALAYSIA					
MEXICO		10.34	0.09	13.77	24.20
NICA	45.37				45.37
PANAMA	7.86	96.38	0.04		104.27
PERU	19.57	396.59		31.93	448.09
PHILIPPINES			13.50		13.50
RWANDA	91.21				91.21
TANZANIA	1.52				1.52
THAILAND			391.19		391.19
UGANDA	3.61				3.61
URUGUAY		60.11			60.11
VENEZUELA		227.35			227.35
VIETNAM			15.39		15.39
TOTAL	1,255.80	5,532.34	513.57	1,373.02	8,671.91

Table 5 Internal Rates of Return to CIAT Gemplasm Improvement Research (%)

Crop	Rate of Return
Rice	57
Forages	36
Beans	27
Latin America and the Caribbean	26
Africa	59
Cassava	24
Latin America and the Caribbean	12
Asia	75

Chart 1

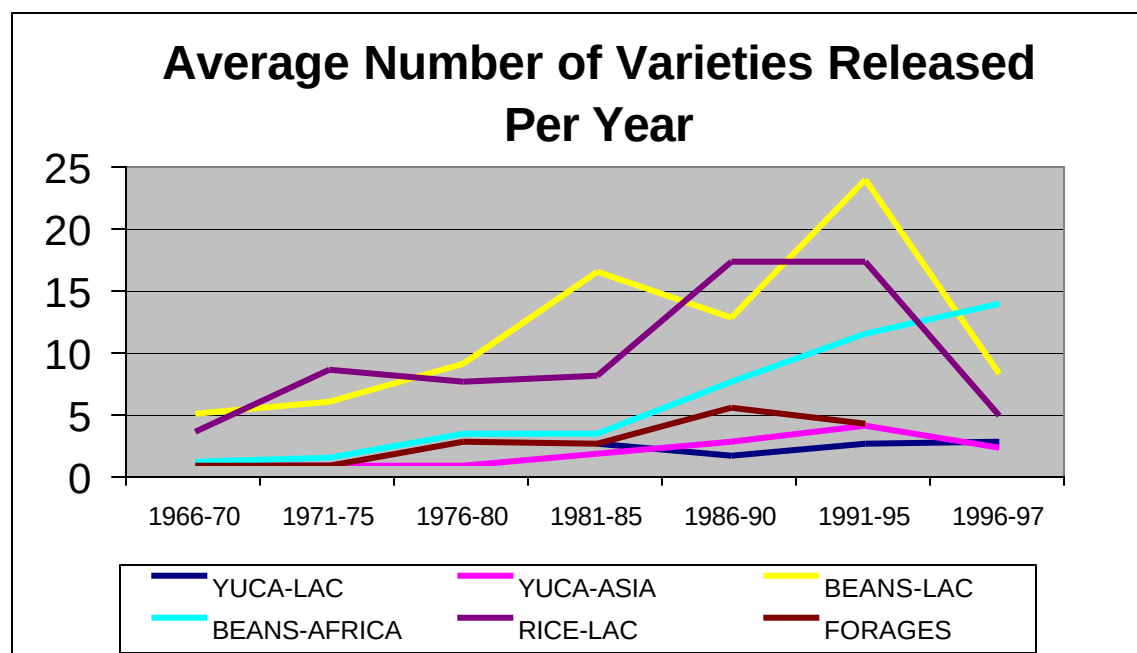


Chart 2

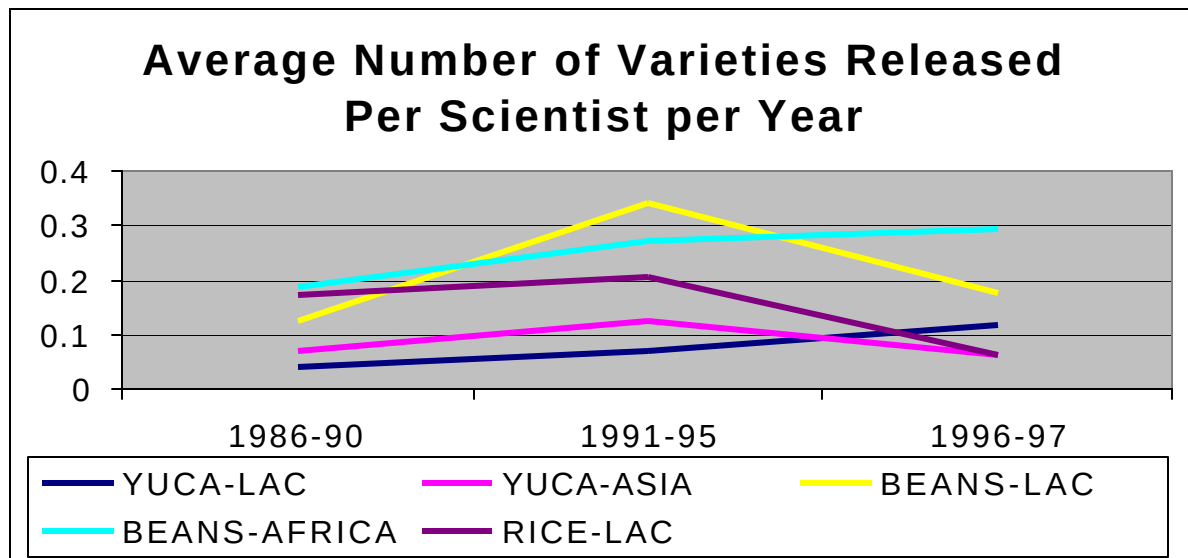


Chart 3

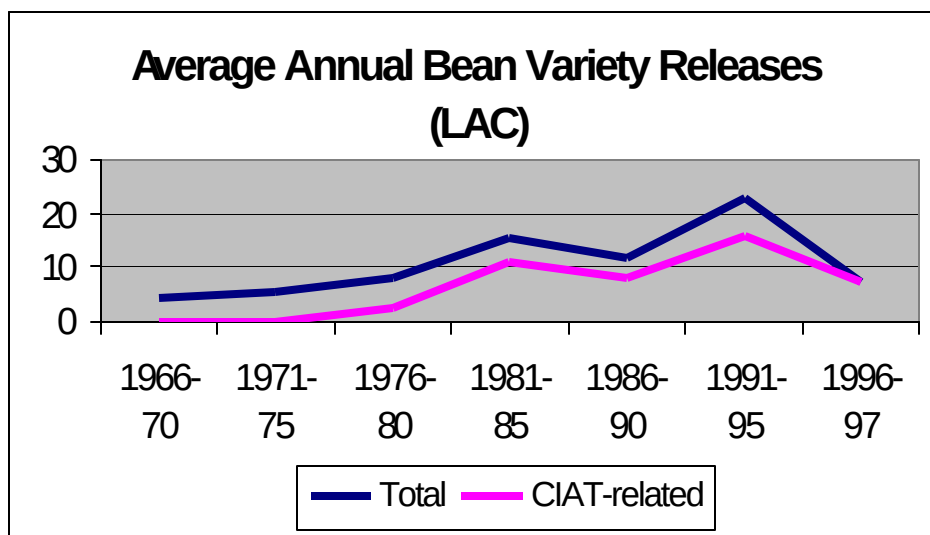


Chart 4

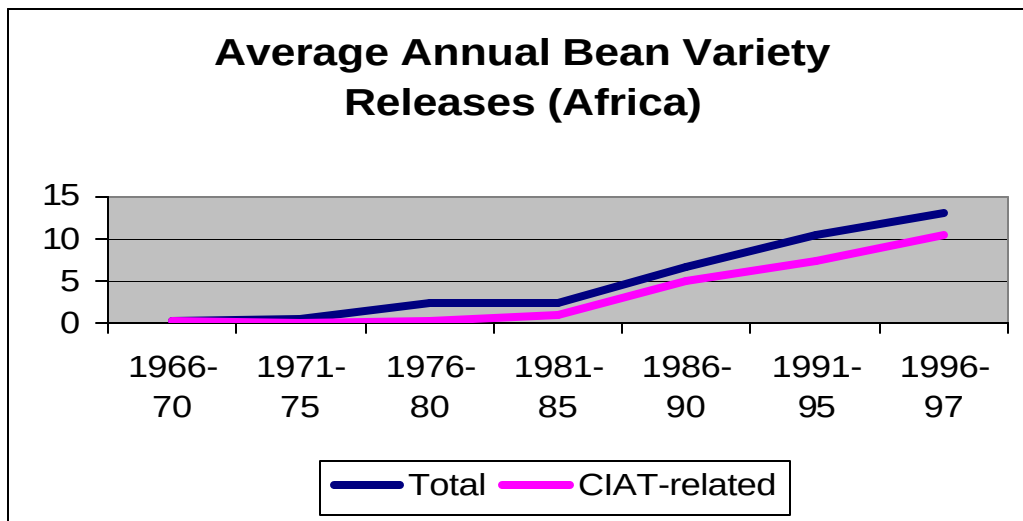


Chart 5

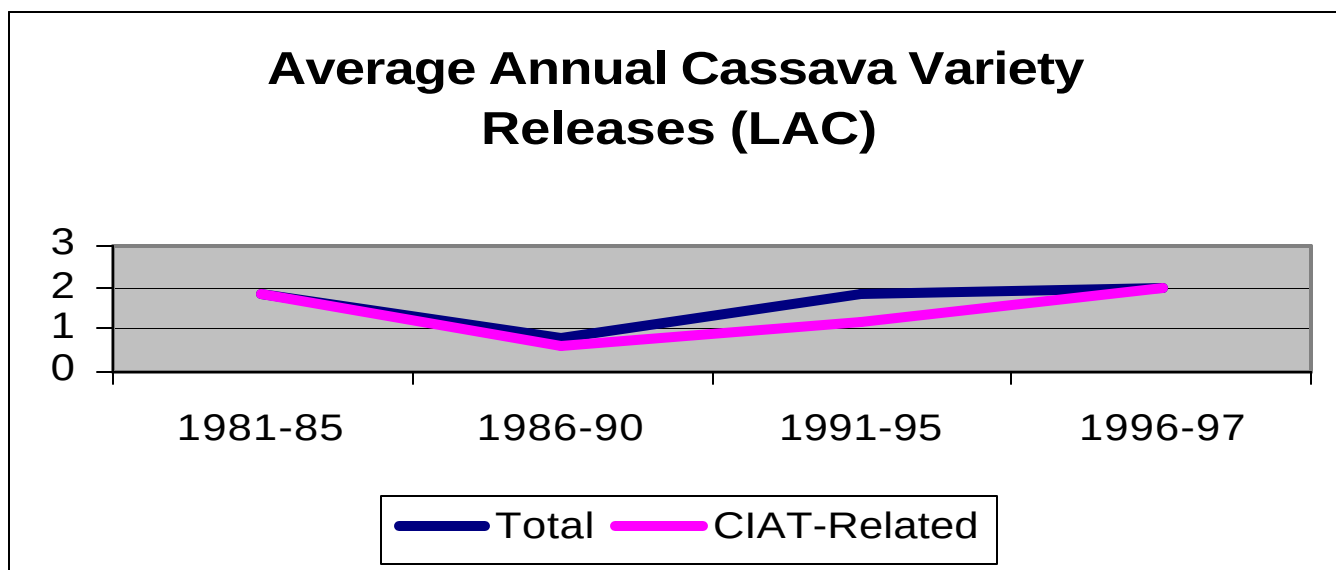


Chart 6

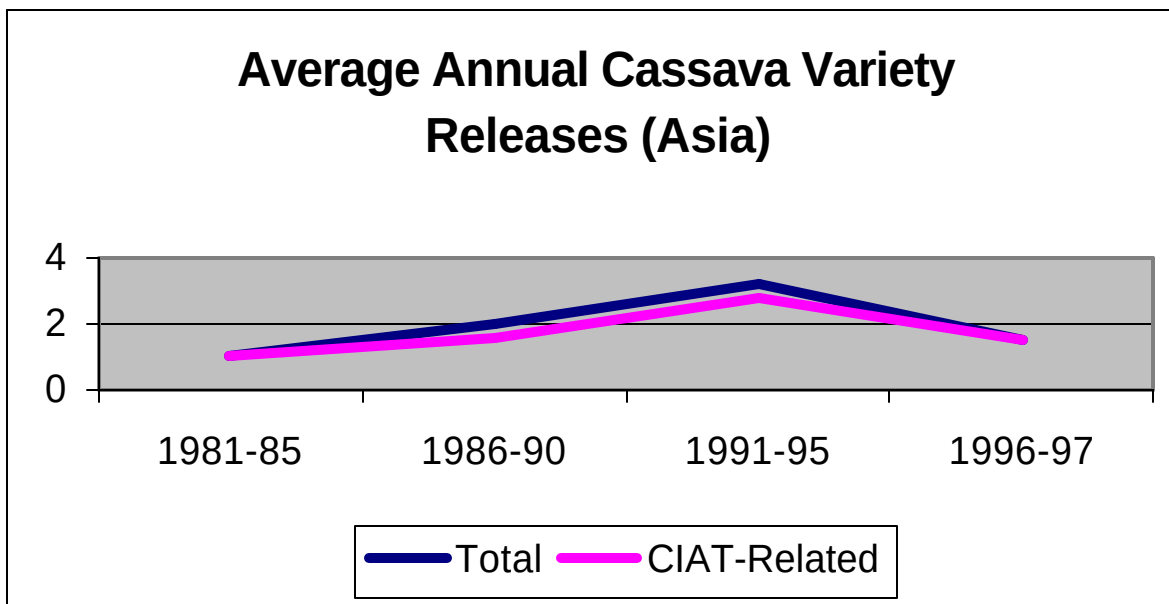


Chart 7

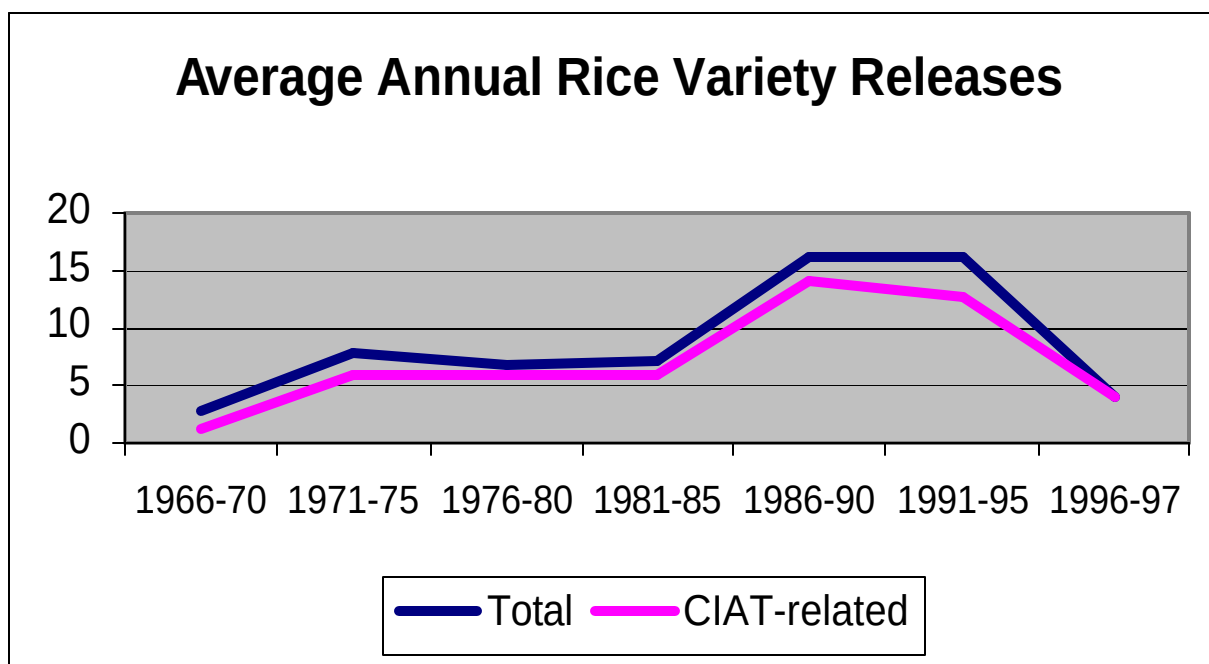


Chart 8

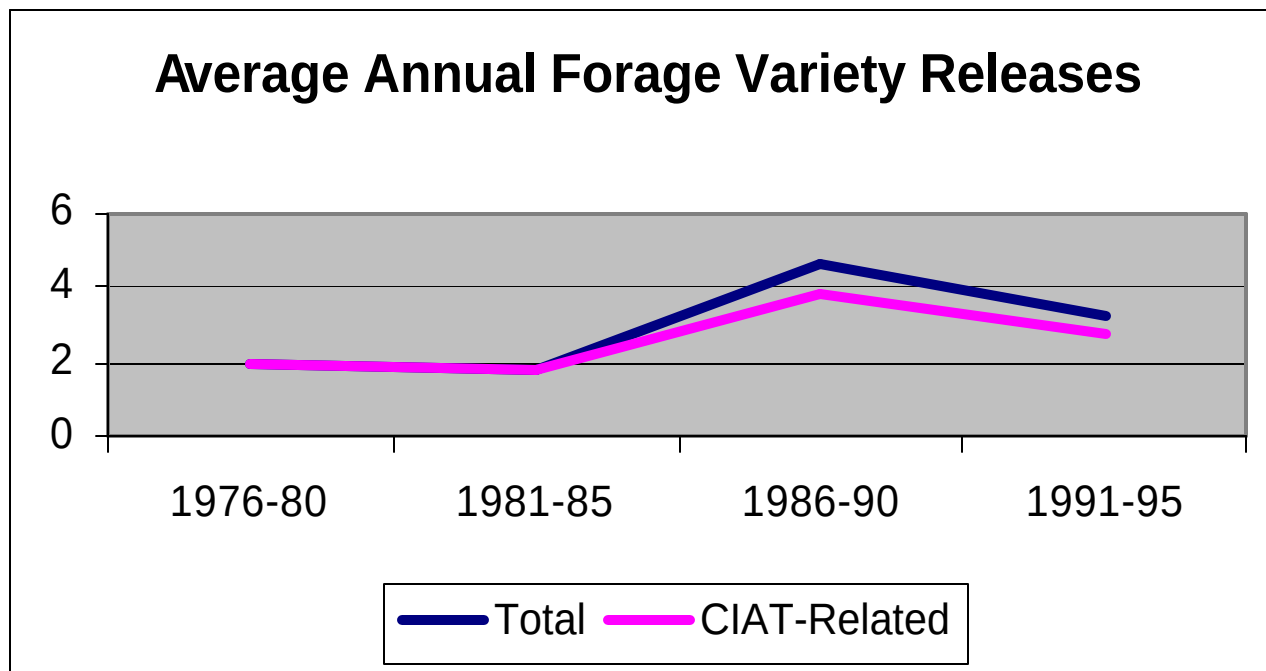


Chart 9

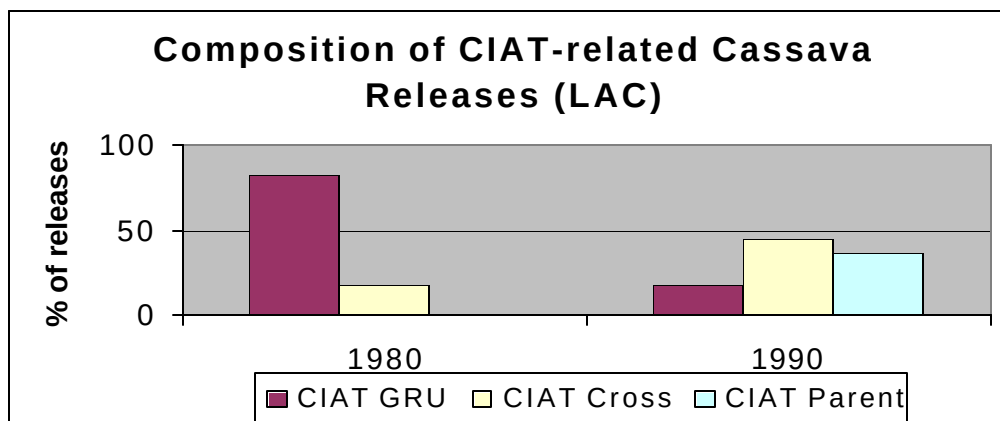


Chart 10

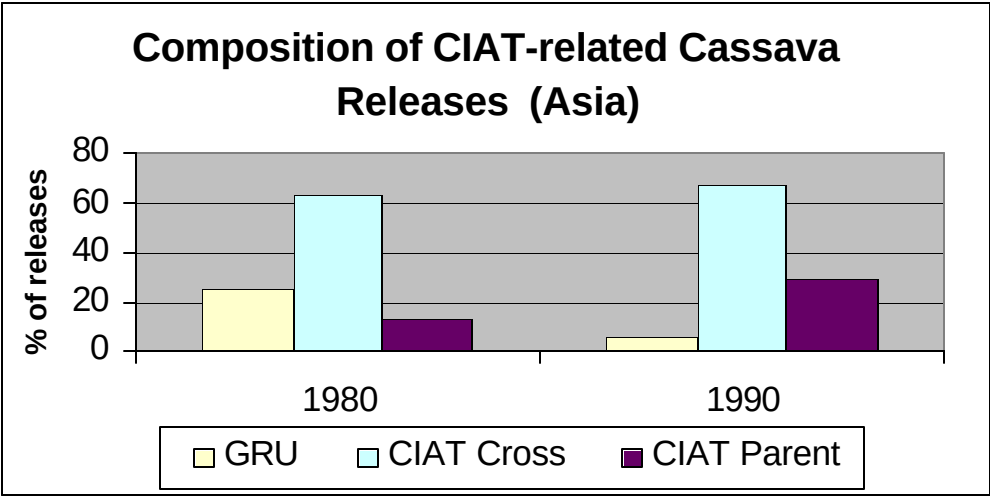


Chart 11

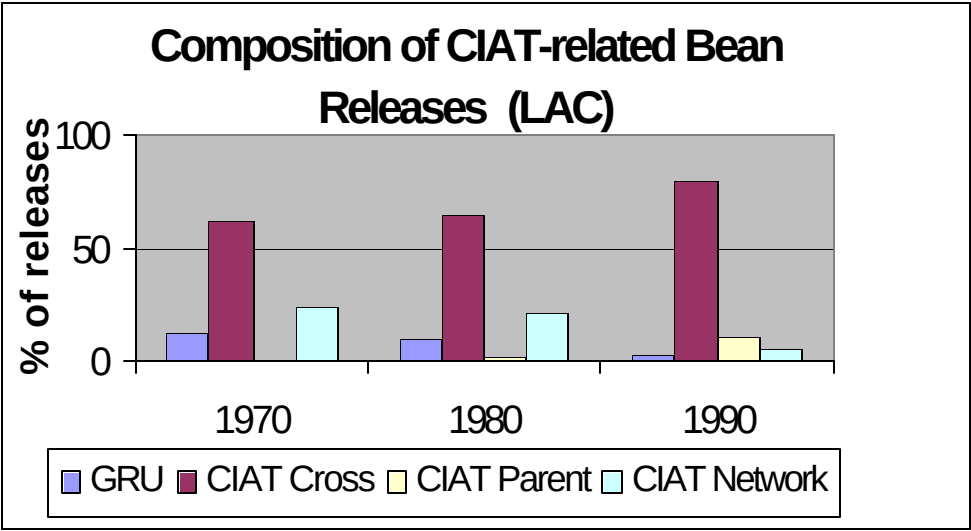


Chart 12

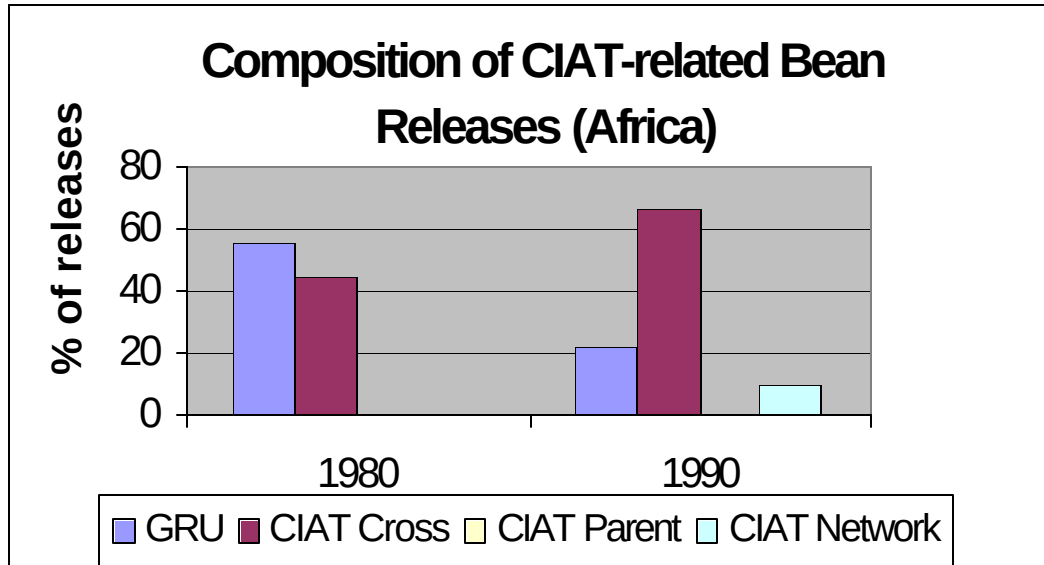
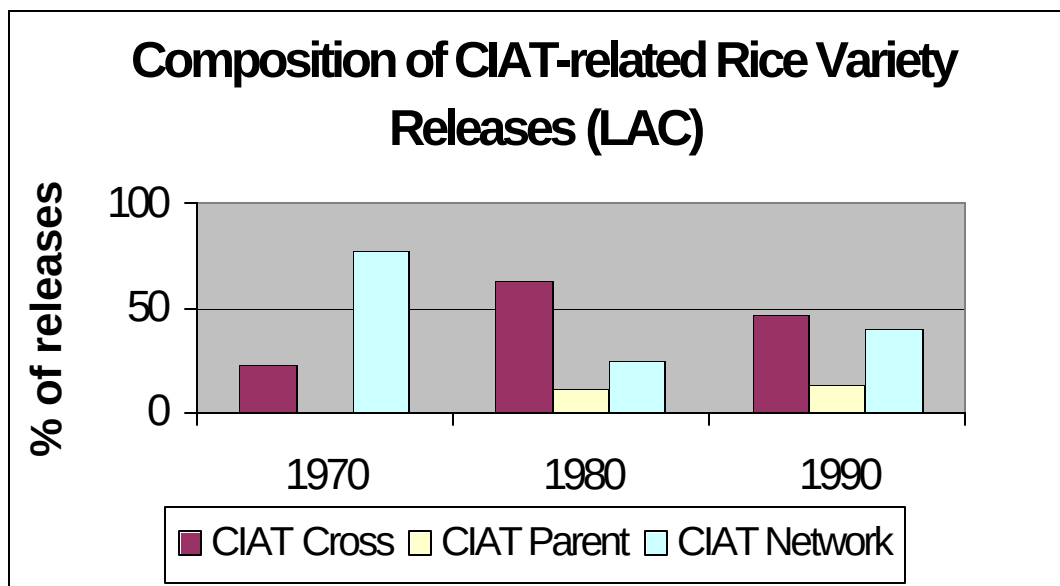


Chart 13



Collaborating individuals and Institutions:

- CIAT's bean, rice, cassava and tropical forages programs
- Robert Evenson and Douglas Gollin, IAEG/Yale University

Donors:

- CGIAR Impact Assessment and Evaluation Group (IAEG)

2.2 EMPIRICAL STUDIES OF PAST RESEARCH IMPACT

2.2.1 Technical Change in the Savannas and Forest Margins of Colombia - by: *Libardo Rivas*

Meta para el 2000

Efectuar la evaluación del impacto económico *ex-post* de la adopción de nuevas tecnologías de arroz y forrajes en la Amazonia y Orinoquia de Colombia (A&O).

Principales Conclusiones:

- Las dos actividades evaluadas, arroz y ganadería, muestran procesos de adopción diferentes en cuanto a intensidad y velocidad en el tiempo, que obedecen a múltiples factores tales como cantidad y calidad de recursos, organización gremial, disponibilidad de insumos y riesgos asociados a cada una de ellas.
- El desarrollo y adopción de nuevas variedades y formas de producción en el cultivo de arroz ha sido uno de los mayores éxitos tecnológicos en la agricultura, no solo en A&O, sino también en Colombia y en América Latina en general. Ha sido un proceso de carácter masivo que ha afectado la productividad, la producción y los precios.
- En la ganadería la dinámica de la adopción y la magnitud del impacto económico logrado han sido menores, no obstante en las áreas donde la adopción se ha documentado, se aprecian importantes avances de la productividad y cambios significativos y positivos en el uso de la tierra.
- Para el período 1967-1997 el valor presente de los beneficios sociales atribuibles al cambio técnico en la producción de arroz en Colombia equivalen a una anualidad de us\$136 millones. Para dar idea de su magnitud relativa se estima que la producción colombiana de arroz en 1997 se valoraba en us\$ 551 millones a precios del productor y en us\$ 1.4 billones a precios del consumidor.
- Los beneficios tecnológicos en A&O resultantes de la adopción tecnológica en arroz, se estimaron en us\$ 38 millones por año. Dada la caída de los precios reales al consumidor – 42% en todo el período evaluado - y la poca apertura del mercado de arroz, tales beneficios sociales se concentraron en los consumidores, quienes capturaron más del 90% de los beneficios totales.
- El empleo de tecnologías mejoradas en la producción de arroz derivó en un significativo ahorro de tierra. Para obtener los actuales niveles de producción en A&O usando la tecnología tradicional, hubiera sido necesario la utilización de una superficie de 308 mil hectáreas, más del doble del área efectivamente utilizada.
- Se calcula que en Puerto López - Puerto Gaitán, en el período 1978-2000, el valor anual de la producción adicional de carne debido al uso de pasturas mejoradas se

aproxima a los us\$ 5 millones. En el piedemonte del Caquetá, en un período más corto 1986-2000, tal valor se estima en us\$ 3 millones por año.

- El ahorro de tierra derivado de la utilización de mejores forrajes en Puerto López- Puerto Gaitán es de alrededor de un cuarto de millón de hectáreas y en el piedemonte caqueteño de unas 30 mil hectáreas. En ésta última zona predominan los pequeños y medianos productores, con un tamaño promedio de finca de 156 has, quienes hacen un uso cada vez más intensivo de la tierra, en explotaciones dedicadas a la producción conjunta de carne y de leche.
- Los resultados obtenidos evidencian el alto retorno social de la investigación agropecuaria para A&O de Colombia y al mismo tiempo llevan a reflexionar sobre el impacto del cambio técnico y su dimensión temporal. Su evaluación debe efectuarse dentro de una perspectiva de largo plazo, en un proceso donde a través de los años se logran resultados intermedios, los cuales conducen finalmente al logro de las metas sociales tales como reducción de la pobreza, conservación de los recursos naturales y del medio ambiente y en definitiva crecimiento económico sostenido.

Resumen

En esta área de trabajo y dentro del marco del convenio de cooperación técnica y científica MADR- CIAT, se efectuó la evaluación del impacto económico ya logrado en la Amazonia y Orinoquia (A&O) de Colombia, resultante de la aplicación de nuevas tecnologías de producción en arroz y ganadería

La evaluación incluye dos de los principales agroecosistemas del mandato del CIAT: Las sabanas (Llanos Orientales) y los Márgenes de bosque (Amazonia). Figura 1.

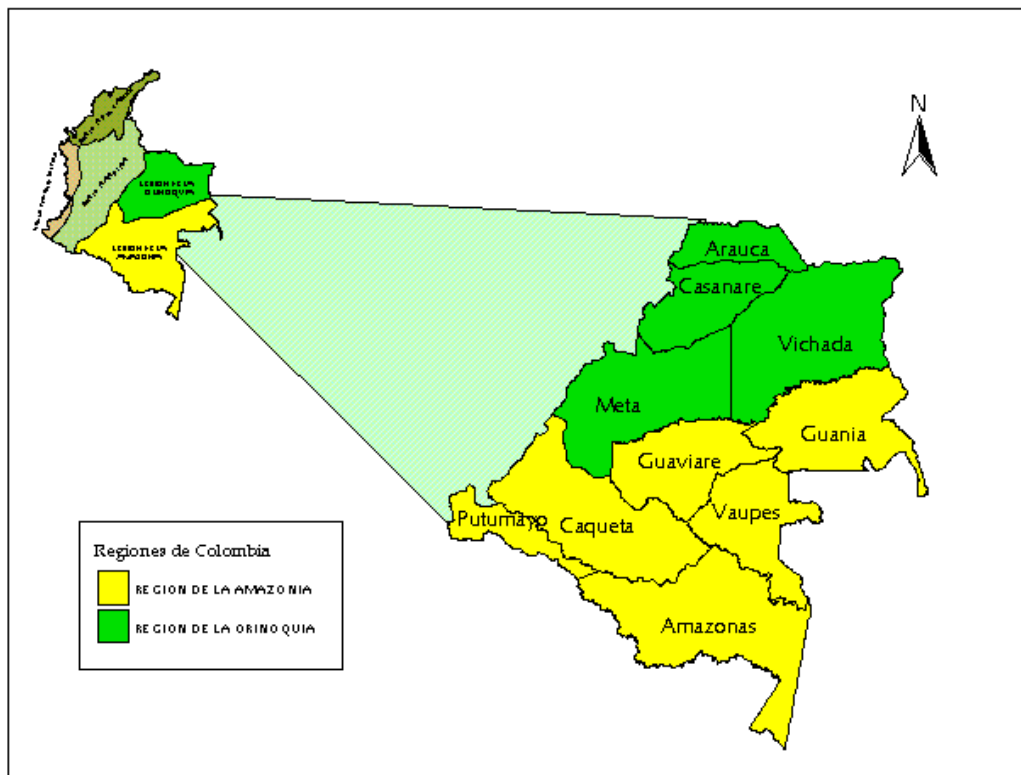
En el caso de la ganadería se evaluó el impacto económico de nuevas tecnologías de forrajes utilizadas por los productores en la región de referencia, en producción de carne y de leche. Se incluyen dos regiones específicas en donde el CIAT ha venido trabajando desde hace más de 15 años: El área de Puerto López – Puerto Gaitán en los Llanos Orientales y el Piedemonte del Caquetá en la Amazonia.

En éstas dos áreas específicas el Centro cuenta con una dilatada experiencia de trabajo colaborativo con muchas instituciones nacionales, lo cual ha derivado en un importante acervo de información técnica y científica y en la elaboración de varios estudios sobre la adopción de las nuevas tecnologías de forrajes. En el Cuadro1 aparecen los materiales forrajeros liberados para las zonas de referencia.

Para la evaluación del impacto del cambio técnico en arroz la información básica requerida tal como áreas impactadas, variedades utilizadas y cambios de la productividad es muy completa, abarca un extenso período y se encuentra consignada en diversos documentos y estudios técnicos del Ministerio de Agricultura, FEDEARROZ y el CIAT

La generación de nuevas tecnologías arroceras ha resultado en un masivo proceso de adopción tecnológica, cuyo impacto se ha diseminado a lo largo y ancho de todo el país, por un lapso superior a las tres décadas. En la figura 2 se ilustran los hitos mas sobresalientes del proceso de desarrollo tecnológico en el cultivo de arroz en Colombia y en el Cuadro 2, las nuevas variedades liberadas en el transcurso de tres décadas.

Figura 1. Amazonia y Orinoquia de Colombia: Divisiones Territoriales



Adopción de pastos mejorados

La estrategia de la investigación en forrajes ha buscado el desarrollo de nuevas variedades de pastos y leguminosas y de métodos de producción, que permitan incrementar la productividad, la sostenibilidad y la competitividad de las actividades ganaderas en esa parte de Colombia. A comienzos de la década del 80 se inició la liberación de nuevos materiales de gramíneas y leguminosas adaptadas a las condiciones de clima y suelo particulares de A&O de Colombia.

Los estudios de adopción de los nuevos materiales forrajeros comenzaron hacia finales de la década del 80 y se concentraron en los municipios de Puerto López – Puerto Gaitán en los Llanos Orientales y el Piedemonte del Caquetá, en la región Amazónica colombiana.

Tales trabajos se enfocaron principalmente hacia la estimación, mediante muestreos en las fincas, de las superficies sembradas con los nuevos cultivares y en la identificación de los principales factores que afectan los procesos de adopción.

Cuadro 1. Materiales forrajeros liberados adaptados a las condiciones de A&O de Colombia.

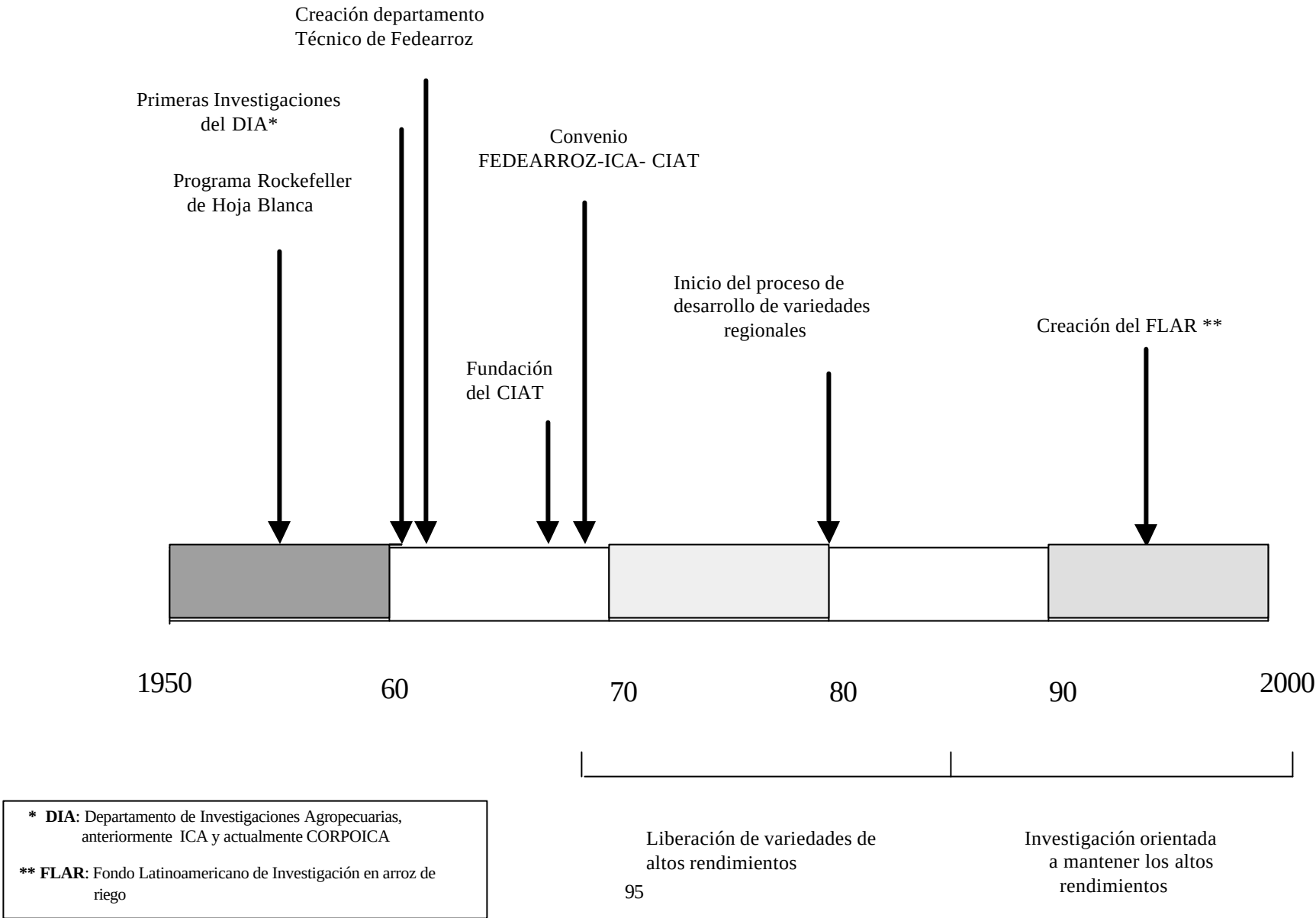
Gramíneas y L	Ecotipo CIAT	Nombre del cultivar	Año de liberación
Gramíneas			
<i>Andropogon gayanus</i>	621	Carimagua 1	1980
<i>Brachiaria dictyoneura</i>	6133	Llanero	1987
<i>Brachiaria brizantha</i>	26646	La Libertad	1987
<i>Brachiaria humidicola</i>	679	Humidicola	1990
Leguminosas			
<i>Centrosema acutifolium</i>	5277	Vichada	1987
<i>Stylosanthes capitata</i>	10280	Capica	1983
<i>Arachis pintoi</i>	17434	Maní forrajero	1992

En el Cuadro 2 se muestra la evolución de las superficies cultivadas con nuevas pasturas: gramíneas puras, leguminosas puras y praderas mixtas de gramíneas y leguminosas, en la zona de Puerto López - Puerto Gaitán en los Llanos Orientales de Colombia. La información se refiere a los años muestrales 1989 y 1992 y se adiciona una estimación, que se considera conservadora, para el año 2000.

Los estudios de adopción muestran como la gramínea *B. decumbens*, la más extendida en A&O, progresivamente ha sido sustituida por las nuevas brachiarias, mas tolerantes al “mión”, la plaga de los pastos que mayor daño económico causa. El uso de pasturas mixtas de gramíneas y leguminosa, una práctica muy poco empleada hasta hace unos pocos años, comienza a ser mas frecuente en las ganaderías de la región.

El principal recurso forrajero en los Llanos Orientales es la sabana nativa, que está disponible para el pastoreo durante todo el año, pero que presenta muy baja calidad forrajera y soporta cargas animales muy bajas. La introducción de nuevos materiales forrajeros ha permitido diversificar el germoplasma y sustituir lentamente pasturas nativas de muy baja productividad por pastos mejorados altamente productivos.

Figura 2. Hitos en el Desarrollo Tecnológico del cultivo de Arroz en Colombia



**Cuadro 2 Evolución de las pasturas, según tipo en la Altillanura Oriental de Colombia:
Area de Puerto López – Puerto Gaitán**

Especies	1989		1992		Estimación al 2000	
	Area total (ha.)	% del total	Area total (ha)	% del total	Area total (ha)	% del total
Total pasto	960192	100.0	1025984	100.0	1076647 1/	100.0
Sabana nativa	871459	90.8	853145	83.2	835124 2/	77.6
Pasto mejorado	88733	9.2	172839	16.8	241523	22.4
Total gramíneas, leguminosas y asociaciones	88733	100.0	172839	100.0	241523	100.0
<i>B. decumbens</i>	45559	51.3	67580	39.1	71662 3/	29.7
<i>B. humidicola</i>	26479	29.8	57476	33.3	72083 3/	29.8
<i>A. gayanus</i>	4453	5.0	7129	4.1	7210 3/	3.0
<i>B. dictyoneura</i>	1371	1.5	5584	3.2	12431 4/	5.1
Otras gramíneas	3598	4.1	4013	2.3	5358 5/	2.2
Total gramíneas puras	81460	91.8	141782	82.0	168744	69.9
Asociaciones (gramíneas + Leguminosas)	6950	7.8	30780	17.8	72531 6/	30.0
<i>B. decumbens</i> + <i>S. capitata</i>	1490	1.7	15137	8.8	35669 7/	14.8
<i>B. humidicola</i> + <i>S. capitata</i>	0	0.0	6765	3.9	15941 7/	6.6
<i>B. dictyoneura</i> + <i>S. capitata</i>	847	1.0	5558	3.2	13097 7/	5.4
<i>A. gayanus</i> + <i>S. capitata</i>	2480	2.8	621	0.4	1463 7/	0.6
<i>A. gayanus</i> + <i>C. acutifolium</i>	339	0.4	0	0.0	0 7/	0.0
Otras asociaciones	1794	2.0	2699	1.6	6360 7/	2.6
Leguminosas puras	323	0.4	277	0.2	248 1/	0.1

1/ Estimado empleando la tasa de crecimiento del período 1989- 1992. 2/ Calculado como la diferencia entre área total en pastos y el área en pasturas mejoradas. 3/ Estimado empleando un modelo logístico ajustado para el período 1978-1992. 4/ Estimado usando un modelo lineal ajustado para el período 1981-1991. 5/ Estimado mediante un modelo cuadrático ajustado para el período 1978-1992. 6/ Calculado utilizando un modelo lineal ajustado para el período 1987-1992. 7/ Se asume que la distribución porcentual de las diferentes asociaciones en el total de las mismas, es similar a la que se observó en 1992.

Fuente: Cálculos basados en cifras de Cadavid et al (1992) y Cadavid (1995).

Cuadro 3. Evolución del área en pasturas en el Caquetá, Colombia:1986-2000.

Tipo de pastura	1986		1997		Estimación al 2000		Tasa anual de crecimiento 1986-1997 (%)
	has	%	Has	%	ha	%	
Total pastos	285408	100.0	381421	100.0	386182	100.0	2.7
Pastura nativa	184029	64.5	113271	29.7	109907	29.7	-4.3
Pastos mejorados	101379	35.5	268150	70.3	276175	70.3	9.2
Pastos mejorados	101379	100.0	268150	100.0	276125	100.0	9.2
<i>B. decumbens</i>	7701	76.0	174812	65.2	180109	65.2	7.7
<i>B. humidicola</i>	595	0.6	37757	14.1	38901	14.1	45.8
<i>Echinocloa polystachia</i>	3865	3.8	32406	12.1	33388	12.1	21.3
<i>B. brizantha</i>	0	0.0	12784	4.8	13171	4.8	-
<i>B. dictyoneura</i>	0	0.0	2613	1.0	2692	1.0	-
<i>Arachis pintoï asociado</i>	0	0.0	2616	1.0	2706	1.0	-
<i>Arachis pintoï solo</i>	0	0.0	356	0.1	367	0.1	-
Otras gramíneas	19919	19.6	4795	1.8	4941	1.8	-12.1

Cifras consolidadas de 2973 fincas proveedoras de Nestlé en el Caquetá.

Fuente: Cálculos basados en cifras de Ramírez y Seré (1990) y Rivas y Holmann (1999)

En el Cuadro 3 se presentan las superficies cultivadas con pastos mejorados en el Piedemonte del Caquetá en la región amazónica del país. Allí se observa un proceso de adopción similar al que se aprecia en los Llanos. Las sabanas nativas progresivamente reemplazadas por pastos mejorados, *B. decumbens* sustituida lentamente por otras gramíneas y una importante diversificación del germoplasma forrajero.

El cambio técnico en la ganadería de A&O se ha traducido principalmente en incrementos de productividad a nivel de la finca, pero aún no presenta la magnitud suficiente como para afectar significativamente la producción y los precios del país. Es necesario indicar que a diferencia de los cultivos, la adopción de nuevos forrajes es más lenta, ya que involucra significativos montos de inversiones en establecimiento de pasturas y compra de ganado y eventualmente cambios en los sistemas de manejo del hato y de las pasturas.

Adopción de nuevas variedades de arroz

En los procesos de generación y adopción de nuevas tecnologías de arroz en Colombia y en A&O, se aprecia un claro vínculo entre el sector privado, el sector público y las entidades internacionales de investigación agropecuaria. (Véase Figura 2)

El sector arrocerero colombiano se ha caracterizado por su dinamismo en lo referente a la generación y adopción de nuevas tecnologías. Estas incluyen el uso de insumos modernos, nuevas variedades y equipos y prácticas de preparación, siembra y manejo del cultivo. En el Cuadro 4 se muestran las nuevas variedades de arroz liberadas en el país a lo largo de tres décadas de investigación.

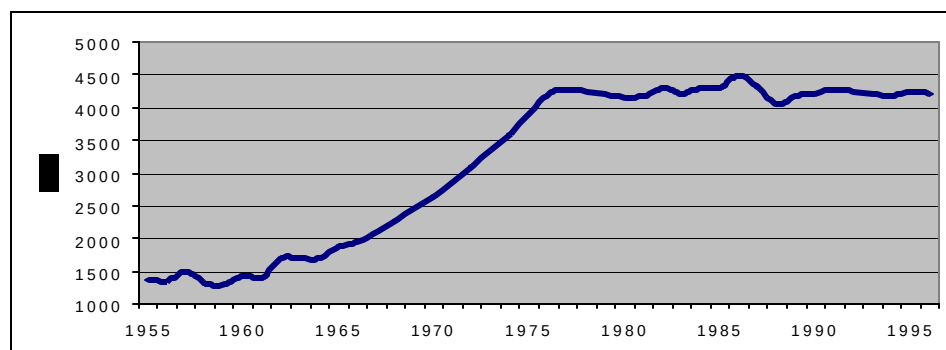
**Cuadro 4 Variedades de arroz liberadas en Colombia
1967-1998**

Año de liberación	Nombre de la variedad	Tipo de germoplasma	Entidad que liberó el Material
1967	IR8 ICA 10	IRRI VLACIR	ICA ICA
1970	IRR 22	IRRI	ICA
1971	CICA 4	CCLS	CIAT – ICA
1974	CICA 6	CCLS	CIAT – ICA
1976	CICA 9	CCLS	CIAT – ICA
1978	CICA 8	CCLS	CIAT - ICA
1980	METICA 1 METICA 2	CCLS CCLS	CIAT – ICA CIAT – ICA
1982	ORYZICA 1	CCLS	CIAT – ICA
1984	ORYZICA 2	CCLS	CIAT- ICA
1987	ORYZICA 3	CCLS	CIAT - ICA
1989	ORYZICA Llanos 4 ORYZICA Llanos 5	CCLS CCLS	ICA ICA
1991	ORYZICA Sabana 6	CCLS	ICA - CIAT –FEDEARROZ
1992	ORYZICA Turipaná 7	CCLS	ICA
1993	ORYZICA Caribe 8	CCLS	CIAT - ICA – FEDEARROZ
1994	ORYZICA Yacu 9 SELECTA 3-20	CCLS VLACIR	CIAT – ICA – FEDEARROZ SEMILLANO
1995	ORYZICA Sabana 10	CCLS	CIAT- ICA
1997	COPROSEM 1	CCLS	COPROSEM
1998	FEDEARROZ 50	CCIPC	FEDEARROZ

CCLS: Cruce de CIAT localmente seleccionado. VLACIR: Variedades o líneas avanzadas de los Centros Nacionales de Investigación distribuidas a través de la red del CIAT. CCIPC: Cruces de los Centros Nacionales de Investigación con padres de CIAT. IRRI: Germoplasma de IRRI adaptado localmente.

El cambio tecnológico en la producción de arroz en Colombia y en A&O implicó: 1) Un rápido incremento de los rendimientos por hectárea. 2) Acelerada expansión de la producción agregada. 3) Significativo aumento del consumo per cápita y 4) Importante reducción de los precios reales a nivel de consumidor final.

**Figura 3. Rendimientos del cultivo de arroz en los Llanos Orientales
Departamento del Meta: 1955-1996**



Fuente: Silva (1968), Tróchez (1971) y Anuarios del MADR

Para ilustrar la dinámica de la productividad arrocera en A&O en la figura 3 se presenta la evolución de los rendimientos promedios en el departamento del Meta en los Llanos Orientales. Se observa un rápido crecimiento de éstos desde principios de los años 60 hasta mediados de los 70. A partir de ese momento los rendimientos tienden a permanecer estables.

Impacto Económico de la adopción de nuevas tecnologías forrajeras en A&O

El impacto económico de las nuevas tecnologías forrajeras se ha manifestado principalmente en los incrementos de productividad por hectárea y por unidad animal, en las regiones en donde tales tecnologías se están utilizando. También han tenido un significativo impacto sobre el uso del suelo, lo cual a su vez implica a mas largo plazo una menor presión sobre las tierras más frágiles desde el punto de vista ecológico.

Dado que es difícil y costoso obtener mediciones de los cambios de la productividad ganadera, expresada por unidad animal o por hectárea, a nivel de grandes regiones o del país en conjunto, en este estudio se utilizó la información sobre productividad obtenida en las pruebas experimentales y en fincas comerciales, adelantadas por el CIAT y otras instituciones nacionales. Las figura 4 ilustra los niveles de productividad de los nuevos materiales forrajeros en los Llanos Orientales de Colombia: Piedemonte y Altillanura. Se asume que la productividad de referencia es la de una pastura de brachiaria tradicional medianamente degradada.

La medición del impacto en este caso se circunscribe a estimar el valor de las ganancias monetarias en producción resultantes del uso de los forrajes mejorados.

Tales ganancia se estiman como:

$$VPA_t = A_{a,t} (PR_{a,t} - PR_{dd,b}) P_t$$

Donde VPA_t = Valor de la producción adicional en el período t

$A_{a,t}$ = Area plantada con el pasto a en el período t.

$PR_{a,t}$ = Productividad física del pasto a en el período t - Tecnología mejorada

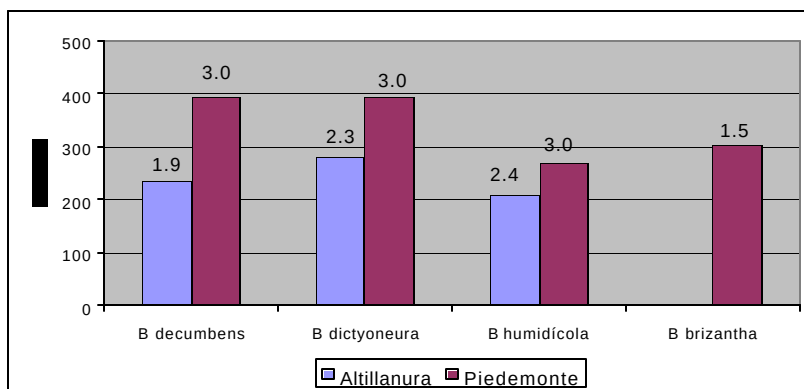
$PR_{dd,b}$ = Productividad física de decumbens degradada en el período base - Tecnología tradicional

P_t = Precio del producto en el período t.

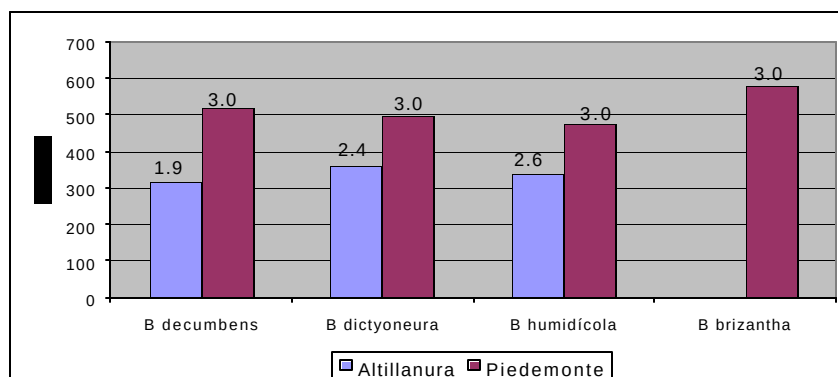
Para la zona de Puerto López – Puerto Gaitán los beneficios tecnológicos se expresan como el valor del flujo de las ganancias en productividad en el período 1978-2000. Para el piedemonte del Caquetá tales beneficios se refieren al período 1986-2000. En el Cuadro 5 aparecen los beneficios recibidos por los productores en esas dos zonas del país y atribuibles al empleo de mejores pasturas.

Figura 4. Productividad promedio de diferentes especies de brachiaria en los Llanos Orientales de Colombia: Piedemonte y Altillanura

a) Brachiarias solas



b) Brachiarias asociadas con leguminosas



La cifra arriba de cada barra corresponde a la carga animal expresada como ua/ha.
Fuente: Pardo et al, 1999

Cuadro 5. Valor presente y anualidades de la producción adicional por el uso de mejores forrajes en A&O 1/

Región	Valor Presente (millones)		Anualidad (millones)	
	\$col	us\$	\$col	us\$
Orinoquia (Puerto López –Puerto Gaitán)				
1978-1992	18094	15.9	2379	2.1
1978-2000	50797	44.5	5518	5.0
Amazonia (Caquetá, Piedemonte)				
1986-1997	15828	13.9	2323	2.0
1986-2000	26386	23.1	3469	3.0

1/ Valores expresados en \$ de 1997. Tasa de cambio: \$col 1141/ 1us\$. Tasa de descuento:10% anual

Impacto Económico de la adopción nuevas tecnologías de arroz en Colombia y en A&O

El desarrollo, difusión y adopción de nuevas tecnologías en el cultivo de arroz en el país y en A&O, ha sido un proceso masivo y de larga duración que ha implicado cambios sustanciales en la productividad, la producción, las superficies cultivadas, los precios al consumidor y los niveles de consumo

Durante 1967-1997 la producción colombiana de arroz casi se triplico, en tanto que el área cultivada solo creció 1.3 veces. Este significativo incremento de la producción obedeció principalmente al sostenido aumento de los rendimientos por hectárea, los cuales pasaron de 2.3 a 4.6 ton/ha. (Cuadro 6)

Cuadro 6. Producción, área y rendimientos de arroz en Colombia, A&O y el resto del país: 1967-1997.

Variables	Colombia		A & O		Otras regiones	
	1967	1997	1967	1997	1967	1997
Producción (000tm)	661.5	1830.3	136.8	464.9	524.7	1365.4
Area (000 ha)	290.7	394.1	79.4	108.8	211.3	285.3
Rendimiento (kg /ha)	2275	4644	1720	4273	2483	4786
Cambios 1967-1997:						
Q (000tm)	1168.8		328.1		840.7	
A (000 ha)	103.4		29.4		74.0	
R (kg/ha)	2369		2553		2303	
K	2.765		1.495		2.27	

Fuente: Anuarios del Ministerio de Agricultura y Tróchez, 1971.

En A&O la adopción tecnológica en el cultivo también derivó en sustanciales variaciones de la productividad, la producción y las áreas sembradas. La producción más que se triplicó, la superficie cultivada creció 1.4 veces y los rendimientos promedios pasaron de 1.7 a 4.3 ton/ha.

La estimación del impacto económico resultante del cambio técnico en la producción de arroz, se efectuó empleando el modelo Modexc, el cual incorpora en la evaluación tanto

los cambios en productividad como las variaciones de los precios, lo cual permite estimar los beneficios sociales capturados por productores y consumidores.

Cuadro 7. Beneficios sociales de la adopción tecnológica en arroz Colombia, Amazonia y Orinoquia:1967-1997
(valores en millones) 1/

Grupos Sociales	Colombia		Amazonia & Orinoquia		Otras regiones	
	\$col	us\$	\$col	us\$	\$col	us\$
Consumidor	11420472	1245	398376	349	1022096	896
Productor	41363	36	11600	10	29763	26
Total						
VP	1461835	1281	409976	359	1051859	922
Anualidad	155070	136	43490	38	11580	98

1/ Cifras en pesos de 1997, convertidas a us\$ usando la tasa de cambio de \$col 1141/ 1us\$. Tasa de descuento = 10%

Para Colombia en conjunto los beneficios sociales del cambio tecnológico en arroz son equivalentes a una anualidad de us\$ 136 millones y para A&O se estiman en us\$ 38 millones por año.

Dada la intensidad y cobertura del proceso de cambio técnico y el bajo grado de apertura del mercado de arroz en Colombia durante el período analizado, los mayores beneficiarios fueron los consumidores quienes se apropiaron de una fracción muy alta de los beneficios totales. (Cuadro 7).

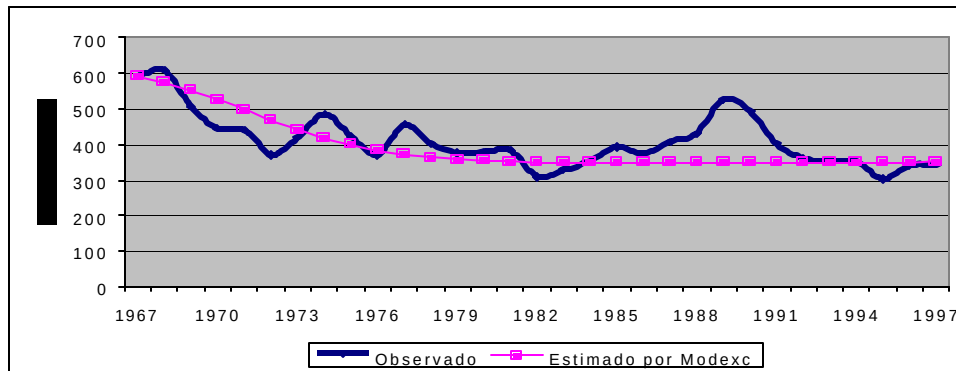
La rápida caída de los precios reales a nivel del consumidor final y el incremento del consumo, generaron altos excedentes tecnológicos para los consumidores. Los productores se beneficiaron con los avances de la productividad que redujeron sus costos unitarios de producción, pero también sufrieron el efecto adverso del desplome de los precios reales.

La figura 5 ilustra la evolución del mercado de arroz en Colombia durante el período de análisis en términos de producción y precios al productor. El cambio técnico evaluado representa el esfuerzo de numerosas entidades públicas y privadas, nacionales e internacionales, que participaron en diferentes etapas del diseño y difusión de las nuevas técnicas.

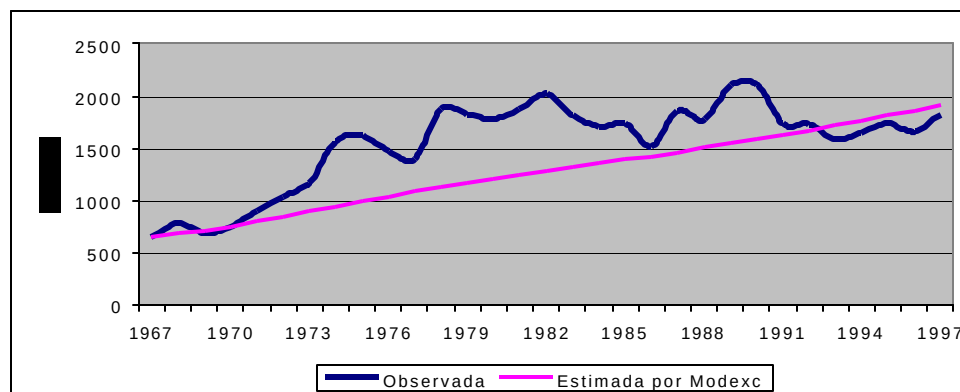
En todo ese proceso hubo una importante participación del CIAT, que demuestra que la cooperación técnica y científica y el trabajo en equipo entre las entidades nacionales e internacionales, es una herramienta válida dentro de una estrategia de desarrollo que busca la modernización de la agricultura colombiana, de forma eficiente, competitiva y sostenible.

**Figura 5. Evolución del mercado de arroz en Colombia
1960-1997**

a) Precios



b) Producción



Los resultados de la evaluación llevan a reflexionar sobre el impacto del cambio técnico y su dimensión temporal. Para evaluarlo es preciso hacerlo con una visión de largo plazo, en un proceso donde a través de los años se van logrando resultados intermedios, que conducen a los impactos finales de largo plazo. Estos últimos están más íntimamente ligados con las metas sociales de desarrollo tales como reducción de la pobreza, conservación del medio ambiente y de los recursos naturales y crecimiento general de la economía.

Lo anterior sugiere que se requiere un seguimiento sistematizado de los resultados intermedios que se van logrando con el transcurso del tiempo, con el propósito de entender los procesos y aplicar los correctivos necesarios cuando se detecten fallas o cuellos de botella, y asegurar que el trabajo de investigación y desarrollo efectuado, tendrá a largo plazo un claro impacto social.

2.2.2 Participatory Research - *by: Nancy Johnson*

Title: Characterizing the impacts and costs of incorporating user participation in natural resource management research

Results

- Framework developed for assessing the impacts and costs of incorporation user participation in natural resource management
- Inventory of over 60 participatory NRM research projects from around the world, including information on research methods, resources, impacts and costs, is available on the web (<http://www.prgaprogram.org/>). Detailed analyses of the cases in the inventory are in process.
- On the whole, the CG lags behind other institutions impact assessment of participatory NRM research. While 46 percent of projects in the inventory reported doing impact assessment, only 21 percent of the CGIAR projects reported doing it.

Progress report

Scientists using participatory methods have observed the success of the approach in a variety of situations, and have documented the results in a number of case studies. The impacts and costs of using participatory approaches as opposed to more conventional approaches are rarely systematically analyzed and reported, however. Until we have a better understanding of the tradeoffs associated with using participatory methods, it will likely be difficult to scale up or institutionalize participatory approaches within agricultural and natural resource management research institutions.

This study aims to improve our understanding of the costs and benefits of using participatory research through the analysis of five research/development projects that used participatory methods in applied research on natural resource management. Using a shared conceptual framework, the incorporation of participatory methods in each case will be evaluated in terms of its impact in four areas:

- 1) Adoption and impact of the technologies developed
- 2) Strengthening of human and social capital among the participating individuals and communities
- 3) Establishment of feedback links to formal research
- 4) Costs of doing research.

What we seek to evaluate in this study is not the overall impact of a research project that used participatory techniques, but rather the incremental affect on impacts and costs that can be attributed to the incorporation of stakeholder participation. Therefore, in each case study the impacts are assessed against an appropriate conventional research counterfactual.

There are many ways of doing participatory research, and different methods may have very different implications for outcomes and impacts. Selecting the appropriate approach will require anticipating how it will impact on both project structure and goals. Based on a typology of participation, a comprehensive set of hypotheses has been developed linking the incorporation of different types of participation at different stages of the innovation process to the four impact areas identified above. In each case study, the relevant hypotheses will be tested within the context of the specific project. While we can only test the limited number of hypotheses that are relevant in the specific cases, taken together the results will provide some empirical evidence upon which to evaluate the usefulness of the typology as a tool for project design, implementation and evaluation.

Five cases were selected for analysis of the costs and impacts of the incorporation of farmer participation in NRM research. Several criteria were used to select the projects. The first criterion was to identify projects that had documented impact or that had been operating long enough to have generated intermediate or final impacts. Additional criteria were to include a range of geographical areas, types of NRM technologies and implementing organizations. The projects selected are:

- World Neighbors soil conservation work in Honduras (1980s and early 1990s)
- Nagaland Environmental Protection and Economic Development (NEPED) agroforestry project, Nagaland, India (1990s)
- CIAT's methodology for forming local agricultural research committees (CIALS), Cauca Colombia (1990s)
- ICRISAT's work on models for participatory testing of soil fertility technologies in Southern Africa (1990s)
- CIP's work with farmer field schools for integrated crop management (ICM) for sweet potato in Indonesia (1990s)

To date, field work has been completed in two cases, CIP Indonesia and ICRISAT in Southern Africa. Further field work is planned for the rest of 1999 and January 2000. The final report is scheduled to be completed on March 31, 2001

Persons and Institutions:

- Nina Lilja and Jacqueline Ashby, PRGA
- CIP, ICRISAT, CIAT, NEPED, and World Neighbors/Cosecha (the five cases)

Donors:

- BMZ
- Ford Foundation

2.2.3 Marker Assisted Selection in Beans - by: Norha R. de Londoño

Antecedentes

La búsqueda de resistencia al virus del Mosaico Dorado del Frijol ha sido un propósito importante para el CIAT dado su efecto devastador en los cultivos de frijol de Centroamérica y Brasil, donde su incidencia conduce a pérdidas en productividad que oscilan entre un 40 y 100 por ciento.

El gen que transmite la resistencia al virus del Mosaico Dorado del Frijol es recesivo por lo cual la complejidad en la selección de materiales es mayor dada su falta de expresión morfológica en condiciones de heterocigosis.

En 1991 el CIAT presenta avances en la búsqueda de materiales resistentes al virus con efectos positivos en la producción frijolera de Centroamérica.

Los logros del CIAT en la lucha contra el virus del Mosaico Dorado del Frijol en los primeros años de la década del 90 se debieron básicamente a la selección de materiales provenientes de cruza y retrocruza llevadas hasta generaciones avanzadas F4, F5.

Dada la condición de transmisión del virus por semillas y por vectores (la mosca *Bemisia Tabacci* o mosca Blanca) el manejo de la selección de los materiales de prueba es dispendioso riesgoso y de alto costo.

El advenimiento de métodos de selección varietal utilizando marcadores moleculares ha introducido una herramienta en la lucha contra el virus y el CIAT la ha incorporado al proceso de selección.

Objetivo del estudio

-Objetivo general

Valorar la eficiencia introducida por el uso de marcadores moleculares en la selección de materiales resistentes al virus del Mosaico Dorado del Frijol

-Objetivos específicos

- Cuantificar los costos asociados a cada uno de los métodos de selección varietal:
Tradicional en campo y asistido por marcadores moleculares
- Identificar las ventajas y limitaciones asociados a cada método.
- Cuantificar las ventajas asociadas a cada método, en términos de tiempo y de riesgos colaterales.

Tiempo estimado del proyecto

Ocho meses

2.2.4 Early adoption of *Arachis* in Costa Rica

Collaborators: T. Wuenscher (University of Hohenheim), M. Peters, P. Argel, L. Rivas, F. Holmann, D. Pachico (CIAT)

Background: In Costa Rica, *Arachis pinto* is in the early phase of adoption by farmers as component of grass-legume pasture associations and – to a lesser extent - as a cover crop in plantations. The present study attempted to identify the present state of distribution, the economic benefit and limitations and potentials for wider adoption of this multipurpose legume.

Methods: Out of 7138 livestock farmers registered for the zone 112 farmers were randomly selected for a survey. On top of these 42 farmers who have tried *Arachis pinto* as a component of pastures (28 adopters, 6 non-adopters) and cover crop (5 adopters in orange plantations, 3 non adopters, 2 orange, 1 coffee) were selected.

Results and Discussion: In the random interviews an adoption rate of 4.5 % was found. However, nearly 90% of farmers knew *Arachis*, of which 77% were aware of its value as animal feed and/or cover crop, 54% thought that *Arachis* could be a beneficial component of their farming systems, and 28% did not know its potential utility. Nearly 80% of adopters have introduced *Arachis* based on institutional recommendations and most farmers were satisfied with the results achieved with the legume.

About 2/3 of interviewers indicated that major constraints to animal production were quality of available feeds in the dry and wet seasons and lack of fertilizers. On the other hand, the main solution envisaged by farmers to improve their livestock systems, is intensification through the use of improved forage varieties, thus offering the potential of wider adoption of improved grasses and legumes such as *Arachis*. A simulation exercise based on existing data, predicted an increase of area under *Arachis* from presently 1.6 % in the northern zone of Costa Rica to more than 25% in 2005.

The main reasons identified for the relative slow adoption of *Arachis pinto* in Costa Rica include:

1. Time lag in adoption of forages in general,
2. Legumes as a new forage component in contrast to grasses,
3. Aggressiveness and hence weed potential of *Arachis* and
4. Lack of experience and information on the legume

The results point out the paramount importance of institutional contacts for the adoption of *Arachis* and possibly forage legumes in general. Therefore more interaction with farmers through participatory approaches and extension services is needed. This includes further training of field staff of NARS, Extension Services and NGOs on participatory methods. Continued institutional support in promoting *Arachis* is essential to ensure a wide adoption rate in Costa Rica and in other countries of Central America.

OUTPUT III: DATABASE AND METHODOLOGIES

3.1 Data Base Development - by: James A. García

Durante 2000 se continuaron realizando labores de obtención, compilación, actualización y adición de datos clave a las bases de datos del proyecto. En general, todas las bases de datos fueron actualizadas con nueva información disponible para un año adicional.

En particular, la Base de datos Socioeconómicos de América Latina y el Caribe, la cual contiene información proveniente de diversas fuentes, fue además adicionada con nuevas series de información. Estas nuevas variables, las cuales hacen referencia a indicadores de desarrollo humano que tienen que ver con aspectos tales como pobreza, salud, educación, fuerza laboral, entre otros, se relacionan en el cuadro 1.

Cuadro 1. Series de datos adicionadas durante 2000 a la base de datos Socioeconómicos de América Latina y el Caribe.

Variable	Unidad
Esperanza de vida al nacer: Mujeres, Hombres, Total	Años
Mortalidad: Materno Infantil Menores de 5 años Mujer adulta Hombre adulto	Tasa por 100000 nacidos vivos Tasa por 1000 nacidos vivos Tasa por 1000 nacidos vivos Tasa por 1000 Tasa por 1000
Educación: Ingreso de Mujeres a la escuela primaria.	% del grupo
Ingreso de Hombres a la escuela primaria	% del grupo
Ingreso a la escuela primaria (Total)	%
Gasto público en educación	% del PNB, % del gasto total
Salud: Vacunación DPT	% niños menores de 1 año
Vacunación Sarampión	% niños menores de 1 año
Vacunación Tuberculosis	% niños menores de 1 año
Casos de Tuberculosis	# por 100000 personas
Casos de Malaria	# por 100000 personas
Casos de SIDA	# por 100000 personas
Médicos disponibles	# por 100000 personas
Enfermeras disponibles	# por 100000 personas
Gasto público en salud	% del PNB, % del PIB
Pobreza: Población Rural con acceso a agua potable	%
Población Urbana con acceso a agua potable	%
Población Total con acceso a agua potable	%

Índice de Gini	Índice
Distribución del Ingreso	% para el quintil superior
Distribución del Ingreso	% para el quintil inferior
Población con ingreso menor a 1 US\$/día	%
Población bajo línea de pobreza nacional	%
PIB real per cápita quintil más pobre	PPP\$
PIB real per cápita quintil más rico	PPP\$
Pobres (Urbano, Rural, Total)	%
Población sin acceso a servicios de salud	%
Población sin acceso a servicios de sanidad	%
Desnutrición en niños menores de 5 años	%
Niños que no llegan a grado 5°	%
Desarrollo Humano:	
Tasa de alfabetismo Mujeres	%
Tasa de alfabetismo Hombres	%
Tasa de alfabetismo adultos	%
Degradación Ambiental:	
Agua renovable disponible per capita	Mts ³ /año
Agua fresca retirada	% del agua disponible
Agua fresca retirada per capita	Mts ³
Tasa anual de Deforestación	%
Tasa anual de Reforestación	%
Emisión CO2 per capita	TM
Población:	
Tasa de crecimiento	%
Tasa de fertilidad	Nacimientos/mujer
Tasa de natalidad	%
Tasa de mortalidad	%
Población estimada al 2015	Millones
Perfil Laboral:	
Fuerza laboral en Agricultura, Industria, Servicios	%
Tasa de crecimiento del salario real	%

La mayoría de las variables relacionadas disponen de información que permite visualizar su comportamiento promedio a través de las décadas posteriores a la década del 60.

Adicionalmente, a la base de datos Socioeconómicos de América Latina y el Caribe le fue incorporada información sobre la competitividad de algunos productos agropecuarios. Esta información proviene del estudio sobre Competitividad de la Agricultura en América Latina de Hertford y García (1999).

3.2 Web Page Development - by: James A. García

3.2.A Adiciones

Toda la nueva información almacenada en las diferentes bases de datos está disponible vía Internet. Las Figuras 1, 2, 3 y 4 muestran, respectivamente, el menú de acceso a datos sobre competitividad, los resultados de una consulta realizada a datos de competitividad y los resultados a consultas sobre datos indicadores de pobreza. Estas gráficas obtenidas pueden ser modificadas directamente por el usuario ya sea en lo que respecta a tipo de gráfica, color, título, o cualquier otra de sus características.

Figura 1: Menú de acceso a datos sobre competitividad de algunos productos agropecuarios.

Competitividad - Netscape

File Edit View Go Communicator Help

Back Forward Reload Home Search Netscape Print Security Stop

Bookmarks Location <http://webp.ciat.org/Impacto/Competitividad/competi.asp> What's Related

Intranet - CIAT Impacto A/V Translation

Base de Datos de América Latina

Competitividad

Defina su Selección :

País	Producto
ARGENTINA	ALGODÓN SIN DESMOTAR
BOLIVIA	ARROZ CON CASCARA
BRAZIL	AVENA
CHILE	BANANO
COLOMBIA	CAFÉ, VERDE
COSTA RICA	CAÑA DE AZÚCAR
DOMINICAN RP	CEBADA
ECUADOR	CEBOLLA, SECA

Fuente de Datos: Hertford, R. y García, J. A. (1999) "Competitividad de la agricultura en las Américas." Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia. 88 p.

Para descargar la versión en inglés en formato PDF, [clicke aquí](#).

Ejecutar Limpiar

Impact Assessment The Impact of Agricultural Research

evaluación de Impacto - Centro Internacional de Agricultura Tropical (CIAT) - Cali, Colombia

Figura 2: Respuesta, en forma gráfica, a consulta realizada.

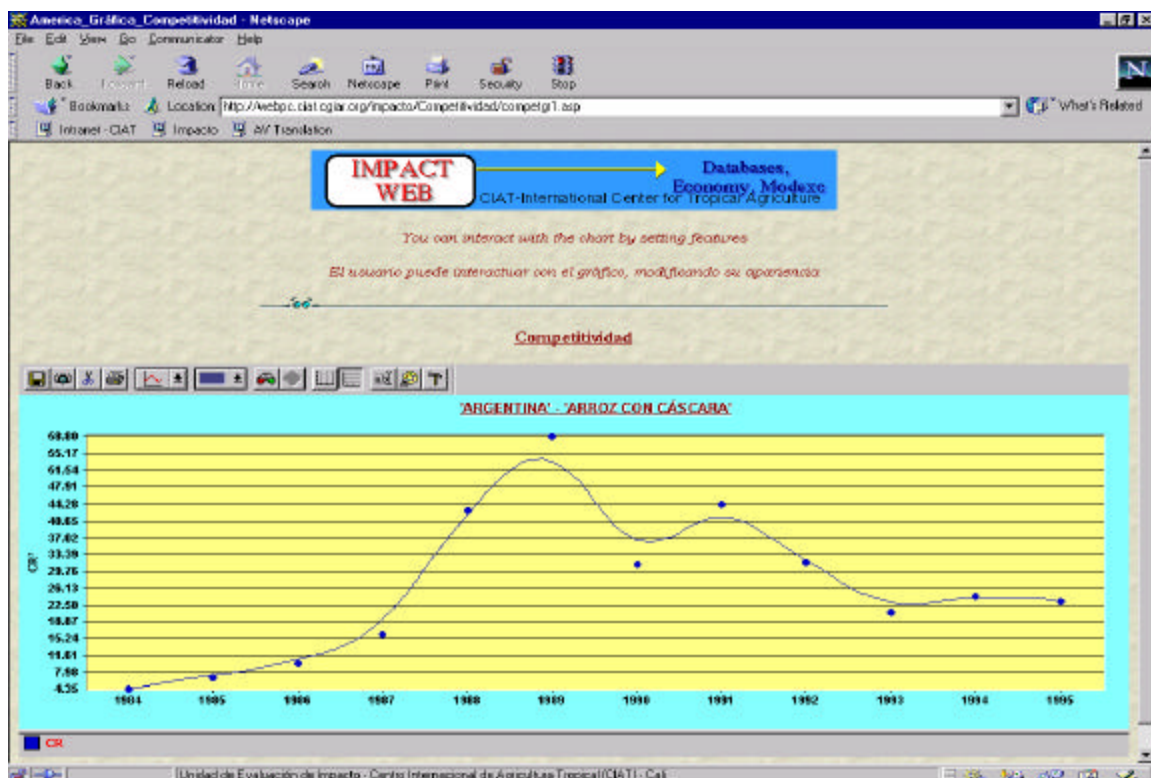


Figura 3: Respuesta a consulta sobre Indicadores de distribución de ingresos.

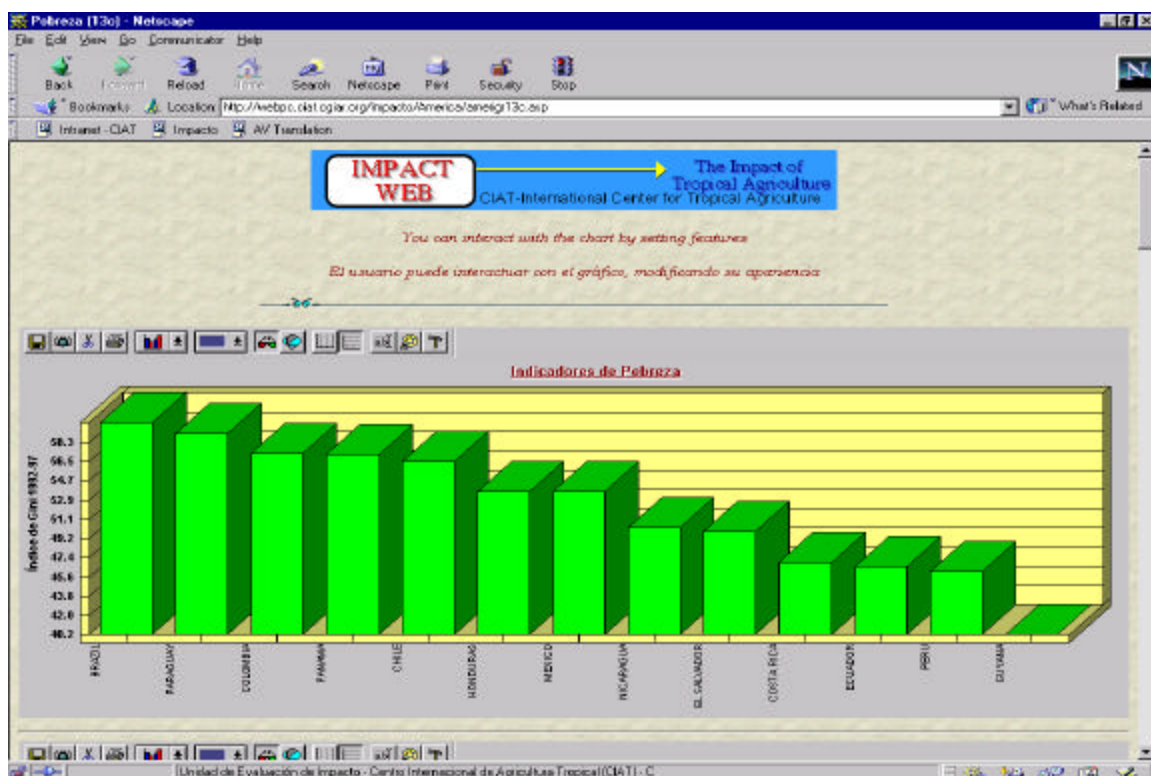
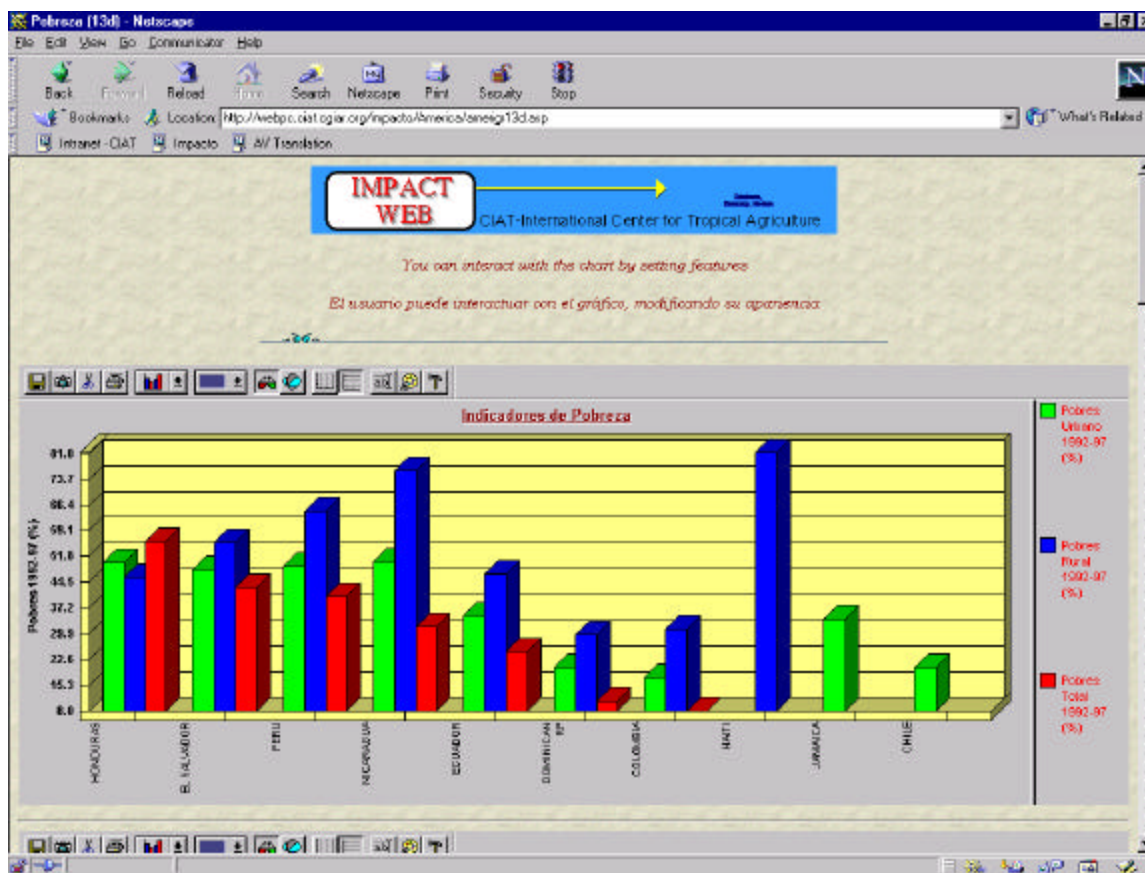


Figura 4: Respuesta a consulta sobre Indicadores de Pobreza.

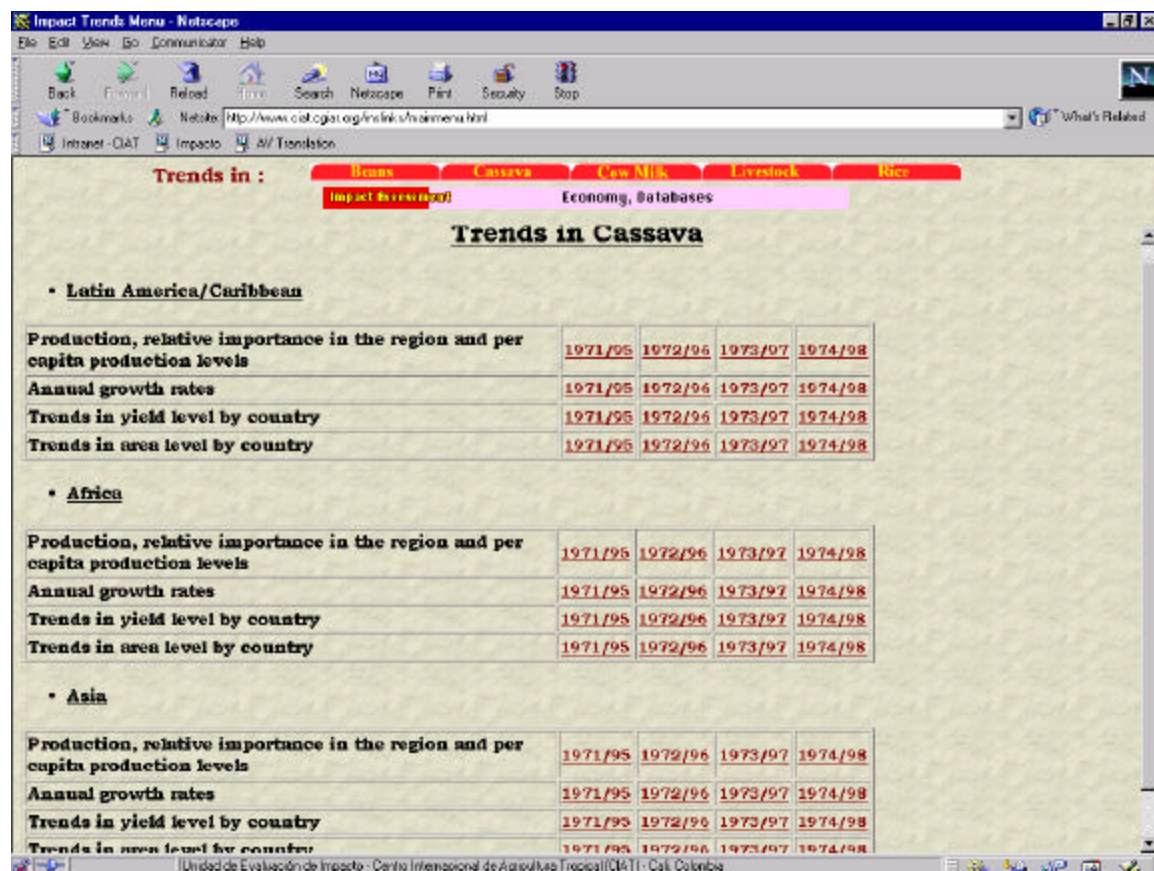


3.2.B. Trends in CIAT Commodities

Utilizando el sistema de generación automática de reportes, disponible en la Base de Datos Socioeconómicos, se generaron los cuadros correspondientes a los "Trends 2000" en los cuales se muestra la tendencia histórica en la producción, el área y el rendimiento para los productos Arroz, Frijol, Carne, Leche y Yuca.

La información mencionada, al igual que los cuadros correspondientes a años anteriores, está disponible para América Latina, Africa y Asia, y puede ser consultada vía Internet como se ilustra en la Figura 5.

Figura 5: Trends in CIAT Commodities - 2000.



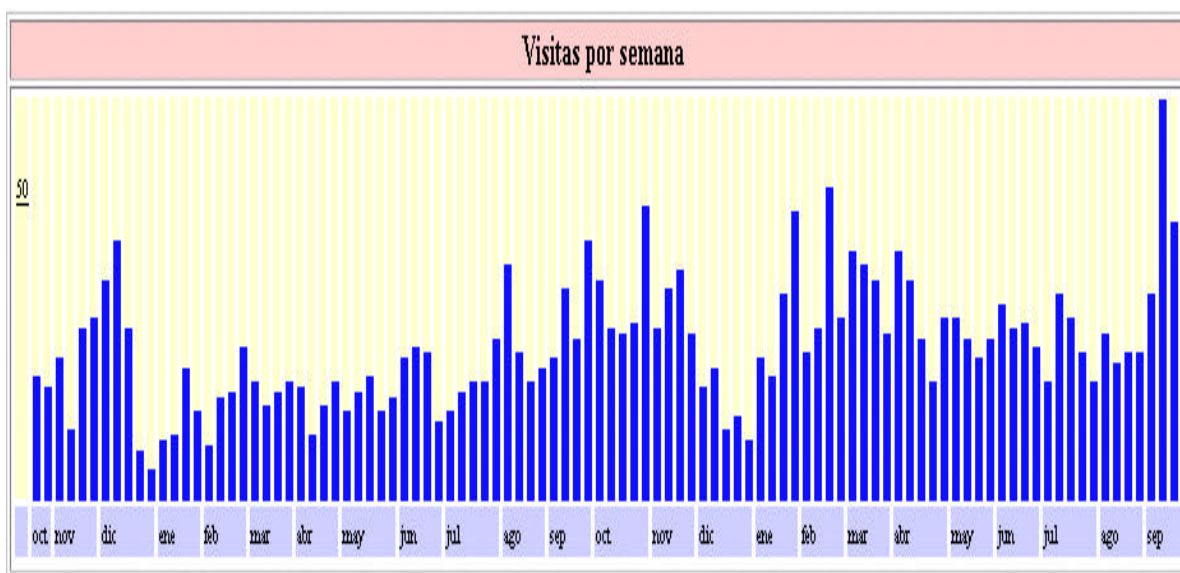
3.2.C. Utilización del Web y consultas a las bases de datos vía Internet

El sistema de información de la página Web de Impacto reporta que durante el período 20/Sep/1999 al 20/Sep/2000, fueron realizadas un total de 1541 visitas lo que significa un incremento del 52.73% con respecto a período similar en el año inmediatamente anterior.

La Web ha sido consultada por usuarios de 65 países ubicados en los diferentes continentes. El 31.17% de las visitas son originadas por usuarios vinculados a instituciones u organizaciones sin ánimo de lucro, el 12.04% provienen de Estados Unidos y Canadá, el 10.72% se generan desde 14 países europeos, el 9.55% corresponden a consultas hechas desde 10 países suramericanos, el 4.38% a visitas de usuarios de 9 países de Centro América y el Caribe y el 4.45% a accesos realizados desde 18 países asiáticos, 5 países africanos además de Australia. El 27.7% restante corresponden a usuarios cuya nacionalidad no ha podido ser de identificada por el sistema de registro.

En la Figura 6, donde se vislumbra una tendencia creciente, se muestra el comportamiento de la Web de Impacto, en términos de las visitas semanales que ha recibido a partir de la segunda semana de octubre de 1998.

Figura 6: Visitas a la Web de Impacto.



3.3 Methods - Economic Surplus Models - *by: James A. García, Libardo Rivas*

Durante 2000 se realizaron mejoras al modelo de análisis de excedentes económicos - MODEXC, en lo que respecta a las facilidades de interacción con el usuario.

De igual manera, el manual del usuario, tanto para la versión en Inglés como para la versión en Español, fue actualizado a los últimos cambios realizados al modelo y colocado en la Web a disposición de los interesados.

Las estadísticas registradas muestran, que personas vinculadas con diferentes tipos de instituciones radicadas en 30 países a lo largo de todos los continentes han obtenido copia del modelo y su manual.

OUTPUT IV: MONITORING SYSTEMS

4.1 Evaluation in Agroecological Reference Sites – *by: M. V. Gottret*

2000 Milestones

- A methodological and conceptual framework was developed to assess the impact CIAT Integrated Natural Resource Management (INRM) action-research in the reference sites and a paper was written and presented at the Workshop on Integrated Natural Resource Management in the CGIAR: Approaches and Lessons. 21-25 August 2000, Penang, Malasia (see Gottret and White 2000)
- Based on the above framework, a methodology was developed and applied in the Rural Agroenterprise Development Project (SN-1) training course (II International Course: The Promotion of Rural Agroenterprises for Sustainable Rural Development) for Baseline Analysis, Project Planning, and Impact Assessment.
- Paths-to-development impact were developed for the two NRM Division Projects: Community Management of Watershed Resources in Hillside Agroecosystems (PE-3) and Rural Agroenterprise Development (SN-1)
- A complete set of preliminary development impact indicators was developed for the four types of capitals: human, social, economic/financial and natural, as well as indicators for the each critical path-to-development impact.
- Fieldwork was started in Central America reference sites of San Dionisio (Nicaragua) and Yorito (Honduras) with the objective to: (1) present and share the process of impact assessment with CIAT local teams in order to raise long term capacity, interest and commitment with the process, (2) initiate an inventory of available data and key stakeholders, (3) adjust and validate the development impact vision with CIAT local teams, local institutional partners, community organizations, and selected members of communities, (4) conduct an initial assessment of developed social and human indicators, and (5) elaborate an initial analysis on the use and usefulness of CIAT decision-support tools (DSTs) by key stakeholders.

4.1.1 Assessing the Impact of Integrated Natural Resource Management: CIAT Challenges and Experiences - *by: Veronica Gottret and Dougals White*

Introduction: INRM and Impact Assessment

With its world-renowned contribution of increasing agricultural productivity, current and future expectations of the Consultative Group on International Agricultural Research (CGIAR) remain high. Yet while advances of the Green Revolution have led to enough food being produced to feed the world, problems of poverty and natural resource

degradation persist (CGIAR 1995). In response, the CGIAR has expanded its mandate to address these pressing issues by introducing Integrated Natural Resources Management (INRM) research in its agenda. As such, “INRM research and development activities within the CGIAR provide the basis for the development of sustainable agricultural landscapes within which the products of the genetic improvement programs can gain maximum impact for the benefit of the poor” (INRM, 1999).

The introduction of the INRM concept challenges scientists of the CGIAR. Increased complexity of research and development (R&D) interventions¹ as well as more stringent and rapid reporting of results by the donor community lead to a need to monitor and evaluate social, economic, environmental and biophysical change. The current situation poses special challenges for socioeconomic and impact assessment (IA) research, particularly as this change has increased the demand for a more holistic IA² approach beyond traditional economic surplus analysis.

Difficulties of assessing the impact of INRM research stem from its own definition, as there is not a universally accepted one. Proponents (from the Bildeberg Consensus) generally perceive the term to represent a responsible and broad-based management of the land, water, forest and biological resources base (including genes) needed to sustain agricultural productivity and avert degradation of potential productivity (INRM, 1999). Izac (1998) emphasizes that INRM is not a straightforward concept as it embraces social, economic, environmental and biophysical components. INRM changes (at different spatial and temporal scales) and is assessed in terms of multiple objectives (e.g. poverty alleviation, resilience, natural resource conservation, economic growth, human and social development) that reflect the needs and expectations of different stakeholders (Izac and Sanchez, 1998). Therefore, INRM research requires a wider geographic scope (manageable plot and farm level analyses expand to more unwieldy scales of community, watershed and even larger areas), which brings numerous complicating ecological, social, cultural, institutional, economic and political factors. Furthermore results are rarely visible in a short time frame such as the agricultural cycle, and it is still not clear how far the scientists should work across the research-development continuum in order to increase the probability of achieving impact.

The second difficulty on INRM research IA arises from its requisite inclusion of multiple stakeholders. The CGIAR Centers have two sets of clients to whom they are ultimately held accountable: beneficiaries of research and the donor community. Research beneficiaries include rural dwellers, NARs, NGOs and other partner institutions, each with their own perspectives and interests. In order for INRM research to affect change in terms of sustainable natural resource use and poverty alleviation, ultimately local people

¹ R&D focus has changed from classical agronomy to ecological sciences, from analytical research to systems dynamics, from top-down to participatory approaches, and from factor-oriented management to INRM.

² Guijt (1998) defines the term “Impact” as “the effects of an intervention on its physical surroundings, the people involved, and/or the organizational context. This refers to short term outputs of products, medium term results, and longer term consequences or outcomes.”

must alter their livelihood strategies³. How this is most “efficiently” accomplished often runs counter to the constraints placed by the external donors. Furthermore, not only should results be effective in a research site but they need to be replicable and scaled up (or out) to other locations. Scoones (1997), analyzing the feasibility of scaling up success stories, concludes that the major lesson is that no blueprint can be provided. Change occurs as a result of an unpredictable combination of contingent circumstances, which are historically specific and relate to a range of imprecise political, economic, social and personal factors.

However, efforts to scale up and generalize are anathema to a countervailing group of development practitioners, (many within the donor community) who espouse the importance of local experience, understanding and decision-making. This group emphasizes that rural dwellers are more than mere recipients of INRM research, but are the true clients who express their demands accordingly. These processes of local awareness and prioritization are the actions that drive development (Guijt and Shah, 1998). INRM practitioners need to be ready to accept a low priority ranking by locals for their activities, perhaps only initially, as other needs such as education and health care could be deemed more important.

A third issue concerns tradeoffs amongst the multiple stakeholders. With the reach of INRM expanding beyond the farm or household level, the possibility and gravity of conflict increases. Many of the problems related with INRM - pest, water and soil management - move beyond the farm level because of their biophysical characteristics and multiple actor decision-making process. Management affects the natural resources that are common to a group of people who live locally, and to an external population who are affected, albeit sometimes indirectly. Understanding and properly addressing both private and public incentives are the key difference between previous CGIAR efforts and those of INRM. As a result, optimal decisions require an analysis of tradeoffs, as well as a careful negotiation and collective action amongst them (e.g. individual farmers, households, communities, and policymakers).

In this paper we present advances and travails of CIAT scientists as they develop and implement an IA Framework for three INRM sites in Latin America (Hillsides, Savannas and Forest Margins). In Section 2, the importance and growing interest of IA for INRM research as a planning, learning and accountability tool is presented. Section 3 is a brief historical perspective of the relationship between development thought and IA methodologies. Section 4 contains an analysis of the major challenges of developing and implementing an appropriate methodology that satisfies the needs of multiple stakeholders. This is followed in Section 5 with a proposed Conceptual and Analytical Framework for INRM research IA, along with first insights about CIAT efforts on implementing an IA process in its INRM sites. Section 6 finishes with some conclusions and recommendations.

³ A term employed by the Sustainable Rural Livelihood approach of IDS/DFID (Scoones, 1998). According to the author, three broad clusters of livelihood strategies are identified. These are agricultural intensification/extensification, livelihood diversification and migration.

Importance and Growing Interest in INRM Impact Assessment

When a variety of complex social, economic, biophysical and institutional innovations are being developed, IA needs to be a key part of the INRM research process. As stressed by Pachico et al. (1998), IA should not initiate as a retrospective exercise after a research program has produced an innovation that has entered into use. IA needs to be a crucial part of research planning and it cannot be tacked on at the end of an intervention, rather it must be built into the design and implementation from the beginning. As such, a Monitoring⁴ and Evaluation⁵ (M&E) process is required for proper IA.

This implies a connection between project planning, monitoring and IA phases. Indicators of achievement, success and results are established during the planning phase but they are used, validated and enriched throughout the implementation and ex-post phases (Quintero Uribe, 1997). Furthermore, a continuous M&E process should permit a better understanding of the performance of innovations under different human, social, natural and economic/financial endowments, and under different historical, political, macroeconomic and cultural contexts. However, as stated by Guijt (1998) despite the obvious advantages of M&E, few organizations carry out systematic M&E of their activities, making overall IA a difficult task.

One of the strategies used by the CGIAR to develop INRM research products is the implementation of pilot R&D projects in selected reference sites. To increase potential development impact, the leading Centers in INRM research develop and plan research strategies with partners. As a result, the Centers conduct not only conventionally defined research activities but are also involved with “action-research” activities that support development initiatives led by or in collaboration with partners. Yet the allocation of CGIAR resources to Ecoregional programs in general and INRM research specifically, is being questioned (TAC, 1991). INRM research is considered to be too site specific and multi-sectoral for a modest international research program to generate significant and demonstrable impacts. Skepticism within the international agricultural research donor community can in part, be explained by the lack of rigorous assessments of the economic, poverty and environmental impacts of the research (Scherr, 2000). In order to validate the contribution of research outputs to development impact, the assessment of INRM research is an important research component in these sites. Continued financial support requires confirmation that innovations produce sufficient improvement in production, poverty and environmental outcomes that can be applicable beyond the specific reference sites. Yet application of research results does not imply a

⁴ According to Guijt (1998) “Monitoring” refers to “the systematic and continuous process of assessing the progress and changes caused by the implementation of an activity over a certain period of time, usually using pre-determined indicators or recurrent questions.”

⁵ Guijt (1998) defines “Evaluation” as a “a process of identifying the broader positive and negative outcomes of an activity or process to reach a conclusion about its overall value and whether objectives have been met.” Often such conclusions relate to longer-term objectives, such as effectiveness, equity of impact, sustainability and cost-effectiveness. In contrast with monitoring, which establishes with a certain frequency what the outputs (desired or not) are of an activity, an evaluation process will try to assess how these outputs contribute in the longer term to the intended objectives. Therefore evaluation is usually less frequent than monitoring activities and is undertaken sometime after an activity starts to allow for changes to occur and assessment to be possible.

top-down approach. Learning processes for use in other areas is a major objective of the reference-site strategy. Moreover, an understanding of the contexts that contribute to the success of the innovation must also be achieved to help in the identification of “recommendation domains” for the innovations.

Evolving CGIAR Agenda and Impact Assessment Methodologies

Both international agricultural research and methodologies used to assess its impact have long reflected contemporary rural development thought. Since the 1980s, the CGIAR has been concerned with measuring the impact of its research (Anderson et al., 1998) and has produced a vast amount of studies concentrated on assessing the adoption of agricultural production technologies. Reviews of these types of studies can be found in Dalrymple (1986a, 1986b), Seré (1986), Timothy et al. (1988), Echeverría et al. (1989), Pachico (1992), Byerlee and Moya (1992), Evenson (1992), Stifel (1992), and Collinson and Tollens (1994).

Economic impact of agricultural research and returns to investment continue to be synthesized and extended (Alston et al. 1995). The new robust quantitative methodologies employ economic surplus methods, which estimate the net present value of benefits, internal rates of return and cost-benefit ratios. Also, a broad literature has arisen to assess total factor productivity through aggregate production and cost functions, production density functions and input-output market interfaces. Microeconomic assessments include input savings and consumer preferences (Bantilan, 1998). As the CGIAR included in its agenda post harvest research, studies on the impact of new post harvest and processing technologies have been conducted (i.e. Mullen, 1985; Mullen et al., 1991; Scobie et al., 1991; Best et al., 1994; Gottret and Henry, 1994; Gottret et al., 1997; and Ospina, et al., 1998). Most of these studies also use consumer surplus models that were extended to consider the size and distribution of benefits in the context of multiple factors and multiple-product markets.

While techniques for evaluating the impact of adopting improved germplasm, new cropping and post harvest technologies are well known and utilized, IA methodologies became a critical issue for INRM in the mid 1980s. As a result of larger scope issues of INRM, much remains to be done to enable IA to evaluate the final effect of more complex R&D projects in addition to economic criteria.

As expressed by Izac (1998) there are two fundamental differences between IA for crop improvement research and for INRM research. First, natural resources generate a number of ecosystem services, and they do so differently at various spatial scales (farming system, watershed/village/ landscape, region and global). Second, as a consequence of the first, the diversity of stakeholders in NRM is much wider than in crop improvement research, whereby different categories of stakeholders are associated with the different spatial scales.

Furthermore, these more complex R&D challenges mark an era of disappearing controlled experiments, making it more difficult to attribute the success or failure to any

one intervention. Guijt (1998) states that establishing cause-effect linkages is more complex than just tracking changes, and is not as simple as comparing ‘before’ and ‘after’ situations, as many other influences will have occurred and affected the situation simultaneously. Also, the other option to compare ‘with intervention’ and ‘without intervention’ situations, in the hope of establishing clear causal links may not be the most appropriate because the following reasons: (1) obtaining data for the ‘without’ situation may be time-consuming and costly, (2) households who are not being benefited by an intervention are unlikely to be willing to monitor their situation or have it monitor, and (3) it may be too difficult (if not impossible) to control for other factors that may influence the outcome of an intervention.

INRM Impact Assessment Methodological Challenges

Following the above discussion on the evolution of IA methodologies accordingly with the evolution of the CGIAR agenda, there is no commonly accepted protocol for assessing the impact of INRM on sustainable rural livelihoods. Persistent issues include the following: (1) finding feasible spatial and temporal scale boundaries, (2) integrating and negotiating stakeholder development objectives, (3) stakeholder participation in the IA process, (4) defining and empirically assessing sustainable rural livelihoods, (5) linking research outputs to development impact and attributing outcomes to it, and (6) developing output, outcome and development impact indicators. In this section these methodological challenges are discussed and some approaches to deal with these challenges proposed.

Finding Feasible Spatial and Temporal Scale Boundaries

According to Pachico et al. (1998) the measurement of impact across scales is a central issue in the IA of INRM research. For example, the impact of erosion on the natural resource base varies from the plot to the slope face, the watershed and river basin. Scherr (2000) states that for the case of hillsides, many of key environmental impacts expected must be evaluated at the landscape scale. However, landscape-scale impacts of INRM can only result if significant number of farmers adopt the innovations, and depend upon the spatial pattern of adoption.

With respect to temporal scales, Scherr (2000) argues that longer time periods are required to assess sustainability and the degree and significance of environmental impacts, but these longer periods increase the likelihood of major socioeconomic or biophysical shifts taking place that confound the impacts of innovations. Therefore, IA for INRM must be designed to consider long-term change. Scherr (2000) proposes the use of different instruments such as time series of remotely sensed variables, panel data sets, historical reconstruction of plot or community level trends with local people, and participatory historical mapping. Yet, the issue of protracted results may not be entirely compelling stand-alone argument that creates challenges for INRM. Agricultural crop improvement research programs took a minimum of a decade from the outset of a program to the delivery of the first outputs, and in many cases it took even longer. Thus INRM research may not require a significantly longer time horizon to produce results

(Pachico et al., 1998). Rather, a new climate of more stringent reporting within timeframes is more likely culpable.

Integrating and Negotiating Stakeholders Development Objectives

As discussed in Section 3, the diversity of stakeholders in INRM is much wider than in crop improvement research, and each one has a different emphasis in their objectives and expectations. The merging of stakeholders with different interests and backgrounds (farmers and rural inhabitants, community organizations, local governmental and non-governmental institutions, national and international Centers, donors, politicians etc.) can often lead to communication difficulties and differences in opinion and perceptions. So plagued are IA efforts of INRM. Box 1 presents some insights of preliminary work done in the CIAT Hillside reference sites in Central America.

While CGIAR Centers share most of these different stakeholder development objectives and goals, the main objective of the Centers work in their reference sites is not the development of the reference site per se. Rather development should be the result of interventions and justify extrapolations of the research innovations. In other words, the ultimate goal is not the achievement of site-specific tangible outcomes, but the development of social, economic, biophysical and institutional innovations that can be extrapolated beyond the reference site, as required by its mandate of developing international public goods. As such, processes are more important or as important as the final development outcome.

While there can be a strong and useful complementarity between local and external perspectives, incorporating local views into scientific discussions may require profound flexibility on both sides. Small holder farmers and researchers not only describe the world with different words, but also may hold incompatible views of how the world functions. At the extreme, van Dusseldorp and Box (1993) contrast a fatalistic view held by some farmers with the “voluntaristic” view of research, where the world can and should be manipulated with direct intervention. Research conducted within either of these two worldviews is unlikely to be seen as legitimate from the opposing perspective.

Moreover, differences in communication among scientists, farmers, policymakers and other stakeholders can sabotage dialogue and learning among these groups. This albeit less extreme (and hence less visible) issue can nevertheless affect the ability to synthesize the distinct IA perspectives. Holland (1998) shows how research terminology can come to dominate discussions with other stakeholders, making communication meaningless⁶. Such communication difficulties may be symptoms of fundamental differences in the ways that scientists and other stakeholders learn. Improving communication may not improve the situation without a willingness also to be more flexible about styles of researching and learning. These communication breaches will pose special challenges to

⁶ For example, the term “significant” passed from Philippines researchers to extension agents and then to farmers served as an unchangeable “trump-card”. Use of the word “significant” would supposedly convince people about natural phenomena and eventually became employed by a farmer to explain results in his field to mystified visiting farmers.

measuring the impact of INRM where people from many disciplines and backgrounds must be involved. Insights by van Dusseldorp and Box (1993) do not bode well, “in experience with interdisciplinary research in the Philippines and the Dominican Republic, we found it more difficult to bridge the gap between individual disciplines than between researchers and cultivators”

Box 1. Concealing Different Development Objectives in Central American Hillside

In July 2000, workshops and interviews were held with a range of different INRM stakeholders (community members and organization leaders, as well as personnel from local institutions) in hillside reference sites of Nicaragua and Honduras. The objectives were to identify and conceal their development visions and objectives, and assess their interest in participating in an IA process.

Inhabitants of poor rural communities typically have a clearer, more tangible and short-run development vision and objectives, and lower expectations than those of external agents such as national or international cooperation and support institutions¹. Rural people express their desire to have a community where people have enough to eat, as well as a more diversified diet, and where they are able to buy clothes and shoes for the family (especially the children). They also aim to have access to basic infrastructure, appropriate education and health services. However as a result of land degradation, water scarcity, recent natural disasters and promotional campaigns by external institutions, there is a growing consciousness about natural resource preservation. Rural dwellers prioritized improving in land productivity and water availability. These interests are expressed by the desire to have a community with more trees, especially around the watershed, and to employ farming practices that at least help maintain soil fertility.

Often caught in the middle between donors and recipients, local support institutions (governmental and non-governmental) share the final development vision and goals of rural inhabitants of developing sustainable rural livelihoods with site-specific tangible results. Furthermore capacity building through the developing and/or strengthening of community organizations are central efforts to empower communities

On the other hand, the initial appraisal to determine the interest of these institutions in participating in IA, showed that locals are not as much interested in the learning process and its systematization as CGIAR Centers do. However, they do have interest in showing that tangible results were obtained towards the desired development state, and furthermore, that their intervention has contributed to that change. In general, they are more interested in the action (implementation) part and the tangible results of this action than in the evaluation, reflection and learning process. Furthermore, it seems that most of their interest was based on donor-led demands.

Participatory Monitoring and Evaluation (PM&E) approaches have been proposed and implemented in order to develop partnerships of multiple stakeholders for efficient, effective, and socially inclusive monitoring (Guijt, 1998; Abbot and Guijt, 1998). One of the expected benefits to PM&E has been that monitoring efficiency can be improved by harnessing multiple perspectives. However, Abbot and Guijt (1998) argue that this benefit cannot be assumed as it requires considerable investment and commitment, in terms of time and resources, as well as careful design, to bring different world views and

languages together. Cooperative integration will not happen through good intentions alone. Insights of an experience in trying to start a multi-institutional approach to IA in the Peruvian Amazon (a forest-margins reference site) are presented in Box 2.

Box 2. Elusive Consensus and Hidden Agenda in the Peruvian Amazon

In April 1999, over twenty institutions in Pucallpa, Peru attended a two-day *Indicator Framework and Impact Assessment* workshop. The event had the dual objectives of establishing a structure to measure the impact of research and development efforts and to improve institutional coordination. These institutions consisted of NGOs, international and national from diverse sectors of agricultural research/extension, health, natural resources management and the university.

Small groups of participants constructed research to development causal pathways by first identifying the goals of sustainable development. A series of intermediate steps, representing the activities required to achieve the goal, connected the institutional outputs with development. While some of the paths were relatively easy to construct, those of institutional cooperation and policy were the most challenging.

Even though there was consensus after the meeting to continue the process of IA, the working groups organized to refine indicators and identify people to collect data met only for a few times. Troubles of finding convenient times to meet for overworked contributors and differing incentives of the institutions contributed to group disintegration. With decision making power being concentrated in the capital, incentives to obfuscate and even embellish reports exist in the highly politicized environment.

Stakeholder Participation in the Impact Assessment Process

The identified benefits of PM&E are numerous. First, since the application of INRM research produces a broad range of impacts in communities, including many of a social nature, these changes can be difficult for outsiders to observe (e.g. changes in the access to forest resources, changes in conflict between communities over water access).

Externally defined IA studies may risk serious problems caused by omitted variables and the subsequent misinterpretation of findings (Scherr, 2000) Hence, PM&E can improve the accuracy and relevance of the collected data and information and their analysis.

Second, the participation in self-evaluations can be a powerful contribution to local institution building. Guijt (1998) emphasizes that PM&E enhances local capacity to record and analyze change, and improve community-based initiatives, thus empowering rural communities. Third, PM&E is more cost-effective and as such can make a more rational use of limited human and financial resources (Guijt, 1998).

Many issues lie at the heart of a participatory IA process. According to Guijt (1998) in a serious participatory process, people affected by any intervention should be involved in the definition of the monitoring goals, the design of the system, the selection of indicators, data collection and analysis, and in the end should use the analyzed data and results. However, with respect to stakeholder participation on IA, a fundamental question

to be asked is why anyone should bother assessing change, and for whom will the information and the process of collecting information, bring benefits.

Abbot and Guijt (1998) state that most project-initiated M&E processes make the rather tenuous assumption that the monitoring process has value for local people. It can be argued that farmers and rural inhabitants know what has changed and improved (or not) towards the achievement of a sustainable livelihood and overall quality of life. Therefore, they do not need to collect and analyze data to prove that this has (or has not) been the case, nor they are accountable for external intervention outcomes. Besides participatory M&E approaches can be costly for local people considering the opportunity costs involved in taking away a significant amount of time which could otherwise be spent in income-earning activities.

Therefore, data collection on a voluntary, unremunerated basis (as often happens in participatory processes) is unlikely to be sustained unless the information has some direct relevance or value for community members, community organizations, as well as local and national institutions. As such, there is a need to identify different interest groups (both locally and externally) as well as their assessment needs and interests. Parallel IA processes can be conducted with the different groups and then integrated.

Furthermore, before taking the decision to start a PM&E process it is important to have a basic understanding of the limitations of what is possible in order to avoid poor quality work and disillusionment. Guijt (1998) argues that efforts to involve multiple stakeholders on IA faced the difficulties caused by the limited understanding of what M&E actually involves, as well as limited local expertise and financial resources. Therefore it is important to consider the implications of bringing together multiple stakeholder groups in a participatory process. Each group has different needs, priorities, capacities, power to speak, norms for trustworthiness of information, and expectations of being involved. While working mainly with partners may generate potential biases, at the same time, participation in self-evaluations can be a powerful contribution to local institution capacity building" (Scherr, 2000).

However, de la Rive Box (1990) states "*...there has been renewed effort to devise ways to link IA to local people's capacities in ways that are less dependent on outsiders' insights and empathy, and more reliant on partnerships and negotiated procedures and conclusions, thus reflecting the biases and cultures of both parties.*" Moreover, Guijt (1998) and Abbot and Guijt (1998) offer a wide range of proved methodologies for designing and implementing PM&E process for the assessment of sustainable agriculture initiatives.

Defining and Empirically Assessing Sustainable Rural Livelihoods

If INRM is a means to improve rural livelihoods and make them sustainable, then there is a need to more precisely define what we mean by "sustainable rural livelihoods". The World Commission on Environment and Development has defined "sustainable development" as "development or progress that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Izac, 1998). In

operational terms, sustainable development requires the achievement of economic, social and environmental well being for current and future generations. Drawing from Chambers and Conway (1992), Scoones (1998) defines “sustainable rural livelihoods”, as “the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks, maintain or enhance its capabilities and assets, while not undermining the natural resource base.”

Thus sustainable rural livelihoods can be seen as a combination of at least three dimensions:

- **economic and financial**, which includes employment and economic growth
- **natural resources**, which relates to sustainability not only in terms of adaptation, vulnerability and resilience, but also the preservation of the natural resource base, and
- **human and social**, which not only deals with individual and collective capabilities but also with the sustainability of the development processes

Nevertheless, as discussed in the previous section, the term “ sustainable rural livelihoods” is broad and has different meanings for different stakeholders and requires a negotiation process to reach to a consensus about its meaning. However, even if rural communities and institutions share a common understanding and definition of sustainable rural livelihoods and a vision about the desired modified development state, it remains a methodological challenge to assess these changes empirically. There is still a need to define better quantitative and qualitative indicators to changes in the development state of communities, and especially to reconcile institutional indicators with rural communities perceptions and indicators.

A broad-based and potentially useful approach of sustainable rural livelihoods is a framework that has a number of basic elements. According to this approach, the key question to be asked in any analysis (including impact) of sustainable rural livelihood is:

Given a particular context (of policy setting, politics, history, agroecology and socio-economic conditions), what combination of livelihood resources (different types of ‘capital’) result in the ability to follow what combination of livelihood strategies (agricultural intensification/ extensification, livelihood diversification and migration) with what outcomes? Of particular interest in this framework are the institutional processes (embedded in a matrix of formal and informal institutions and organizations) that mediate the ability to carry out such strategies and achieve (or not) such outcomes (Scoones, 1998).

Linking Research Outputs to Development Impact

Sander (1998) proposes that to locate and assess the impact of research it is important to understand if and how people and organizations react to it, and whether they change their actions as a result of it. As such, recent work of the International Development Research Center (IDRC) sees these responses, called “reach”, as an essential part of IA. Their proposed methodology traces the multiple, often non-linear chains of events linking the

researchers and their findings with the other actors who are essential to change, and look for evidence of change along the way.

However, one of the major difficulties encountered in trying to assess the effect of INRM research on development impact has been the lack of a clear link between research outputs and development strategies that can lead to development impact. This is especially important in the case of research, where the chain of events from research products to their usage to development impact is not always as straightforward⁷. Hence, INRM research IA should start with a proper planning stage that permits the articulation of steps between research and development strategies, with clear short and long run intermediate and final development objectives. Therefore, IA begins with a clear definition of the desired impact, where it is expected, for whom it is anticipated, and the pathway for getting there. Even though “outputs cannot be assessed fairly unless they are identified from the start” (Goldsmith, 1983), unexpected outcomes need to be also noted with intermittent revisions of the research strategy.

Therefore, the planning stage should provide more immediate to longer-term R&D objectives. To do so, it is important to identify three different levels of ‘impacts’:

- **outputs**, defined as the immediate product of a project after using the given inputs
- **outcomes**, which are the consequences of the outputs afterwards, and
- **impacts** that are the broader and longer term aims

For this purpose, Guijt (1998) proposes the mapping of hierarchical objective trees, as well as a participatory tool called “impact flow diagrams”. An impact flow diagram is not more than an open-ended method that helps identify a wide range of impacts: positive and negative, expected and unexpected, and direct and indirect.

Once clear R&D strategies are developed and objectives mapped, a M&E process allows assessment of the progress towards the achievement of desired ‘outcomes’. The performance assessment of these ‘outcomes’ yields further information about likely or potential ‘impacts’, and serves as a crucial feedback loop to adjust or refine the R&D strategies as needed. As stressed by Goldsmith (1993) an impact cannot be claimed by an intervention unless it can be explained logically and justified

As one moves along the pathway from an intervention to development impact, it also moves from the specific intervention with “performance or output indicators” that depend exclusively on the project, to “outcomes” that depend on the intervention and on its

⁷ Goldsmith (1993) stresses the unspoken hypothesis that a causal connection runs through interventions to outputs, outcomes at the final user or client level impacts. While the connections are plausible, they are often treated as a “black box” that cannot be analyzed or explained in detail. He states that “no-one has yet found an easy way, for example, to find out the effect of policy advice to a country: the final impact may be great, but the causality is usually too subtle to measure exactly. The subtlety is particularly acute with agricultural research and technology diffusion, in which a long chain of events separates innovations made in the scientist’s laboratory from their employment in the farmer’s field.”

boundary partners⁸ in its sphere of influence. However, final sustainable livelihood impacts go beyond the sphere of influence of an intervention and depend on a range of structural factors. These structural factors include the context conditions and trends (e.g. the policy setting, the cultural and social differentiation and the agroecological conditions, among others), the livelihood resources and the institutional processes and organizational structures.

Developing Output, Outcome and Development Impact Indicators

Once project objective trees map the chain of events from project outputs to final development impacts, the next step is to develop indicators that permit to evaluate whether objectives are being achieved. Guijt (1998) argue that indicators are central to most M&E approaches and are simply an aid for communicating complex processes, events or trends to a wider audience. She defines them as *“a quantitative or qualitative characteristic of a process or activity about which changes are to be measured”*. However, indicators are only meaningful if they relate to needed information and if the users know how to interpret its meaning. Since indicators are only a proxy for a complex reality, they must be relevant and accurate enough, rather than perfect, and need to be selected carefully.

Guijt (1998) also considers that selecting indicators is probably the most difficult step in establishing a M&E process. The following difficulties are mentioned:

- each ‘output’, ‘outcome’ and ‘impact’ can be monitored using a range of different indicators
- chosen indicators are likely to change over time as the external environment changes and as the project objectives are adjusted, and
- bringing different people together in a participatory process to select indicators reveals their different information needs and expectations of monitoring

Therefore important recommendations when developing and selecting indicators include the following:

- objectives and users of the M&E process should be clear
- project objectives, outputs, outcomes, and impacts should be well thought and mapped to make easier the process to develop indicators
- indicators must generate information that will be used, and falling in the trap of collecting a great deal of irrelevant information should be avoided
- indicators should be chosen by the people who are to do the data collection and analysis and the end-users of the information to be credible
- only indicators that are feasible to monitor, analyze and disseminate with the available resources should be chosen, and
- indicators should reflect the needs of quantitative and/or qualitative information .

⁸ “Boundary partners” are defined by Smutylo, 1998 as *“those individuals, groups, or organizations with whom the initiative interacts directly and on whom the initiative can anticipate some opportunities for influence. These actors are called boundary partners because even though the initiative works with them to effect change, it does not control them.”*

A Proposed Conceptual and Analytical Framework for INRM Impact Assessment

The conceptual framework for IA proposed by CIAT is based upon the sustainable rural livelihoods approach (Scoones 1998). Therefore the IA framework (Figure 1) starts with an initial assessment or baseline study to describe the current development state, where the community has a given level of livelihood resources or capitals⁹. Communities and individuals undergo different development processes in their desire to reach an improved modified development state. Different local development processes can be identified such as:

Local organization and coordination processes, where individuals get organized for different activities that require collective action and make decisions that affect the community as a whole, either in a positive or negative manner.

Economic and productive processes, where individuals and households develop activities with food security and income-generation purposes. These processes include decision-making as to what to produce, how, with whom, where to sell, etc. Once decisions have been made, planned activities are implemented, leading to action and results. Then evaluation (informal or formal) of the means and results leads to a new planning-action-evaluation cycle.

Local knowledge generation processes, which provide communities with the “know-how” that differentiates them from other communities. These processes are based mainly on local knowledge development and diffusion from generation to generation.

Internal communication and information processes, which permits the diffusion of knowledge, information and experiences within the community.

External relations and negotiation processes that are used by communities to relate with the external environment and negotiate with external agents around different interests, needs and objectives.

Development processes are aimed to enable communities reach a modified development state, moving it from an “initial” development state towards a “desired” one. At the same time, institutional processes, organizational structures and external interventions influence the access to livelihood resources and the composition of the livelihood research portfolio. Hence, interventions support different livelihood strategies. Agricultural R&D projects usually offer support for agricultural intensification and diversification strategies by providing technology and information, training, technical

⁹ *Natural capital* is defined as the stocks (soil, forests, water, air, genetic resources, etc.) and environmental services (hydrological cycle, pollution sinks, etc.) from which resource flows and useful services for livelihoods are derived.

Economic/financial capital is defined as the capital base (cash, credit/debt, savings, and other economic assets, including basic infrastructure and production equipment and technologies) which are essential for the pursuit of any livelihood strategy.

Human capital is defined as the skills, knowledge, ability to labor and good health and physical capability important for the successful pursuit of different livelihood strategies.

Social capital is defined as the social resources (networks, social relations, affiliations and associations) upon which people draw when pursuing different livelihood strategies requiring coordinated actions.

assistance and DSTs, among others. Land reform and/or land-use policies may affect agricultural extensification strategies. Rural microenterprise development projects provide business development services (i.e. market information and contacts, advising, technical assistance, training on management skills, etc.) and credit that would have an impact on livelihood intensification, diversification strategies and/or migration strategies.

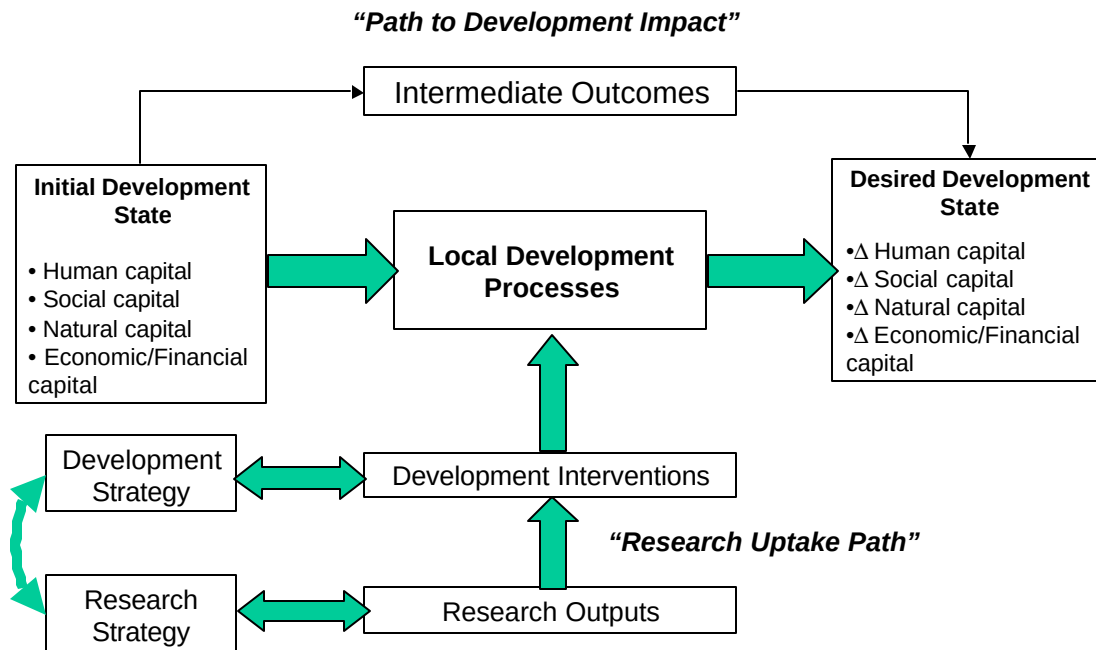


Figure1. Conceptual and analytical framework for IA of R&D interventions on sustainable rural livelihoods.

On the other hand, institutional development programs could influence the ability of institutions and organizations to access livelihood resources and the portfolio of livelihood strategies by strengthening and/or facilitating community organization and their capacity for decision-making and action-development. Other intervention entry-points could be the strengthening of local capacities for innovation and diffusion or the empowerment of individuals and communities to improve their capacity to participate and negotiate with external agents.

The conceptual and analytical framework makes it possible then to develop an impact assessment framework that links research outputs to development interventions, through a “research uptake path”. The impact assessment framework also makes it possible to link development interventions that affect local development processes through the “path-to-development impact”, resulting in intermediate outcomes or milestones that show progress towards the achievement of final development impacts.

A Challenge to CIAT: Assessing INRM Impact Across Three Agro-Ecosystems

CIATs Natural Resource Management (NRM) projects work in different sites throughout Latin America, Asia and Africa. For the initial phase of INRM Impact Analysis, the Latin

America sites in the Hillsides (Yorito, Honduras and San Dionisio, Nicaragua), Savannas (Puerto Lopez, Colombia) and the Forest Margins (Pucallpa, Peru) were selected. In these sites, the Center's NRM Division integrates the work of its six projects with themes of Overcoming Soil Degradation, Community Management, Land Use Planning, Sustainable Systems for Smallholders, Agroenterprises Development, and Participatory Research, as well as with CIAT's germplasm research. Thus, CIAT integrates germplasm, technology and institutional innovations into pilot activities that are introduced, together with development partners to achieve the Center's mission of reducing poverty while preserving the natural resource base. These partners lead or play a major role in development planning and implementation, freeing CIAT researchers to focus their time in agreed-upon research activities. Center-employed coordinators play a crucial role in managing partner relationships.

Initial efforts to develop a methodology to assess the impact of CIAT NRM projects across the three agro-ecological reference sites focused on developing and/or selecting indicators to be measured in order to collect baseline data to compare 'before' and 'after' situations. These indicators ranged in scale from plot level to farm, landscape-watershed, region and continent. However scientists found it difficult to agree upon definitions of scale beyond the farm level. While physical boundaries such watershed was helpful to associate biophysical measures, policy decision-making followed political boundaries such as municipalities. In the end, consensus was found to analyze data using human-defined scales.

Moreover, besides the difficulties on the process of negotiating and developing indicators among NRM projects and scientists, the major constrain to move the IA effort forward was that the pathways from research outputs to development impact were not mapped during the project planning phases. The principal reason for this situation was that the 'logical framework' tool used for planning purposes, although being useful for monitoring project performance and reporting, does not go beyond project 'outputs'. As such the planning process did not provide a chain of expected events from project outputs to intermediate outcomes and final development impacts. Therefore, the development of indicators was set aside temporarily in order to first develop what has been called "the paths-to-development impact", which are not more than the mapping of the sequence of expected research outputs, outcomes and impacts in order to link research outputs with development impact.

Figure 2 shows the path developed for CIAT's Community Management of Hillside Resources Project research outputs. One of the interventions of this project is an inter-institutional organizational model that provides a forum for coordinated planning, implementation and evaluation activities aimed to solve specific NRM problems. Hence, the path developed for this organizational intervention is presented in shaded squares as the backbone of the path-to-development impact, as this is the platform where research outputs are to be used and adjusted.

DSTs for stakeholder analysis aim to improve the identification of relevant stakeholders to participate in the forum. Other DSTs developed by the project and other projects of

the NRM Division (i.e. participatory land use planning, market opportunity identification and evaluation, bio-economic modeling, etc.) should improve the understanding of problems, opportunities and tradeoffs, improving the design and implementation of action plans to solve demand-led prioritized NRM problems.

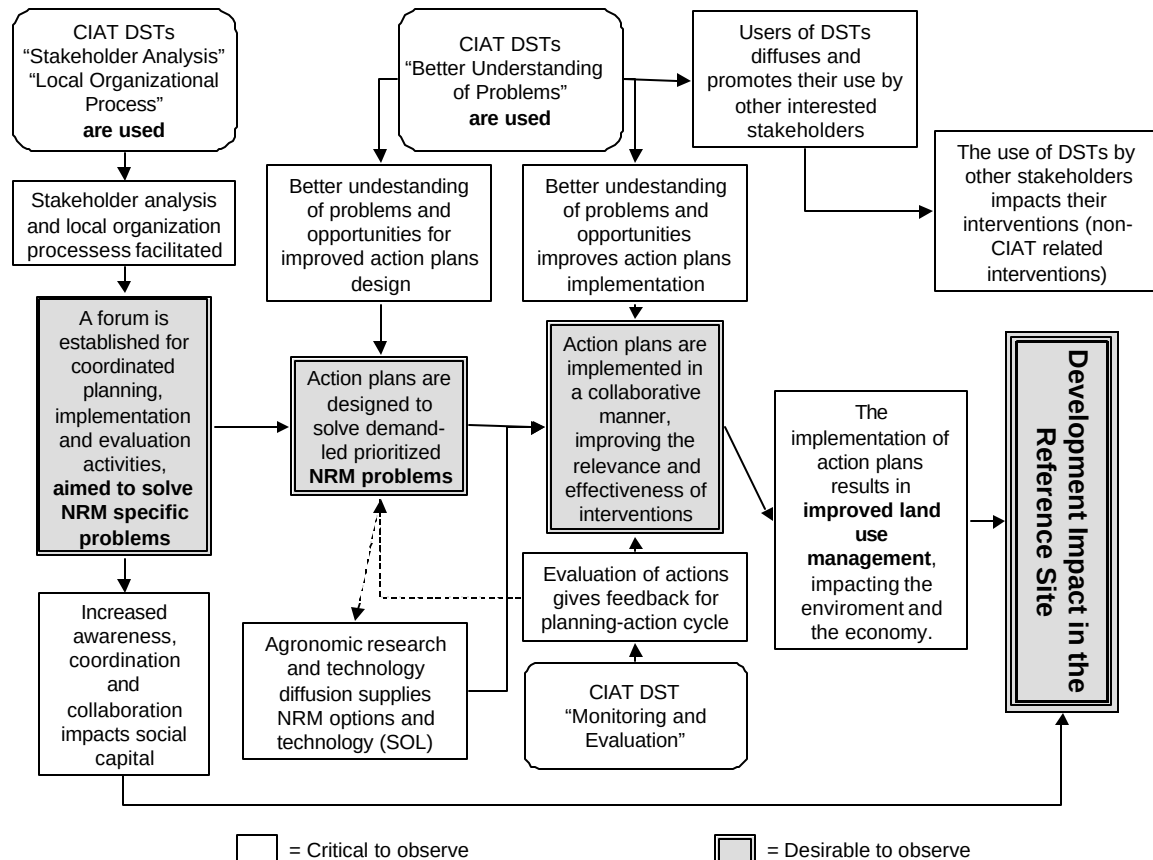


Figure 2. Paths to Development Impact of CIAT's Community Management of Hillside Resources Project research outputs: Inter-Institutional Consortium, Selected DSTs, and Agronomic Research.

At the same time, action plans provide demands for agronomic research, which then provide technological information and options for action plans implementation. DSTs for monitoring and evaluation should facilitate the evaluation of action plans implementation and give feedback for the planning-action cycle. All of the above should result in improved land-use management, impacting the environment and the economy, thereby, contributing to development impact.

Another more specific example of a research-to-development impact path is presented in Figure 3 for the Rural Agroenterprise Development Project. Again, this path is based in an alternative organizational model that provides a forum for coordinated planning, implementation and evaluation activities aimed to develop rural entrepreneurial activities. Hence, the path developed for this organizational intervention is presented in shaded squared as the platform where research outputs are to be used and adjusted.

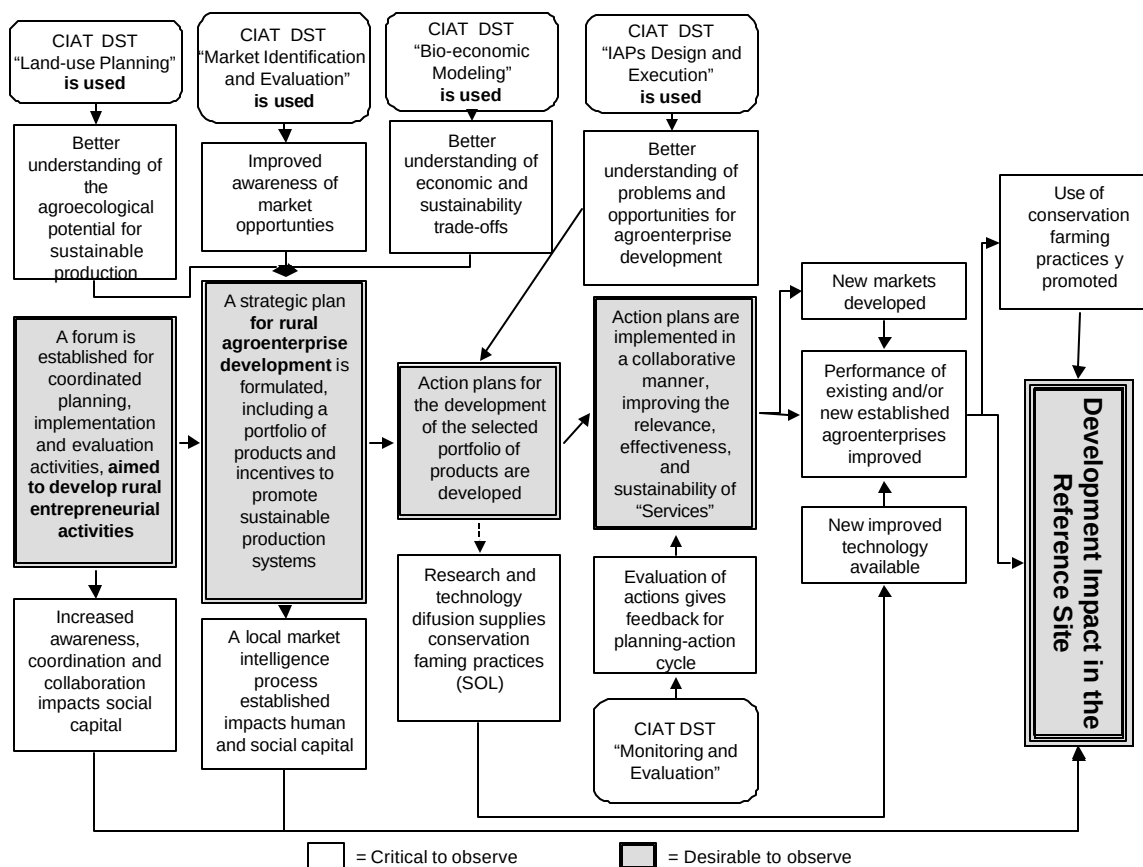


Figure 3. Paths to Development Impact of CIAT's Rural Agroenterprise Development Project research outputs: Rural Agroenterprise Support Services, Selected DSTs and Technology (Germplasm, Agronomic and Post harvest).

The set of DSTs developed by the project, but also in collaboration with other CIAT NRM projects should permit (1) a better understanding of the agroecological potential for sustainable production, (2) an improved awareness of market opportunities, and (3) a better understanding of economic and sustainability trade-offs. This information should lead to the design of a strategic plan for rural agroenterprise development, including a portfolio of products and incentives to promote sustainable production systems.

Based on a given portfolio of products, another DST developed by the project for the design and execution of Integrated Agroenterprise Projects (IAPs) provides a better understanding of problems and opportunities for agroenterprise development, supporting the design of action plans for the development of the selected portfolio of products. At the same time, action plans provide demands for agronomic research, which then provide technological information and options for action plans implementation. DSTs for monitoring and evaluation should facilitate the evaluation of action plans implementation and give feedback for the planning-action cycle.

All of the above results in the improvement on the performance of existing agroenterprises and/or the development of new markets to establish new agroenterprises, therefore, contributing to development impact. Furthermore, the economic incentives developed by the strengthened or new agroenterprises is expected to promote the use of conservation farming practices, thus contributing to improved land use management, related with the diversification of production systems mainly, and development impact.

Besides providing a clear understanding of a given intervention and its path from research to development impact, these pathways also permit a proper definition of R&D hypotheses and assumptions. In most of the situations the move from one milestone to the next may require that other external factors to the intervention also operate properly. Therefore, an intervention would also need to be proactive in ensuring that these assumptions are operational if development impact is to be achieved.

Once the “paths-to-development impact” are properly mapped, indicators can be selected to assess the achievement of each milestone along the pathways as well as for development impact. However, if a participatory monitoring and evaluation process is to be achieved and impact assessment use, as a monitoring and evaluation tool, indicators need to be negotiated among the different stakeholders, especially development impact indicators. A first list of proposed intermediate and development indicators, by type of capital is presented in Table 1.

In order to validate these indicators with those of the main stakeholders and beneficiary communities, workshops with stakeholder institutions and community organizations need to be conducted. In these workshops an analysis would be made on the desired development state (the vision of the watershed and its communities). Based on this desired development state, actual conditions would be described and milestones to be reached in the next years would also be described. The results of this analysis with stakeholders should make it possible to validate and prioritize the intermediate and final development impact indicators.

Once indicators are selected and prioritized, quantitative and qualitative data from previous studies conducted by both CIAT and other institutions, as well as from census data will be reviewed. A first assessment on the availability of studies that have already collected primary data in the reference sites, shows that there are a huge amount of collected information that is based mainly on surveys, and on semi-structured interviews, which can serve the baseline information needs. Available information from previous studies will be compared with the selected intermediate and final development indicators for monitoring and evaluation. Existing information will be organized in a database, and information gaps identified.

Depending on the type of data that needs to be collected, different methodologies can be used from surveys to semi-structured interviews and focus group discussions, among others. The baseline database will then be complemented with the primary data collected. First, a descriptive analysis of the baseline data will be conducted in order to describe the

initial development state of the reference sites, and conduct a cross-site comparative analysis of existing conditions.

Table 1. List of Proposed Development Indicators

<i>Economic and Poverty Indicators</i>	
<i>Food Security</i>	
• Total and gendered available food in the household • Seasonal available food in the household	
<i>Income</i>	
• Farm income (\$/ha) • Household income (\$/HH, \$/capita) • Household income stability (Standard Deviation) • Income sources (on/off farm, agricultural/non-agricultural) • New products or processes introduced in the agricultural sector • Participation on final consumer price (community gate price / final consumer price of most important selected commodities) • Value added to primary production (selling price / primary product farm-gate price) • Distribution of income sources	
<i>Equity</i>	
• Farm and household income comparisons by well-being group and by gender • Distribution of economic surplus or value added. • Land tenure situation (% farmers who own land, mean farm size)	
<i>Employment Generation</i>	
• Number of jobs (total, gendered and seasonal) • % of active population employed (total, employees, self-employment, and gendered)	
<i>Environmental Indicators</i>	
<i>Production System</i>	
<i>Land use intensification</i>	
• Number of cropping cycles per year • Fallow area as percentage of total area • Fallow time as percentage of cropping cycle • Fallow species diversity (native and enrichment with introduced species) • Legume diversity • Land with improved pasture	
<i>Land use diversification</i>	
• Number of species/crops per farm and /landscape • Number/type of cropping systems within the farm • Number of weeks per year that the soil is exposed to erosive effects (win and water) • Number of perennial crops in the cropping systems • Spatial distribution of crops • Temporal distribution of crops • New resource management practices introduced in the agricultural sector	

Table 1. (Cont.)

<i>Land productivity</i> • Kg/ha/year for selected crops, livestock and forest products • Total factor productivity • Product / energy ratio (biophysical measure) Forest • Area of forest cover (ha/farm, ha/community, ha/municipality) • Map of forest cover (spatial and temporal distribution) • Secondary forest regeneration • Species diversity in secondary forest (native successions and enrichment with introduced species) Soils <i>Mass Balance</i> • Nutrient Balance (nutrient input/ nutrient output). Desired level is Nutrient Balance = 1 at the farm and landscape level <i>Land productivity</i> • Kg/ha/year for selected crops (already an indicator of production systems) Water balance Area and spatial and temporal distribution of degraded land and pasture Water <i>Water pollution</i> • Contamination points <i>Water quality</i> • Sedimentation, • Turbidity • Levels of nitrates and phosphates • Conductivity <i>Water availability</i> • Volume of water by season • Volume of water by levels of rain Other indicators • Agro-chemical use (kg/farm, # of applications) • Burning of agricultural residues (Yes/No) • Air pollution (Yes/No, CO, CO₂)
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Table 1. (Cont.)

<i>Human/Social Indicators</i>
<i>Community Empowerment and Equity in Decision Making</i>
• Projects designed and mobilize by the community and/or local and/or external institutions (# and description)
<i>Participation in Local Policy Decision Making</i>
• Existing channels and mechanism for participation in democratic governance • Community access to political decision making • Community capacity to influence political decisions that affect the community
<i>Human Capital</i>
<i>Education and Experience</i>
• Individual capacity (# years formal / non formal education, # years experience)
<i>Individual Capacities</i>
• Capacity to participation in key decisions that affect NRM and primary production and agroenterprises. • Capacity to innovate in agriculture, agroenterprises and NRM. • Knowledge of key cause-effect of NRM problems • Knowledge of key cause-effect of agricultural production, processing and marketing relationships • Capacity to manage agroenterprises, CIALs, community organizations, Consortia, and farm.
<i>Access to opportunities</i>
• % of children with access to primary education • % of youth with access to secondary, technical and university education • Technology • Market • Infrastructure • Health • Information
<i>Social Capital</i>
<i>Structural Social Capital</i>
• Organizational density • Networks • Support organizations • Procedures and norms • Precedents
<i>Cognitive Social Capital</i>
• Conflict resolution • Collective action • Solidarity • Trust • Reciprocity • Cooperation

Table 1. (Cont.)

<i>Quality of Life Indicators</i>
• Nutritional Levels • Access to health services and medicines • Access to consumption goods (clothes, shoes, etc.) • Migration • Local well-being indicators

Conclusions and Recommendations

As INRM research has been introduced in the CGIAR agenda, the theme of assessing and demonstrating its impact has challenged scientists, especially socioeconomists. The complexity of INRM interventions, with multiple objectives, diverse stakeholders, and a wider geographic scope, requires a more holistic IA approach beyond analysis at the farm level and traditional economic surplus analysis. As such, a methodology that assesses changes not only in the economy, but also in the environment, the organizational context, and the people that permits to evaluate the impact of INRM research on the achievement of sustainable rural livelihoods is needed.

Three characteristics that differentiates INRM from traditional crop improvement research poses methodological challenges for IA. First, its own definition is still not clear as it embraces social, economic, environmental and biophysical components. Hence, the concept changes at different spatial and temporal scales and is assessed in terms of multiple objectives. Second, INRM requires the inclusion of multiple stakeholders, each with its own needs, priorities, capacities, power to speak, norms for trustworthiness of information, and expectations of being involved. Third, the different interests and perspectives of multiple stakeholders may be in conflict, requiring rigorous tradeoff analysis and negotiations.

Since INRM develops complex economic, social, environmental and biophysical innovations, IA needs to be a key part of the R&D process. As such, a rigorous assessment of the changes brought becomes essential. However, this M&E process should start with a thoughtful planning process that should go beyond defining research products. Therefore, during the planning stage, impact strategies that maps expected intermediate outcomes and development impacts should be develop, along with their respective assumptions and hypothesis.

Moreover, beyond accepting the importance of IA as a planning and learning tool, it is essential to validate the contribution of research outputs to development impact. Continued financial support requires confirmation that innovations produce sufficient improvement in production, poverty and/or environmental outcomes to justify large-scale dissemination, to extrapolate research products beyond the reference sites, and produce important impacts at least at a regional level if not globally.

The CGIAR has been concerned with measuring the impact of its research since the 1980s. As such impact assessment methodologies were developed accordingly with its changing research agenda. Hence, IA methodologies became a critical issue for INRM in the mid 1980s. However, as a result of larger scope issues of INRM, much remains to be done to enable IA to evaluate the final effect of more complex R&D projects in addition to economic criteria.

More complex R&D interventions also make it more difficult to attribute the success or failure to any one intervention. Establishing cause-effect linkages is more complex than just tracking changes, and is not as simple as comparing 'before' and 'after' situations, as many other influences will have occurred and affected the situation simultaneously. Moreover, the option of comparing 'with intervention' and 'without intervention' situations, in the hope of establishing clear causal links may not be the most appropriate. Among many other reasons, it may be too difficult (if not impossible) to control for other factors that may influence the outcome of an intervention to make the two sites comparable.

Given the above difficulties for developing an appropriate IA methodology for INRM research, there is no commonly accepted protocol for assessing the impact of INRM on sustainable rural livelihoods. Persistent issues include finding feasible spatial and temporal scale boundaries, integrating and negotiating stakeholder development objectives, stakeholder participation in the IA process, defining and empirically assessing sustainable rural livelihoods, linking research outputs to development impact, and developing appropriate and manageable indicators.

With respect to the first two issues, it can be argued that finding feasible spatial and temporal scales is not necessarily one of the most important issues, but rather the identification, negotiation and participation of multiple stakeholders. However, the inclusion of multiple stakeholders in the IA process requires a serious and thoughtful decision and consequently resources need to be allocated accordingly and a longer process expected. One way to deal with this issue could be to identify different interest groups (both locally and externally) as well as their assessment needs and interests, and as needed, parallel IA processes can be conducted with different interest groups and then integrated.

Furthermore, if a true participatory IA process is to be established, people affected by any intervention should be involved in the definition of the monitoring goals, the design of the system, the selection of indicators, data collection and analysis, and in the end should use the analyzed data and results. However, with respect to stakeholder participation on IA, a fundamental question to be asked is why anyone should bother assessing change, and for whom will the information and the process of collecting information, bring benefits.

The IA framework and methodology presented in this paper proposes that IA should start with thoughtful, well-defined and shared development vision and objectives. Based on these objectives, a development strategy needs to be design and research products defined

accordingly, in a demand-led manner, if research-for-development products are to be produced. This planning process would then permit a proper mapping of research outputs, intermediate outcomes that clearly shows how research outputs are articulated and used by the development strategy, and the final expected impacts of these R&D process. These maps are called “paths-to-development impact” and some examples are presented in this paper for two projects of CIAT’s NRM Division.

Once paths-to-development impacts are mapped, the next issue is the selection of an appropriate and manageable set of indicators for the critical outputs, intermediate outcomes and development impacts. Indicators are central to most M&E approaches, however, selecting indicators is one of the most difficult steps in establishing a M&E process. Indicators are only meaningful if they relate to needed information and if the users know how to interpret its meaning. Since indicators are only a proxy for a complex reality, they must be relevant and accurate enough, rather than perfect, and need to be selected carefully.

The proposed IA methodology would permit tracking relevant types of changes over time. However, establishing cause-effect, or at least influence, linkages is more complex and is not as simple. Therefore, there is a need for further IA research to develop a model for assessing and validating these paths-to-development impact in order to evaluate the contribution, or at least the influence, of a given intervention to final development goals. This model could also be useful to conduct ex-ante impact analyses of different R&D interventions from organizational models to decision-support tools (DSTs) to technology and information as a criteria for INRM research priority-setting.

4.1.2 Fieldwork in Central America Reference Sites to Start the Impact Assessment Process and Baseline Data Collection - by: *Veronica Gottret and O. Westermann*

Objectives

- (1) To present and share the process of impact assessment with CIAT local teams in Nicaragua and Honduras in order to raise long term capacity, interest and commitment with the process.
- (2) To initiate an inventory of available data and key stakeholders in order to start and maintain a continuous impact assessment process in the CIAT reference sites
- (3) To adjust and validate CIAT’s development impact vision with CIAT local teams, local institutional partners, community organizations, and selected members of communities. As a result, it is expected to establish a process of negotiation and prioritization of development impact indicators among the different stakeholders.
- (4) To conduct an initial assessment of developed social and human indicators with focus on institutional collaboration for NRM, agricultural research and agroenterprise development activities.
- (5) To elaborate an initial analysis on the use and usefulness of CIAT decision-support tools (DSTs) by key stakeholders in the reference sites. Additionally, to assess the effect of the elaboration of DSTs in the reference sites.

Major Fieldwork Activities

- (1) Interviews were conducted with support institutions that work in the reference sites in order to (a) define their objectives and activities in the reference site, (b) assess their relations with other local support institutions and community organizations (Venn Diagrams), (c) construct their development vision, (d) identified the mechanisms use for decision-making and assess the use of CIAT decision-support tools, and (e) assess their perception on community participation in decision-making and leadership.
- (2) Workshops were conducted with CLODEST and REDOLLYS in Yorito and with Campos Verdes in San Dionisio in order to (a) construct their development vision (How would we like to be in 10 years?), (b) describe the current situation (How are we now?), and (c) describe their “path to development impact” (How would we like to be in 3-5 years?), and (d) assess the density of community organizations and the relationship among them.
- (3) Meetings were conducted with key informants of four selected communities (two in San Dionisio and two in Yorito) in order to: (a) construct their development vision and (b) assess the levels of collective action in the communities.
- (4) An inventory was made of available databases that could serve to set up an impact assessment baseline. Based on this 9 databases were identified for San Dionisio, and 11 databases for Yorito.
- (5) The proposed methodology for impact assessment was presented to CIAT local teams in Nicaragua and Honduras during the Montelimar Laderas Workshop, and to smaller groups in the Managua and Tegucigalpa offices. The methodology was also presented to CIAT local partners in a workshop in Yorito, both CLODEST and non-CLODEST members.

Products of the Fieldwork

- (1) All the interviews and workshops were taped and are transcribed.
- (2) A summary of all interviews was written in a chronological order
- (3) An inventory of the different surveys and interviews conducted in San Dionisio and Yorito has been bone. This inventory includes (a) the name of the study, (b) the content of the survey and/or interview, (c) the sampling procedure if available, and (d) the availability of the data set in the CIAT offices, or if an agreement with the institution that owns the data set is needed.
- (4) Based on the above information an analysis for each critical path is being conducted including: (a) a list of proposed indicators for the critical path, (b) the degree in which this critical path was achieved or not is analyzed, (c) the usefulness of the proposed indicators is evaluated, and (d) needs for further information and analysis are listed.
- (5) The set of preliminary development impact indicators developed for the four types of capitals (human, social, economic/financial and natural) are being contrasted with the

“development visions” defined in the workshops with CLODEST, REDOLLYS and Campos Verdes. Also the short-term expected changes are contrasted with the “paths to development impact” developed for project.

CIAT Collaborators:

- Jacqueline Ashby, Director for Research, Natural Resource Management
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- Alejandro Imbach, Former Project Manager Land Use Project (PE-4)
- Douglas White, Agricultural and Environmental Economist, Sustainable Systems for Smallholders Project (PE-5)
- Olaf Westermann, Research Fellow, Community Watershed Management Project (PE-3)
- Libardo Rivas, Economist Impact Assessment Project (BP-1).
- Susan Allan, Consultant, Sustainable Systems for Smallholders Project (PE-5)
- Nathalie Beaulieu, Research Fellow, Land Use Project (PE-4)
- Jaime Jaramillo, Savannas Group Coordinator, Land Use Project (PE-4)
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- Ann Braun, Former Project Manager Participatory Research Approaches Project (SN-3)

4.2 Building a Strategy and Methodology for Research with Participatory Focus in CIAT-Bolivia – by Gottret, M. V., Brekelbaum, T. and Holland, D.

2000 Milestones:

- A Planning and Reflection workshop was held to “*Construct a Strategy and Methodology for Incorporating a Participatory Approach Focus in CIAT-Bolivia*” on April 10-14, 2000 in Santa Cruz Bolivia. These workshop was facilitated by a inter project team of CIAT consultants and their counterparts form the Centro de Investigación Agrícola Tropical (CIAT-Bolivia). One of the objectives of this workshop was to enhance the capacity of CIAT-Bolivia to design a monitoring and evaluation system to follow-up participatory approach initiatives as a learning and evaluation process.

Background, Objectives and Results of the Workshop

Following up on the initial phase of an institutional strengthening project, coordinating by the Participatory Research Approaches Project, SN-3 (see 1999 Annual Report, p. 93), CIAT staff traveled to Bolivia. This team of CIAT consultants from the SN-3, BP-1, Rural Agroenterprise Development (SN-1), Sustainable Systems for Smallholders (PE-5) facilitated a workshop with staff of the Centro de Investigación Agrícola Tropical (CIAT-Bolivia). A Planning and Reflection workshop was help outside Santa Cruz, Bolivia. The purpose of the workshop was to “*Construct a Strategy and Methodology for Incorporating a Participatory Approach Focus in CIAT-Bolivia.*” Specifically, the CIAT consultants and their counterparts from CIAT-Bolivia carried out the following activities during the workshop:

1. Presented and analyzed case studies of different participatory research approaches in Latin America that are relevant to CIAT-Bolivia (Programa Campesino-a-Campesino, Diagnóstico, Investigación y Participación (DIP), Programa Regional de Reforzamiento a la Investigación Agronómica sobre Granos en Centroamérica (PRIAG), Farmer Research Committees (CIALs) and Farmer Field Schools).
2. Presented the Rural Agroenterprise Development Project approaches and methodologies with focus on its participatory research and development approaches.
3. Analyzed the conceptualization and focus on participatory approaches and come up with a joint definition of the basic concepts and principles of these approaches. Based on this analysis, CIAT-Bolivia staff evaluated their on-going projects and their degree in which farmers participate on them.
4. Designed a pilot project profile for to be executed by CIAT-Bolivia with the support of CIAT based on participatory approaches for local development as a learning-by-doing process, and that includes a monitoring and evaluation system that feedback the learning process and serves for ex-post impact assessment purposes.

The CIAT-Bolivia group decided it was important to organize their interactions on a more formal basis. Thus they decided to form a CIAL (called CIAC in Bolivia) of researchers who have sufficient time, interest and who want to participate. At the same time, the idea of forming a Group of Mentors, whose role would be to support the CIAC, was proposed. The two bodies would maintain a continuous flow of information between them. The members of the CIAC were elected and functions for this Ad Hoc Committee (1 July 2000) were proposed, together with a schedule of the tasks to be carried out. The primary task was to finalize the proposal of the draft concept note, which was prepared by the CIAT consultants as part of the consultancy. This concept note will be use to mobilize resources to fund this interinstitutional project, with the possible participation of the SN-3, SN-1 and BP-1 projects.

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Donors supporting research reported in this document

- BMZ-Germany
- Consultative Group on International Agricultural Research
- Ford Foundation
- Inter-American Development Bank
- Ministry of Agriculture, Colombia
- Rockefeller Foundation
- Special Panel on Impact Assessment (TAC-SPIA)
- Swiss Development Cooperation ISDC
- Systemwide Program for Collective Action and Property Rights (CAPRI)
- Systemwide Program on Participatory Research and Gender Analysis (FPRGA)

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